JOHN MARLEY.

PRESIDENT OF THE INSTITUTION OF MINING ENGINEERS. 1889-90.

Born on November 11th, 1823, and died on April 4th, 1891.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

TRANSACTIONS.

VOL. XLVIII.

1898-99.

Edited by M. WALTON BROWN, Secretary.

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NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING, Held in the Wood Memorial Hall, Newcastle-upon-Tyne, August 6th, 1898.

Mr. GEO. MAY, Retiring President, in the Chair.

The Secretary read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on July 23rd and that day.

The Secretary also reported the proceeding of the Council of The Institution of Mining Engineers.

ELECTION OF OFFICERS, 1898-99.

The Chairman (Mr. G. May) appointed Messrs. J. W. Fryar, C. H. Steavenson, W. Ridley, and W. R. Bell as scrutineers of the ballot papers for the election of officers for the year 1898-99. The scrutineers afterwards reported the result of the ballot as follows:

President.
Mr. William Armstrong.

Vice-Presidents.
Mr. T. W. Benson. Sir William Thomas Lewis.
Mr. T. Forster Brown. Mr. R. Robinson.
Mr. J. L. Hedley. Mr. J. G. Weeks.

Council.
Mr. Henry Ayton. Prof. H. Louis.
Mr. W. C. Blackett. Mr. C. W. Martin.
Mr. Benjamin Dodd. Mr. J. H. Merivale.
Mr. T. E. Forster. Mr. H. Palmer.
Mr. W. F. Hall. Mr. A. M. Potter.
Mr. T. E. Jobling. Mr. J. A. Ramsay.
Mr. A. C. Kayll. Mr. T. O. Robson.
Mr. H. Lawrence. Mr. F. R. Simpson.
Mr. W. Logan. Mr. J. Simpson.
Mr. G. B. Forster proposed a vote of thanks to the retiring President (Mr. G. May), Vice-Presidents and Councillors for their services during the past year.

Mr. W. C. Blackett seconded the resolution, which was cordially adopted.

Mr. P. Kirkup moved, and Mr. M. Walton Brown seconded, that a vote of thanks be accorded to the scrutineers for their services, which was unanimously adopted.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1897-98.
The following table shows the number of members of the various classes during a few recent years:—

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<td>1,020</td>
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The Council are pleased to report a continued expansion of the membership as recorded in the preceding table, and urge the members to endeavour, at all times, to extend it. The class of Associates, comprising persons employed in subordinate positions in mines, has proved successful, and has materially assisted in increasing the roll of members.

The members have to regret the deaths of Mr. Thomas John Bewick, Mr. Stephen Campbell Crone, and Mr. William Lishman (Sunderland), who had for many years been actively connected with the Institute, and had served on the Council,

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With the view of rendering the Wood Memorial Hall more useful to the members, the Council have had plans prepared for lighting from the roof extension of the book-shelving, erection of entrance-porch, furnishing warming, decoration, etc., at an estimated cost of about £2,000. The work is now in progress, and it is hoped that the alterations will be completed on September 1st next ensuing.

With the view of reducing the expenses of the Institute, the Council have agreed to let Room No. 4, now held under lease, to the Coal Trade Associations, at a rental of £75 per annum, for a term of 7 years, from November 11th, 1897.

A portrait of the late Sir George Elliot has been presented by his grandson, Sir George Elliot. The Council trust that the series of portraits of Past-Presidents may be completed by gift or bequest, and that succeeding Presidents will each in rotation assist in maintaining the completion of this collection.

The meetings of Students and Associates have been continued, and one paper has been printed in the Transactions.

The revision of the composition, payable in lieu of the annual subscription, has been approved, as shown by the number of members who have so compounded. The Council will invest the amounts so received, as suitable investments are suggested to them.

The additions to the Library by donation, exchange, and purchase have been:—
Bound volumes 286
Pamphlets, reports, etc. 246
A total of 532 titles.

and the Library now contains about 7,739 volumes and 1,750 unbound pamphlets. The Card Catalogue renders the books readily available for reference. The Library (including the books and weekly engineering papers) is available to members residing in the vicinity, from 10 a.m. to 5 p.m. daily, and those residing at a distance may make use of the books by communication with the Secretary. Some of the files of publications have been rendered incomplete by the neglect of members to return borrowed books, and it is earnestly requested that members will return the missing volumes.

The Library would be rendered more valuable if members would present volumes, etc., which they can spare from their own libraries. Members would also render valuable service to the profession by bequeathing books, reports, plans, etc., to the Library, where they would be available for reference, and maintain the memory of the donor.

[4]

By arrangement with the Literary and Philosophical Society of Newcastle-upon-Tyne, whose premises are connected with the Library of the Institute, members of either institution are permitted (on producing a member's pass) to refer to the books in the Library of either institution.

The publication of the Sinkings and Borings has been completed, and the series of six volumes may be purchased from the Secretary. Members are desired to send copies of any unpublished sections of strata in Durham or Northumberland, or their section-books on loan, to the Secretary, with the view of their being published in a supplementary volume.

The prices of the Transactions and other publications of the Institute have been reduced, and members are recommended to complete their sets before the stock is exhausted (volumes iii. to vi. are now out of print).

A General Index to volumes i. to xxxviii. of the Transactions of the Institute is in preparation, and the Council trust that it will be received with approval by the members.

The Council suggest that Indian and Colonial members should arrange local meetings for the reading and discussion of papers, and trust that success will attend such efforts.

The report of the Committee on Mechanical Ventilators is approaching completion, and will be issued during the current year to the members.

Mr. John Herman Merivale has been appointed to represent the Institute at the Conference of Corresponding Societies of the British Association for the Advancement of Science at Bristol in September next. Messrs. James McMurtrie and W. B. Harrison will represent the Institute at the meeting of the Sanitary Institute to be held in Birmingham in September next. Mr. John Daglish acts on behalf of the Institute as a governor of the Durham College of Science, Newcastle-upon-Tyne. Mr. W. Cochrane is the Institute representative on the Science and Art Committee; and Mr. Henry Ayton, on the Scholarships Committee of the Northumberland County Council.

The Federated Institution of Mining Engineers has now become The Institution of Mining Engineers, and the Council urge the members, who may be interested in other societies, to use their influence in favour of federation, by which the success of the Institution will be completely assured.
The Institution of Mining Engineers has now completed its ninth year, during which General Meetings have been held in Edinburgh, on September 14th, 15th and 16th, 1897; in Newcastle-upon-Tyne, on

February 22nd, 23rd and 24th, 1898; and in London, on May 19th, 20th and 21st, 1898. A meeting of students, associates, and junior members was held in Newcastle-upon-Tyne, on August 18th, 19th, and 20th, 1897. The meetings held in this district were well attended, and the thanks of the Institute are due to the Committees who made the arrangements, and to all of those who, by their services, contributed to the holding of these successful meetings.

The President's (Mr. George May) students' prize was awarded to Mr. G. P. Chaplin, for his paper on "Cornish Methods of Mine-timbering."

Prizes of books have been awarded the writers of the following papers, communicated to the members during the year 1896-7:

"Cornish Methods of Mine-timbering." By Mr. G. P. Chaplin.
"The Mineral Resources of the Colony of Queensland." By Mr. William Fryar.
"Notes on the Coal-seams of the Transvaal, and Description of a Modern Pit-head Plant." By Mr. W. T. Hallimond.
"Notes upon Foreign Mining Laws and Adequate Areas for Mining Concessions." By Mr. H. D. Hoskold.
"The Education of Metallurgists." By Mr. Saville Shaw.
"Notes on the Sinking of Two Shafts at Claravale Colliery." By Mr. F. R. Simpson.

The members may be congratulated upon the number and varied nature of the papers printed in the Transactions, and the Council trust that similar contributions will be forwarded as liberally as heretofore.
In conclusion, the Council desire to impress upon the members that the success of
the Institute in the future is dependent upon an increase in the membership, so as to
meet the increased expenses incurred by its connexion with The Institution of Mining
Engineers.

The Chairman moved the adoption of the report.

Mr. Thomas Doug-as, in seconding the resolution, regretted the death of three
gentlemen with whom he had been personally connected in former years, and whose
demise it had been necessary to place on record.
The report was unanimously adopted.

The Treasurer read the Report of the Finance Committee as follows:—

REPORT OF THE FINANCE COMMITTEE.
The Finance Committee submit herewith a statement of accounts from August 1st,
1897, to June 30th, 1898, covering a period of only eleven months. This is in
consequence of the Council having decided that the books shall in future be closed
on June 30th in each year, in order to allow greater time for the preparation and audit
of the accounts than was possible when they were closed on July 31st and submitted
to the annual meeting at the beginning of August. Owing to this change, a proper
comparison with the accounts of the previous year cannot be instituted.
The total income during the period named was £2,749 9s. 6d. Of this amount, £113
was paid as life-compositions in lieu of annual subscriptions, and £89 11s. 10d. was
received from the South Wales Institute of Engineers and The Institution of Mining
Engineers, in repayment of moneys previously expended by this Institute in
connexion with the Fan Committee's Report, leaving £2,546 17s. 8d. as the ordinary
income.
The names of several members whose subscriptions were in arrear have been struck
off the list of members, and the amounts written off in consequence are for the
current year £48 6s. 0d., and arrears £67 4s. 0d.
The total expenditure amounted to £1,883 16s. 0d., and the sum of £950 has been
placed on deposit with the bankers.

[7]

During the month of July, additional subscriptions have been received amounting to
£114 9s. 0d., and payments have been made of £284 11s. 6d., including £200 on
account of the alterations to the Wood Memorial Hall, so that the balance of capital at
July 31st was £9,278 12s. 11d., as compared with £8,769 13s. 1d. at July 31st, 1897.

The Chairman (Mr. G. May), in proposing the adoption of the Report of the Finance
Committee, said that the members could congratulate themselves upon the
continued success of the Institute.

Mr. G. B. Forster seconded the motion, which was unanimously adopted.

[8]

ACCOUNTS.

THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND INSTITUTE OF MINING AND
MECHANICAL ENGINEERS FOR THE YEAR ENDING JULY 31ST 1898

Dr.
July 31st, 1897.

<table>
<thead>
<tr>
<th>Description</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>To Balance at Bankers</td>
<td>725</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>&quot;     in Treasurer's hands</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&quot;     Outstanding Amounts due for Authors' Excerpts</td>
<td>£5</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Less—Written off</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>827</td>
<td>11</td>
<td>2</td>
</tr>
</tbody>
</table>

July 31st, 1898.

<table>
<thead>
<tr>
<th>Description</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>To Dividend of 7 1/2 per cent. on 146 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd., for year ending June, 1898</td>
<td>219</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Interest on Mortgage of £1,400 with Institute and Coal Trade Chambers Company, Ltd</td>
<td>24</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>South Wales Institute of Engineers, proportion of Fan Committee Expenses</td>
<td>34</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>The Institution of Mining Engineers, repayment of do.</td>
<td>55</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Sales of Transactions</td>
<td>89</td>
<td>11</td>
<td>0</td>
</tr>
</tbody>
</table>

To Subscriptions for 1897-98 as follows :

<table>
<thead>
<tr>
<th>Description</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>690 Members</td>
<td>1,449</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>69 Associate Members</td>
<td>144</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>79 Associates</td>
<td>82</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>35 Students</td>
<td>36</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>75 New Members</td>
<td>157</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>30 New Associate Members</td>
<td>63</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15 New Associates</td>
<td>15</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>11 New Students</td>
<td>11</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Totals</td>
<td>1,196</td>
<td>11</td>
<td>0</td>
</tr>
</tbody>
</table>

To Subscribing Firms, viz.: —

<table>
<thead>
<tr>
<th>Description</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 @ £4 4s</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>1 @ £2 2s</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Totals</td>
<td>6</td>
<td>6</td>
<td>0</td>
</tr>
</tbody>
</table>

To New Subscribing Firms, viz.

<table>
<thead>
<tr>
<th>Description</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 @ £4 4s</td>
<td>8</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Totals</td>
<td>1,976</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

To Life Compositions :

<table>
<thead>
<tr>
<th>Description</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Members</td>
<td>41</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1 New Member</td>
<td>24</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2 New Associate Members</td>
<td>48</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Totals</td>
<td>113</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Less—Subscriptions for current year paid in advance at the end of last year

<table>
<thead>
<tr>
<th>Description</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add—Arrears received</td>
<td>2,039</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Add—Subscriptions paid in advance during current year</td>
<td>2,290</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Totals</td>
<td>2,364</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

£3,577 0 8

Cr.

June 30th, 1898.

<table>
<thead>
<tr>
<th>Description</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>By Printing and Stationery</td>
<td>151</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Item</td>
<td>£</td>
<td>s</td>
<td>d</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Books for Library</td>
<td>30</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>Prizes for Papers</td>
<td>11</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Incidental Expenses</td>
<td>49</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>Postages</td>
<td>60</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Sundry Accounts</td>
<td>70</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Travelling Expenses</td>
<td>0</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Salaries</td>
<td>125</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Clerks' Wages</td>
<td>207</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Reporting</td>
<td>17</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>Rent</td>
<td>58</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>Rates and Taxes</td>
<td>20</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Insurance</td>
<td>8</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Furnishing and Repairs</td>
<td>7</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Coals, Gas, Water, and Electric Light</td>
<td>44</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>Expenses of Meetings</td>
<td>20</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Explosives Committee, Rent</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>General Index</td>
<td>17</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>687</td>
<td>19</td>
<td>7</td>
</tr>
</tbody>
</table>

By The Institution of Mining Engineers—Subscriptions

<table>
<thead>
<tr>
<th>Item</th>
<th>£</th>
<th>s</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subscriptions</td>
<td>1,050</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Less—Amounts paid by Authors for Excerpts</td>
<td>6</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,044</td>
<td>9</td>
<td>11</td>
</tr>
</tbody>
</table>

By Investments—

<table>
<thead>
<tr>
<th>Item</th>
<th>£</th>
<th>s</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lambton &amp; Co. Deposit Account</td>
<td>950</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,833</td>
<td>16</td>
<td>0</td>
</tr>
</tbody>
</table>

By Balance at Bankers

<table>
<thead>
<tr>
<th>Item</th>
<th>£</th>
<th>s</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>in Treasurer's hands</td>
<td>66</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>Outstanding Amounts due for Authors' Excerpts</td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>743</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

**Total**

<table>
<thead>
<tr>
<th>£</th>
<th>s</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,547</td>
<td>0</td>
<td>8</td>
</tr>
</tbody>
</table>

We have examined the above account with the books and vouchers relating thereto, and certify that, in our opinion, it is correct.

JOHN G. BENSON AND SON.

CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne,
August 5th, 1898.

[10]

Dr. The Treasurer in Account with Subscriptions, 1897-98.

<table>
<thead>
<tr>
<th>Item</th>
<th>£</th>
<th>s</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>To 829 Members.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 not on printed list</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>830</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 paid Life Composition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>828</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37 of whom are Life Members.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>791</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To 98 Associate Members</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>97 of whom are Life Members.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>91</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To 91 Associates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To 45 Students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Elected Associated Member</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To 23 Subscribing Firms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To 75 New Members.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To 1 New Member, paid Life Composition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To 2 New Associate Members, paid Life</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

£   s  d.   £   s  d.
---|---|---|---|---|---|---|
41  | 0  | 0  | 46  | 4  | 0  |
1,661| 2  | 0  | 191 | 2  | 0  |
95  | 11 | 0  | 46  | 4  | 0  |
90  | 6  | 0  | 157 | 10 | 0  |
24  | 0  | 0  | 48  | 0  | 0  |

---|---|---|---|---|---|---|
Composition
To 30 New Associate Members  @ £2 2s. 63 0 0
To 15 New Associates  @ £1 1s. 15 15 0
To 11 New Students.  @ £1 1s 11 11 0

To 2 New Subscribing Firms 8 8 0

To Arrears, as per Balance Sheet 1896-97 346 10 0
Add—Arrears considered irrecoverable, but since paid -46 7 0

Less—Struck off as irrecoverable—Arrears £67 4 0
" " " Current year 48 6 0

To Subscriptions Paid in Advance

[11]

Cr.  Paid  Unpaid
£ s. d.  £ s. d.
By 690 Members, paid @ £2 2s. 1,449 0 0
By 96 " unpaid @ £2 2s. 201 12 0
By 5 " dead @ £2 2s. 10 10 0
By 69 Associate Members, paid @ £2 2s. 144 18 0
By 22 " unpaid @ £2 2s. 46 4 0
By 79 Associates, paid @ £1 1s. 82 19 0
By 12 " unpaid @ £1 1s. 12 12 0
By 35 Students, paid @ £1 1s. 36 15 0
By 9 " unpaid @ £1 1s. 9 9 0
By 2 Subscribing Firms, paid 6 6 0
By 21 " unpaid 84 0 0
By 75 New Members, paid @ £2 2s. 157 10 0
By 2 Members, paid Life Composition 41 0 0
By 1 New Member, paid Life Composition 24 0 0
By 30 New Associate Members @ £2 2s 63 0 0
By 2 New Associate Members, paid Life Composition 48 0 0
By 15 New Associates, paid @ £1 1s. 15 15 0
By 11 New Students, paid @ £1 1s 11 11 0
By 2 New Subscribing Firms, paid 8 8 0

Less—Struck off as irrecoverable

2,089 2 0 364 7 0
48 6 0

By Arrears 250 19 0 77 14 0
By Subscriptions paid in advance 73 10 0

2,413 11 0 393 15 0
2,413 11 0

£2,807 6 0
GENERAL STATEMENT, JULY 31st, 1897.

LIABILITIES.

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<tr>
<th></th>
<th>£    s.</th>
<th>d.</th>
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<tr>
<td>Subscriptions paid in Advance during the year</td>
<td>73 10 0</td>
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<tr>
<td>* carried over from previous year</td>
<td>2 2 0</td>
<td></td>
<td>75 12 0</td>
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<tr>
<td>Capital</td>
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<td></td>
<td>9,448 15 5</td>
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<td></td>
<td></td>
<td>9,620 10 2</td>
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ASSETS.

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<th>£    s.</th>
<th>d.</th>
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<tr>
<td>Balance of Account at Bankers</td>
<td>674 2 5</td>
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<tr>
<td>* in Treasurer's hands</td>
<td>66 17 0</td>
<td></td>
<td>743 4 8</td>
<td></td>
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<tr>
<td>Outstanding amounts due for Authors' Excerpts</td>
<td>2 5 3</td>
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<td>Arrears of Subscriptions</td>
<td>393 15 0</td>
<td></td>
<td>4,530 0 0</td>
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<tr>
<td>146 Shares in the Institute and Coal Trade Chambers Co., Ltd. (at cost)</td>
<td>3,130 0 0</td>
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<tr>
<td>Investment with the Institute and Coal Trade Chambers Co., Ltd. (Mortgage)</td>
<td>1,400 0 0</td>
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<tr>
<td>Interest on ditto, half-year</td>
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<td></td>
<td>24 10 0</td>
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<tr>
<td>(Of the above amount, £350 is due to Life Subscriptions Account, leaving £323 12s. not invested.)</td>
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<td>Deposit with Lambton &amp; Co.</td>
<td>1,150 0 0</td>
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<td>579 7 6</td>
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<tr>
<td>Value of Transactions and other Publications, as per Stock Account</td>
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<td></td>
<td></td>
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<tr>
<td>Office Furniture and Fittings</td>
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<td>2,200 0 0</td>
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<tr>
<td>Books and Maps in Library</td>
<td>1,750 0 0</td>
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<td>9,620 10 2</td>
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I have examined the above accounts with the books and vouchers relating thereto, and certify that, in my opinion, it is correct. The Share Certificates and Mortgage Bonds have been produced to me.

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
August 5th, 1898.

ALTERATION OF BYE-LAWS, Nos. 8, 9, 10, 11, 12, 14, 15, 16, 21 AND 39.

Mr. G. B. Forster proposed in the print of the proposed alterations of the Bye-laws, that the words "who shall himself sign the undertaking contained therein" should be inserted after the words "knowledge of candidate" in the first, second and third paragraphs of Bye-law 8. With these alterations, he proposed that the amended bye-laws Nos. 8, 9, 10, 11, 12, 14, 15, 16, 21 and 39 be approved.

Mr. Thos. Douglas seconded the motion, which was unanimously adopted.
REPRESENTATIVES ON THE COUNCIL OF THE
INSTITUTION OF MINING ENGINEERS.

The Chairman (Mr. G. May) moved, and Mr. G. B. Forster seconded, a resolution that the following gentlemen be elected as the representatives of the Institute on the Council of The Institution of Mining Engineers:—

<table>
<thead>
<tr>
<th>Mr. Henry Armstrong.</th>
<th>Mr. Henry Lawrence.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. William Armstrong.</td>
<td>Sir William Thomas Lewis, Bart.</td>
</tr>
<tr>
<td>Mr. Henry Ayton.</td>
<td>Prof. Henry Louis.</td>
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<tr>
<td>Mr. R. Donald Bain.</td>
<td>Mr. Henry W. Martin.</td>
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<tr>
<td>Mr. T. W. Benson.</td>
<td>Mr. George May.</td>
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<tr>
<td>Mr. Bennet H. Brough.</td>
<td>Mr. C. A. Moreing.</td>
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<tr>
<td>Mr. William Cochrane.</td>
<td>Mr. John Morison.</td>
</tr>
<tr>
<td>Mr. G. B. Forster.</td>
<td>Mr. Henry Palmer.</td>
</tr>
<tr>
<td>Mr. T. E. Forster.</td>
<td>Mr. John Ridyard.</td>
</tr>
<tr>
<td>Mr. John Gerrard.</td>
<td>Mr. A. R. Sawyer.</td>
</tr>
<tr>
<td>Mr. Nath. R. Griffith.</td>
<td>Mr. F. R. Simpson.</td>
</tr>
<tr>
<td>Mr. W. F. Hall.</td>
<td>Mr. J. B. Simpson.</td>
</tr>
<tr>
<td>Mr. Jeremiah Head.</td>
<td>Mr. A. L. Steavenson.</td>
</tr>
<tr>
<td>Mr. Arch. Hood.</td>
<td></td>
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<tr>
<td>Mr. A. C. Kayll.</td>
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</tbody>
</table>

The following gentlemen were elected, having been previously nominated:—

Members —
Mr. Victor Manuel Braschi, Engineer and Contractor, Apartado 830, City of Mexico, Mexico.
Mr. Michael Curry, Colliery Manager, Edmondsley Colliery, Chester-le-Street.
Mr. Thomas H. C. Homersham, Engineer, Vulcan Iron Works, Thornton Road, Bradford.
Mr. Herbert Lloyd, Civil, Mining and Consulting Engineer, Engineering Offices, Middelburg, Transvaal, South Africa.

[14]

Mr. Arthur Walter Menzies, Mechanical Engineer and Surveyor, Menai Bank, Carnarvon.
Mr. Emil Laurence Oppermann, Electrical Engineer, 7, St. Mildred's Court, London, E.C.
Mr. Trevor Falconer Thomas, Mining Engineer, Llandaff Place, Cardiff.

Associate Members—
Mr. Tom Bower, P.O. Box 104, Kalgoorlie, Western Australia.
Mr. D. W. Brunton, Aspen, Colorado, U.S.A.
Mr. J. Coats, Rossland, British Columbia.
Mr. Benjamin Douglas, c/o Union Steamship Company, Cape Town, South Africa.
Mr. Jesse Gregson, Australian Agricultural Company, Newcastle, New South Wales.
Mr. J. Meiklejohn, Oriental Hotel, Water Street, Vancouver, British Columbia.
Mr. Percy Charles Riches, Public Works Department, Norseman, Western Australia.
Mr. A. E. Ritchie, 63, Queen Victoria Street, London, E.C.
Mr. Erling Einar Thii, Prindsens Gade No. 4, Christiania, Norway.
DISCUSSION UPON MR. T. G. LEE'S PAPER ON "EXPLOSIONS IN AIR-COMPRESSORS AND RECEIVERS."

Mr. W. C. Blackett (Durham) said that until he read Mr. Lee's paper he thought that the use of oil in air-compressing cylinders was a thing of the past. He was surprised at the statement in the paper that they were unable to use soap and water. He had known air-compressors going for 20 years, during which time nothing but soap and water had been used, or really water and soap, because they did not even take the trouble to mix the soap with the water. A lump of soft soap was thrown into the water, which was injected by a force-pump in the form of spray so as to cool the air, and that was sufficient to lubricate the air-compressing cylinders. The fact that others had a difficulty in using soap and water rather pointed to the suggestion that the pistons were probably not of the best construction for the purpose. At a colliery under his charge the top had been taken off one of the pistons, and as an experiment it had been partly packed with hard manilla yarn, like an ordinary squirt-packing. This was last done 2 years ago, and it was still in good condition. They had no trouble with the water passing with the air into the mine and freezing at the exhaust-ports of the air-engines. What little trouble there was with ice, was overcome by injecting into the exhaust-openings a small driblet of water, and since then they had had no further trouble with ice.

Mr. Henry Lawrence said that he had long been of opinion that soft soap and water was a sufficient, and the best lubricant for use in air-compressing cylinders. He found that it formed a fine skin on the inside of the air-cylinder. He thought that the explosion in the air-compressing cylinder was somewhat novel. They had an ignition in the air-compressing cylinder at Clifton colliery in 1895, and it would have warned him that an explosion would happen, and it actually did take place in 1897.

Mr. J. Morison (Cramlington) stated that he read a paper upon the same subject in 1888,* and at that time he was of opinion that the so-called explosion was caused by the vapour of the oil which had become ignited. Now it seemed to him that, in the present case, neither in November, 1895, nor in May, 1897, was there any explosion in the air-receiver or in the air-compressing cylinders, and it appeared to him that the so-called explosions had been improperly attributed to the oil-vapour. He himself attributed them to oil-vapour in 1888, and he held the same view for a considerable time. But in this case and others which had come under his notice, it appeared that there had been a gradual accumulation of residue from the oil, and that this substance had ignited, and in fact created a huge fire in the pipes and air-receiver. At Clifton colliery, it seemed to him beyond doubt that there had been no explosion, but that a considerable fire had arisen in the air-receiver, from the combustion of the residue of the mineral oil which had accumulated in the air-pipes and air-receiver. It was quite clear from the evidence that there had not been an explosion of the oil-vapour. If a fire was developed rapidly, the air in the receiver and pipes would
speedily acquire an increased volume, and would naturally escape at the safety-valves in the same way as any other accumulation of gases


would escape. All that happened, as described in the paper, appeared to be the simple result of a large fire in the pipes and air-receiver.

He had had considerable experience of air-compressing machinery, and could tell Mr. Blackett that although his particular circumstance might enable him to use soft soap and water, it was not by any means the universal experience. Many engineers had tried and abandoned the use of soft soap and water, because it was not suitable to their circumstances. He himself had tried it for a considerable time after the experience that he had had with mineral oil, and in his case the air-compressing cylinders were cut and grooved, and considerable trouble arose with the air-engines down the pit owing to the formation of ice in the exhaust-ports. Hemp did not appear to him to be a suitable packing for the piston of an air-compressor. He thought it would give rise either to considerable friction in working, or would allow of a leakage of air from one side of the piston to the other.

The author, in Table I.,* showed that the maximum indicated pressure in the air-cylinder was above the pressure in the air-receiver, to the extent of a minimum of 7 lbs. and a maximum of 19 lbs. per square inch. This excess of pressure clearly proved that the discharge-valves or air-pipes from the air-compressing cylinder were too small. He thought it had been fully demonstrated that the accumulations of the carbonaceous deposit in the pipes and air-receiver arose from the mineral oil; and he had no doubt that the preliminary fire was initiated in the restricted passage for the air through the valves and the pipes. A considerable number of experiments had been made in Germany with air-compressors,† and it was conclusively proved that the slide valve-ports between the air-cylinder, and the discharge-ports from the cylinders, if not of ample area, or if crooked, were speedily closed by deposits of the decomposed lubricant. The German authorities had issued suggestions which corresponded very much with the recommendations set forth in Mr. Lee's paper, and they recommended the use of oil of good quality, efficient cooling of narrow ports and valves, and an arrangement for a through draught in the air-receiver, in order to prevent accumulations of oil-vapour. The air-receivers should also be fitted with proper sludge-cocks in suitable positions, so that they might be cleared at adequate intervals.

Mr. W. C. Blackett said that, notwithstanding Mr. Morison's opinion, he still condemned the use of oil in air-compressors. The fact

† Ibid., vol. xiv., page 613.

that water and soft soap had not been found to suit some air-compressors did not, to his mind, point so much to the condemnation of water and soft soap as to the condemnation of the conditions, and the conditions should be made to fit the water and soap, and not the water and soap to fit the conditions. With all due deference to the last speaker, it did not follow that a packed piston was not a good one for use in an air-compressor, and probably the members would realize that when they began to put a large quantity of water into a cylinder they began to introduce conditions similar to that prevailing in an ordinary pump. No one, as a rule, attempted to pump water with ordinary pistons and rings. When an action similar to that of a pump was
produced, and it was readily produced owing to the large quantity of water and soap in the cylinder, then they began to be successful in the use of soft soap and water. Anyone watching the motion of an air-compressor could see at once whether it was inhaling air in the return stroke. He was not experienced in the use of high pressures of air, but for ordinary working pressures he maintained that the use of oil was improper, and that soap and water was the only proper lubricant to use.

Mr. Henry Lawrence said that he understood Mr. Morison to state that there had been no explosion of an air-receiver. He (Mr. Lawrence) thought that if Mr. Morison would refer to Plates XLIII., XLIV., and XLV.* showing the condition of the air-receiver after the accident at Ryhope colliery, he would tell the members at once that there must have been some sort of an explosion.

Mr. J. Morison considered that an ignition of the deposit in the pipes and air-receiver might have occurred at Ryhope colliery, and an explosion followed, and if safety-valves were not large enough, and there was a big fire, this would undoubtedly occur.

Mr. H. Lawrence thought that if there was no explosion at Clifton colliery he agreed that it was due to the flame passing out of the safety-valves, and so relieving the pressure. The description of the engineman as to sparks and flames issuing out of the safety-valves and joints of the cylinders and pipes appeared to indicate extraordinary conditions.

Mr. W. C. Blackett suggested that, owing to circumstances, in one case combustion and in another case combustion amounting to explosion might occur.


Mr. J. Morison said that he wanted to put clearly the difference between the formation of explosive gaseous mixtures in the air-receiver and the effect of intense heat expanding the air in the receiver, as the two phenomena were so different.

Mr. T. G. Lees, in replying to the discussion, wrote that his experience with soft soap and water for the lubrication of air-compressing cylinders led him to believe that good results might be obtained for slow speeds, but where the compressors were running up to 50 revolutions per minute, as at Clifton colliery, there was not sufficient lubricating properties in soft soap to keep the cylinders in good condition, and even if the quantity of solution was largely increased, the accumulation of residue required the frequent cleaning of the pistons and cylinders, so that its continued use was very objectionable, as explained in his paper. With regard to packing the air piston with manilla yarn as suggested by Mr. Blackett, this might be effective in some cases, but it was questionable if it would answer for cylinders of large diameter and running at high speeds. As to whether the incidents, related were ignitions or explosions, Mr. J. Morison was probably right in saying that both were simply ignitions of residue from the oil which had accumulated in the air-pipes and receivers, but the writer had no doubt that much oil-vapour was given off and was fired, causing the joints to blow out and finding a speedy release by means of the safety valves on the air-receivers, otherwise an explosion of a dangerous-character would have resulted.

DISCUSSION ON MR. PHILIP KIRKUP’S PAPER ON "THE MANUFACTURE OF FIRE-CLAY GOODS FROM THE UNDER-CLAYS OF THIN COAL-SEAMS."

Mr. P. Kirkup said that it was a difficult matter to judge from a chemical analysis of clay as to its value for any purpose. It was rather significant that in comparing analyses of raw fire-clay it always followed that the alumina and combined water bore more or less relative proportions, so that (indirectly) water in combination in any clay was a measure of its consistency, and in fact a measure of the "hydrated-silicate of alumina," which was the basis of all true clays. The combined water practically
disappeared on the clay being calcined, and the body or consistency was thereby much reduced.
Coke-oven bricks were usually made from a mixture of equal parts of ganister and fire-clay. But good coke-oven bricks without ganister could


[19]
be made from ordinary fire-clay (containing not less than 10 per cent. of alumina) with a proper admixture of free silica in the shape of sand or pure post stone, taking care, of course, that the fire-clay became granular by being put through a riddle, with 16 to 36 apertures per square inch—and that it had sufficient consistency in working up.
In the use of the improved furnace, he might mention that the greater the heat required to burn any bricks the greater would be the economy, inasmuch as the improved furnace was fed with hot air instead of cold air.
Mr. A. L. Steavenson said Mr. Kirkup had given his attention to the temperature that fire-bricks would stand without fusing, but during late years in the erection of retort coke-ovens another quality was necessary, and that was—that the bricks should neither shrink nor swell under high temperature. The retort-oven had a large number of flues, and if the bricks shrank or swelled, the flues and the oven were destroyed.
Mr. Kirkup said that, in making bricks for use in coke-ovens, it was important that a strong siliceous clay should be used, but it must not be forgotten that there was a difference between free and combined silica. A brick made from a clay in which there was a large amount of free silica, when subjected to heat, as in coke-ovens or furnaces, would not contract, but actually expand. The ganister clay, referred to in Table I., containing 85 per cent. of silica and 7 1/2 per cent. of alumina, with an admixture of about 25 per cent. of fire-clay, made an excellent brick for coke-oven purposes. The fire-clay was added so as to improve the consistency, or otherwise it would be impossible to mould and burn the goods.
The Chairman asked whether Mr. Kirkup had any experience of the use of bricks made from different classes of clay in retort coke-ovens, because if bricks expanded serious damage speedily occurred in the flues.
Mr. A. L. Steavenson asked for information as to the pressure that sanitary pipes would carry. He was going to carry a railway over some sewage-pipes, and could not find any information as to the pressure which they would sustain.
Mr. Kirkup said that he had no experience as to the manufacture of bricks suitable for use in the erection of retort coke-ovens. He only made the remark that bricks, made from fire-clay in which there was a large proportion of free silica, would have the minimum of contraction.

The following paper on the "Transvaal Coal-field," by Mr. William Peile, was taken as read :

[20]

TRANSVAAL COAL-FIELD.
By WILLIAM PEILE.
Commencing in Cape Colony, and extending over the Orange Free State, parts of Natal, and Zululand, into the south-eastern portion of the Transvaal, is a vast spread of sandstone strata, containing coal-measures.
The coal-bearing sandstones or coal-measures are about 1,000 feet in thickness, with red sandstone-beds above, and sometimes below them. These beds may be described as horizontal, a striking characteristic feature of the country, accounting
not only for the flat summits of the mountains, the sluggish and winding character of the streams, but also for the level table-land formation of the whole country. The coal-measures have frequently been reduced in thickness by denudation, and pierced through by the upheaval of igneous rocks, or interfered with by the tilted beds belonging to a lower series; as, for example, along the high ridge running east and west at Johannesburg, in which are the banket or gold-bearing conglomerates of the Rand. This ridge, at an elevation of about 5,600 feet above sea-level, forms the divide or watershed of the country, and the High Veld extends all the way to Ermelo, the eastern limit of the coal-field, where all the principal rivers in this part of the country have their sources (Fig. 1, Plate I.).

The Vaal river flows a little to the south, then in a westerly direction, parallel with the High Veld, to the Atlantic Ocean, and forms the southern boundary of the Transvaal. The Komatie, and other rivers to the east, flow into Delagoa Bay. The Olifants, and other rivers to the north—branches of the great Limpopo or Krokodil river—flow into the Indian Ocean.

The coal-measures comprise gravels, clays, coarse and fine grits, and dark and light sandstones, interstratified with carbonaceous and micaceous shales, with seams of coal. Owing to the extensive denudation of the country, these measures have been reduced in the Transvaal to a thickness not exceeding 600 feet in some places. Fortunately, the coal-seams in the Transvaal are comprised in the lower part of the series, and throughout the eastern part of the coal-field we have the seams often exposed, or outcropping- on the breast of the hills, along the banks of the spruits ; often denuded altogether in the valleys, and at shallow depths, even on the High Veld.

In the western part of the coal-field, along both sides of the ridge, but principally to the south, overlying unconformably the upturned beds-of the older series, and subject to their irregularities as well as to denudation, the coal-measures occur in patches, shallow lagoons, or lenticular deposits, covered up with debris of comparatively recent formation. The seams vary in thickness and extent. At the Great Eastern colliery, near Springs, there is a succession of coal-beds 75 feet in thickness, and in a short distance these beds are divided into three or more seams. With only a series of overlying sandstone beds, from the information he has obtained, the writer finds it impossible to satisfactorily correlate them with the seams in the eastern portion of the field.

The coal from these deposits is inferior in quality, splinty and dull in appearance, and contains a high percentage of sulphur and ash; but the situation is convenient for railway-transport to the gold-mines along the Rand.

The sections of strata (Appendix, and Fig. 2, Plate II.) are all taken in the Middleburg district, within the strip of ground between Brugspruit and Witbank stations, on the Delagoa Bay branch of the Netherlands railway. Six distinct seams of coal have been found within a depth of 172 feet, which are marked Nos. 1 to 6, and as No. 5 is the most important seam, all of them have been plotted to that seam as a datum-line. The Blauwkrantz section contains a total thickness of 58 feet of coal, at a depth of 200 feet; and the Schoongezicht borehole proves nearly 180 feet of strata below the bottom seam, through 42 feet of conglomerate and into red sandstone-beds; These several seams may be recognized outcropping in many places over an area exceeding 80 miles square, extending diagonally south-east from Balmoral to Ermelo, and south-west from Belfast in the direction of Heidelberg.

The coal-field may be comprised within a line south of Krugersdorp to a similar line east of Ermelo, about 170 miles in length by 120 miles in width, covering an area of about 20,000 square miles.
The age of this coal-bearing formation has created a considerable amount of geological interest, and it does not yet appear that geologists have determined whether it belongs to the Carboniferous or a more recent period; but as the country is developed, more information, and the discovery of more fossils, will possibly enable the question to be settled.

Owing to the shallow depth of the overlying strata, and to the seams so frequently outcropping, the entire coal-field appears to be free from explosive gas. The formation is also very free from faults, but is subject to intrusions of igneous dykes, with overflows and float-boulders of basalt and diorite spread over the surface, altering the nature of the strata and coal-seams in their immediate vicinity; often changing bituminous seams into semi-bituminous and anthracitic, by driving off the volatile matter in the coal, but not disturbing the general horizontality of the beds. Associated with these intrusions, deposits of magnetite and a softer sedimentary, and sometimes stratified iron-ore, are occasionally met with, perforating and overlying the coal-measures, whilst large areas of the surface are covered with siliceous iron-ore of a pisolithic appearance, sometimes varying to over 2 feet in thickness and generally overlying the coarse gritty sandstone beds on the High Veld, associated with the upper part of the coal-bearing strata. This ore is known throughout the country as old klip, and has often been used for rough building purposes. It appears, along with the hard grit, to have withstood the denudation, or overwhelming force of water that has swept the overlying strata away and so protected the coal-seams, or it may have been formed from the sediment existing in the waters when the denudation of the country ceased and so was left on the high ground, the oxide of iron cementing the sand into the present mass, notwithstanding all later climatic influences.

Peculiar to South Africa is the occurrence all over the country of numerous circular lakes or depressions, sometimes of large extent, locally known as pans, the origin of which the writer had never heard explained. Having regard to the overwhelming flow of water that at one period overran the country, it appears that obstructions from hardened or other strata would cause whirlpools and so wash away the circular areas before the obstructions were overcome, as these pans are frequently found near dykes, whose hardening tendency is evident. At all events the writer had seen no evidence of the bending down of the strata around the circumference, as would be the case if the pans were formed by depressions in the surface, and it would be difficult to account for such depressions on the edges of upturned strata, where the pans are also to be found.

Regarding the undulating character of the surface, it appears to be due to denudation eroding away the beds, and also to the unequal upheaval of the continent through upflows of recent igneous matter. Horizontal as the strata appear, they are nevertheless often locally undulating, and the writer noticed in the district south of Middleburg that the beds have a regular but slight dip to the south-east.

The Kromkranz farm, in the Carolia district, is interesting from a geological point of view, the coal-formation being denuded over the western portion, leaving the grits with the coal-seams standing out cliff-like, 50 to 60 feet high, and water-worn or under-cut along the base in a wonderful manner, snowing what a vast and powerful erosion of the country occurred at one period for a long time.

A picked sample of old klip contained 39.82 per cent. of metallic iron, and 22.82 per cent. of silica. As the average content will no exceed 25 per cent. of metallic iron, it
is therefore too high in silica and too low in iron to be of commercial use in the blast-
furnace.
The magnetite is a splendid sample of iron-ore: very hard and refractory, but used
along with the sedimentary ore, it will work well in the furnace. It is highly magnetic,
affects the compass needle, and small fragments will attach themselves to the pick
just as steel splinters stick to a magnet. It contains 66.23 per cent. of metallic iron.
The sedimentary ore contains by analysis 63.38 per cent. of metallic iron (with a
trace of phosphoric acid), and both ores have been pronounced suitable for making
bessemer pig-iron.
The writer has occasionally seen the sedimentary ore outcropping. The following is a
section:—

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<th>Ft.</th>
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<tbody>
<tr>
<td>Soil</td>
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<tr>
<td>Seamy iron-ore</td>
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</tr>
<tr>
<td>Parting</td>
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<td></td>
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<tr>
<td>Good iron-ore</td>
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<td>8</td>
</tr>
<tr>
<td>Parting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft iron-ore, mixed with clay</td>
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</tr>
<tr>
<td>Parting</td>
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<tr>
<td>Bottom iron-ore, good</td>
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<td>8</td>
</tr>
<tr>
<td>Total</td>
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<td>4</td>
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</table>

The extent of these deposits of iron-ore has not been proved, but there is abundance
of good iron-ore, coking coal, limestone, silica, possibly suitable fire-clay, and
building-stone in the Transvaal, suitable for the manufacture of iron and steel when
the time comes for the erection of smelting-plants and iron and steel-works, whether
independently or under a concession from the government of the South African
Republic.
The plan of the coal-field (Fig. 1, Plate I.) shows the position of the mines and
boreholes. The probable extent of the coal-area, as proved up to the present time, is
contained within the shaded black lines, defined partly from observation, from
published maps, or left incomplete.

The sections of strata (Appendix, and Fig. 2, Plate II.) are from boreholes made in
the small area between Brugspruit and Witbank; Blauwkranz and Landaus boreholes
were put down on high ground and show all the six seams, the others only show No.
5 seam, or Nos. 5 and 6 when deep enough, whilst close to, possibly on, the same
farm, the country is denuded to below No. 6 seam, and contains no coal. It is
therefore important in selecting coal-farms to have a knowledge of the stratification of
the coal-bearing beds. The farms vary in size, but mostly comprise an area of 8,000
to 10,000 acres. The seams vary in thickness and in quality, as may be expected,
and appear to be better in quality, more bituminous and cleaner, towards the eastern
limit; but the writer is not aware of any good proof of the strata by pits or boreholes.
Only the outcrops of the seams have occasionally been opened, and they are rather
difficult to correlate as so little of the strata—on account of their horizontality—is
exposed.
The comparison of the qualities of the coal from three districts [Near Brugspruit, Near
Bethel., Near Springs.] is shown in the following table:—

[Table omitted]
The first sample of coal will evaporate 12.7 pounds of water per pound of fuel.
Taking the direction of the Netherlands railway from Pretoria towards Delagoa Bay (Fig. 1, Plate I.), there is a very undulating but rising gradient to Belfast, the extreme north-eastern limit of the coal-field and highest point in the Transvaal, and then the gradient rapidly falls to the coast. On the northern side of the railway, between Pretoria and Bronkhorstspruit, there are various patches of coal overlying and between wavy upheavals of granite. At Bronkhorstspruit, the coal was found to be poor in quality, and working has ceased. Better coal is found north of Pretoria. Watervaal is being worked, and Honingnest and others are likely to be worked when the railway, now being constructed to Pietersburg, is opened for traffic. In the neighbourhood of Bronkhorstspruit, and probably also in the direction of Middleburg, amongst patches of overlying or altogether denuded coal-measures, recent discoveries of diamantiferous ground with diamonds, etc., have changed the character of many of the farms from indifferent coal-farms to diamond-farms, and high prices are said to have been paid for some of them; whilst veins of copper and other minerals have recently been discovered in the same neighbourhood, but their value has not yet been proved, as far as the writer can learn. Possibly, in the course of time, other parts of the series underlying the coal-measures will be proved, and are not unlikely to reward research and development.

At Balmoral, on the north side, the Douglas colliery is working a patch of coal on a hill-top, about 12 feet in thickness, with probably another bed lying below untouched; the rest of the seam has been denuded all round, exposing a great thickness of red sandstones that would possibly be Devonian, if the coal-measures are Carboniferous. On the south side of the railway, No. 5 seam is being opened up on Honingkrantz and Balmoral; and, further south, one or more seams have been worked at Holfontein, Straffontein, and other places, the coal being transported to railway by ox-waggon; at the present moment, however, all these collieries, except Douglas, are standing.

The railway crosses the boundary of the coal-field just before it reaches Brugspruit, and passes through the most important district yet explored, for about 13 miles, until the seams are all denuded again by the Olifants river before Middleburg is reached. Excellent coke has been made at the Maggie mine and at the Home coal-mine adjoining.

The strata given in the sections (Appendix, and Plate II.) accompanying this paper correspond with the measures to the south, along Steenkool Spruit, where some good coal has been proved, and extend all the way to Carolina and Ermelo. No. 1 seam throughout is of a semi-bituminous character, sometimes like an anthracite coal. Nos. 2 and 4 seams are usually thin. No. 3 seam is variable. The upper part of No. 5 seam is of a splinty character; it has been opened out in many places, but is most vigorously worked at present in the neighbourhood of Witbank, where the bottom coal is excellent, equal in every way to the best British coal. On Blesboklaagte, adjoining Witbank, it was proved by a borehole to be 20 feet in thickness, and the bottom coal is 11 feet 6 inches thick. No. 6 seam is said to be of good quality; it averages from 3 to 4 feet in thickness, but has not been worked, except on the Driefontein farm. The strip of coal on the north side of the railway from Middleburg to Belfast is poor in quality, doubtless owing to the proximity of granite.

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along the northern boundary or limit of the coal-field, but the quality improves to the south. Near Belfast, on Paardeplaats, a colliery belonging to the Transvaal Consolidated Coal-mines Company, Limited, has been opened up on the No. 5 seam, from 12 to 15 feet in thickness, and an average output of 100 tons per day is transported by ox-waggon to the Belfast station. The coal is of better quality than nearer Middleburg, on the northern side of the railway, and the output will no doubt he increased when the colliery is connected to the main line with a branch-railway. Following round the coal-field towards Carolina, the measures all appear thinner, with quartzite and conglomerate overlying the granite, and cut up frequently by basalt dykes running in a north-easterly direction.

Near Ermelo, a bed of oil-shale has been discovered, and it will probably be worked. The writer has not explored the country between Ermelo and Bethel, but on the southern side there are no important collieries except the Fortuna, working a seam from 8 to 9 feet in thickness, at a depth of only 45 feet, belonging to a lenticular deposit. The seam appears to correspond with No. 5 seam, the upper 4 feet being splinty in quality, and the lower 4 feet is a good bituminous coal, it is dipping to the north-east about 3 inches to the yard, and will probably become flatter and rise again.

A borehole would further prove the strata, and possibly the seam now being worked may then be correlated with certainty.

Passing a group of small collieries on the southern side of Heidelberg (the Perseverance, Platkoppe, Transvaal, and Oceana), all working different sections of outlying coal, and handicapped by the cost of transport from 8 to 12 miles by ox-waggon to Heidelberg, we come to the important colliery district of Springs, 32 miles from Johannesburg. Here is a group of collieries fitted up with modern plant, including water-tube boilers, winding and hauling machinery, with elaborate screening, separating and picking arrangements adapted to treat and bag the mixed and splinty varieties of coal up to 1,000 to 1,500 tons per day. These collieries include Springs, Cassel, Great Eastern, Clydesdale, East Rand Coal and Gold, De Rietfontein, Tyne Valley, and, further west, Central, Brakpan, Rand and Apex, with three or four older and less important collieries at Boksburg, including Good Hope, South Wales and Wishaw collieries, all working lenticular deposits of coal, as before described.

On the frontier, at Vereeniging, on both sides of the Vaal River, but

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principally in the Orange Free State, are the important Vaal River collieries belonging to Messrs. Lewis and Marks. Great difficulty was experienced in sinking the Cornelia pit through the surface-clay and quicksands, steel and cast-iron tubing having to be used to a depth of nearly 130 feet. Eventually four seams of coal were passed through, and the quartzite was reached at a depth of about 450 feet. The section is as follows:

<table>
<thead>
<tr>
<th>Description of Strata</th>
<th>Thickness of Strata.</th>
<th>Depth from Surface.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1 Coal-seam</td>
<td>1 9</td>
<td>324 0</td>
</tr>
<tr>
<td>No. 2 Coal-seam</td>
<td>6 0</td>
<td>352 0</td>
</tr>
<tr>
<td>No. 3 Coal-seam, inferior</td>
<td>22 0</td>
<td>420 0</td>
</tr>
<tr>
<td>No. 4 Coal-seam, good</td>
<td>13 0</td>
<td>442 0</td>
</tr>
</tbody>
</table>

No. 4 seam has been chiefly worked, and a good output produced has the character of being a good coal, and very hard to work.

Further westward, a series of beds of coal, about 200 feet thickness, have recently been proved by a borehole on the farm of Syferfontein, about 17 miles south of Krugersdorp, belonging to the Syferfontein and Gold Estates Company, Limited. Coal
was first found at a depth of 313 feet, and continued to a depth of 530 feet when
dolomite was struck. An average analysis of the coal between 313 and 590 feet
gave:—

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Ash</td>
<td>21.1</td>
</tr>
<tr>
<td>Volatile matter</td>
<td>44.0</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>34.9</td>
</tr>
<tr>
<td></td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td>100.0</td>
</tr>
</tbody>
</table>

Whilst one bed at a depth of 513 feet, 3 feet 8 inches in thickness, gave:—

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash</td>
<td>7.9</td>
</tr>
<tr>
<td>Volatile matter</td>
<td>48.9</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>43.2</td>
</tr>
<tr>
<td></td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td>100.0</td>
</tr>
</tbody>
</table>

Calorific power, 12.6 pounds of water per pound of fuel.

This borehole is at the most westerly point where coal has been proved, and how
much further the formation extends it is impossible to say.

The seams are for the most part easily accessible (except, possibly, in the western
part of the coal-field), with good roofs, practically no timber being required, and little
or no water to pump. Natural ventilation is usually relied upon, upcast pits being put
down when extensions underground require them, and the pits being shallow, except
round the shaft, small pillars are left.

Bagging nearly all the coal raised is a very troublesome, as well as a costly
operation. It appears that the Netherlands Railway Company will only allow siding-
connexion within the station-limits, and very few of the

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gold-mines (as yet) are so connected. One ton of coal equals 2,000 lbs., and is
bagged in 200 lbs. lots. A bag costs 5d., and lasts, on an average, three full
journeys, so bags alone cost 1s. 4 1/2d. per ton, and the extra labour employed,
including losses and repairs, brings the cost up to nearly 2s. per ton. Several
varieties of round and nut coal are usually made, including steam, gas, smithy,
household, nuts, and peas. Native labour, at a cost of less than £1 per week,
including monthly wage and keep, is employed wherever possible, under the
supervision of an experienced miner, who usually superintends about 35 boys,
seeing that they get through the work assigned to them. The cost of working,
including bags and bagging, varies according to output and standing charges, from
4s. 6d. to 6s. 6d. per ton, 5s. 6d. being looked upon as an average cost with a fairly
large output. Railway-charges on coal and material are excessive, and a serious-
drawback to the development of the Rand gold-mines, and of many collieries that
have been opened out, particularly those that have ox-waggon charges to pay as
well. The Netherlands Railway Company insist upon supplying all the trucks in use.
They carry 11 tons of bagged coal each, and if a truck is very slightly overloaded
the collieries are promptly fined. A charge of 2s. per waggon is made for taking out of
sidings, and different rates per ton per mile according to distance:

<table>
<thead>
<tr>
<th>Miles</th>
<th>s.</th>
<th>d.</th>
<th>Rate per Ton per Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>115</td>
<td>12</td>
<td>6</td>
<td>1.30</td>
</tr>
<tr>
<td>32</td>
<td>66</td>
<td></td>
<td>2.44</td>
</tr>
</tbody>
</table>
From January 1st, 1898, 20 per cent. has been allowed off the above charges, reducing them to 10s. and 5s. 2d. per ton respectively. No credit is given, cash must be paid down, or a credit balance kept with the railway company.

Witbank is 275 miles from Delagoa Bay, and the railway company take coal, if they have empty waggons returning, at a through rate of 10s. 4d. per ton. The natural situation and facilities for cheaply constructing loading depots for shipment of coal to the Far East and other parts of the world, including the bunkering of steamers trading and calling along the coast, with the development of trade throughout the country, is practically certain before long to make Delagoa harbour another outlet for the coal from Middleburg, with South Wales coal selling on the wharf at 45s. per ton. The Middleburg district already competes favourably with Springs, realizing at Johannesburg about 23s. per ton, against 17s. 6d., thus compensating for the extra cost of transport, and leaving a fair margin for profit wherever collieries are opened, out with good coal, convenient to the Netherlands railway.

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There is a royalty charge, payable to government, of 1 per cent. on the value of coal sold at the pit. Many coal-farms have been taken up or purchased within recent years, either out and out, for coal-rights only, or for all mineral rights. The development of many of them will depend upon the construction of railways, the prosperity of the country, and the increased demand for coal by reason of the sinking and development of the deep-level goldmines along the Rand, and the shipping trade with Delagoa Bay.

APPENDIX.

[Section] No. 1.—No. 3 Borehole, at Blauwkrantz, neab Brugspruit, for the Anglo-French Company, 1897.

[Table omitted]

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No. 2. --No.1 Pit, at Elandsfontein, near Brugspruit, Anglo-French Company.

[Table omitted]

No. 3— No. 1 Trial pit and borehole at Schoongezicht, near Brugspruit, 1897

[Table omitted]

No. 4.-No. 2 Borehole, at Klipfontein, near Brugspruit, for Landaus Transvaal Colliery Company.

[Table omitted]

[Plate I : Map of the Transvaal Coal-Field.
Plate II: Sections of Strata, Middleburg District]

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No. 4.—Continued.
THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
Held in the Wood Memorial Hall, Newcastle-upon-Tyne,
October 8th, 1898.

Mr. WILLIAM ARMSTRONG, President, in the Chair.

The Secretary read the minutes of the last General Meeting, and reported the proceedings of the Council at their meeting on September 30th and on that day, and of the Council of The Institution of Mining Engineers.

The following gentlemen were elected, having been previously nominated :

Members—
Mr. Harry Walton Appleby, Electrical and Mechanical Engineer, Trafalgar Works, Bradford, Yorkshire.
Mr. Archibald Duncan Bailey, Mining Engineer, c/o Senor Don Carlos Wagner, Arequipa, Peru.
Mr. David W. Brunton, Mining Engineer, Denver, Colorado, U.S.A.
Mr. Henry Alexander Judd, Mining Engineer, Lake View South Goldmine, Kalgoorlie, Western Australia.
Mr. George Verney, Mining Engineer, Doubovais, Balka Krivoi, Russia.
Mr. Ernest Ludwig Adolph Weinberg, Mining and Metallurgical Engineer, Aldershot, Queensland.

Associate Members—
Mr. T. Owen Davies, Norseman Gold-mines, Limited, Norseman, Dundas Goldfields, Western Australia.
Mr. Minett Edward Frames, P.O. Box 3517, Johannesburg, Transvaal.
Mr. George F. Harris, Birkbeck Institute, Bream's Buildings, London.
Mr. J. Hoffman, Fairview, Didsbury, Manchester.
Mr. Courtenay de Kalb, The School of Mining, Kingston, Ontario, Canada.
Mr. John William Murphy, Umaria Government Colliery, C.P., India.

Associates—
Mr. James Beckett, Deputy-overman, 57, Pine Street, Teams, Gateshead-upon-Tyne.
Mr. George Emmerson, Assistant-manager, Brandon Colliery, near Durham.
Mr. William Heslop, Deputy, Hunwick, Willington, Durham.
DISCUSSION OF MR. W. MERIVALE'S PAPER ON "OCCURRENCES AND MINING OF MANJAK IN BARBADOS, WEST INDIES."

Mr. W. Merivale (Barbados) wrote that Prof. H. Louis' description of the occurrence of bitumen "in streaks, pockets and veins, in certain horizons, as though the bitumen in a plastic state had filled up all the cracks and fissures," was a very good description of the occurrence of the manjak variety of bitumen in Barbados. There is a very good diagram in Prof. A. H. Green's Physical Geology, reproduced in Fig. 1,

which is exactly the sort of section, dip and all, that be found in the manjak veins. If Mr. Cochrane will imagine a slip along the line marked "flat," he will see how the whole of the upper part of the vein may be carried along with the country hundreds of feet away. Miners working this carried-away portion will soon come to an end of their mineral, and will say, as they all have said here, that it only occurs in pockets. Obviously, what is then required is to study the geology of the country, and find how far the slip has travelled; the rest of the vein should be found at the starting-point. This is certainly not an easy thing to do in this curiously contorted island. It fortunately happens that there have been no slips in the neighbourhood of his mines.

Sir Archibald Geikie's Text Book of Geology gives a diagrammatic section, reproduced in Fig. 2. Prof. H. Louis will see the writer's idea of the immediate origin of manjak in this illustration, that is a vast mass finding its way up through the lines of least resistance. Asphalt can hardly be supposed to have been formed in situ, as it is obviously an intrusive mineral. The slickensides on the walls of the fissures which it fills are sufficient of themselves to prove this opinion. If it was not formed in situ it must have come from somewhere. The question to be answered here is not where did it come from, but how did it come? An enormous force must have been employed to thrust it up. We are dealing in large quantities: nothing less than the shrinking of the crust of the earth, which made the fissures, can have filled them with asphalt. From Utah to Barbados, we find these fissures having the same strike, filled with the same material. Can it be a small quantity? Can the source which was tapped to fill them be trifling in quantity? Why is it that the asphalt in the Trinidad pitch-lake continues to fill up as fast as pitch is dug out of it, and has done so for many years? It is not conceivable that x cubic feet of
manjak were squeezed up into a space containing exactly x cubic feet, but it is conceivable that x cubic feet of manjak were squeezed out of x1000 cubic feet into a space containing x.

* Reproduced from Text Book of Geology, by Sir Archibald Geikie, 1885, Fig. 273, page 533.

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cubic feet. Therefore, although the writer submits the hypothesis to Prof. H. Louis rather as a theory than as an ascertained fact, the writer looks upon it as the only conceivable theory of the origin of manjak.

As to the danger of fire from the dust, he might say at once that when he first began mining he was very much afraid of accidents from this source, but so far (2 years) there has not been a single fire or explosion. Inbye, where at times the air has been so bad that the lamps will scarcely burn, and the fine invisible dust fills the workings, he has seen a fall of manjak loosen a little heap of dust on the walls, which, falling over a lamp has ignited, and formed a brilliant cascade of fire, but the dust in the air has never ignited. The fact that there has not yet been an accident from this cause, however, does not prove more than that, so far, the requisite proportions of air and dust have not yet occurred, and that in ordinary working, with and without good ventilation they do not occur; but that does not disprove the truth of the President's remark that there is a certain amount of danger in working this material. He might add that some parts of the workings are thoroughly wet—roof, walls, and floor—and other parts as thoroughly dry.

We do not find the trouble to our eyes that Mr. Greener mentions as incident to the filling of pitch at Peases' West Bankfoot. In an article on uintaite (gylonite) in the Revue Technique, it is stated that the Americans find their lungs affected by the dust. We find that the dust penetrates the clothing, and forms a fine varnish on the skin, for although it is insoluble in water the heat of the body seems to be sufficient to soften it enough to make it sticky. For days after an inspection, the writer's beard and hair stained his pillow every night, in spite of thorough washing with kerosene oil, or with turpentine; and that the lungs become covered in the same way is, perhaps, proved by the fact that expectoration for some hours afterwards brings up lumps of black phlegm. He had not found, nor had his workpeople (about 100) complained of, any trouble on that account. They suffer chiefly from chills produced by 5 hours' work in pouring perspiration, and then eating their breakfast in one of the adits, in a thorough draught. Their hours are from 6 a.m. to 5 p.m., with 11 to 12 a.m. off for breakfast. He thought that it was not impossible that the negro can stand more discomfort than the white man.

The width of the veins varies from 1/8 inch to 30 feet. He imagined that the average width was about 4 feet. At present prices it pays to work a vein 6 inches thick. There are plenty of leaders from the main veins of that width, and these he reserves for working until a fall of wall, or other contingency, will prevent him from working below.

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Most of the manjak in this island is found with lumps of dirt interspersed in it. The veins at the Merivale mine are entirely free from any extraneous matter: so much so, that he is able to guarantee it as pure to his customers. There are, of course, horses in the veins; some so great that we used at first to believe that the vein had pinched out when we came across them; others smaller, but it is very rarely that we come across a horse of less than 3 cubic feet in measurement. The manjak in the other mines has a quantity of grit in it. In working a vein of 3 feet or less, we cut out the foot-wall for a short distance and then block the manjak down. One of the veins
increased from 5 feet to 9 feet in width for a depth of 100 feet and for a length of 150 feet. In such veins, we pick the manjak out and leave the walls. Possibly Mr. Cochrane could give the writer information on a subject connected with this part of our operations. It is not so easy to dispose of the dust on the market as it is to dispose of rubble—at least, not at the same price. Also, it is, of course, highly desirable to make as little dust as possible in the hewing. Using a pick, the stuff breaks away in flaky lumps with sharp edges and conchoidal fracture—it is not laminated like coal—with about 30 per cent. of dust. A heavy pneumatic channeller would not do, because we move forward so quickly that it would cost too much to be continually moving it and the air-pipes. Would it be possible to use one of those small pneumatic riveters, with a cross-cut chisel fixed on it instead of the hammer, and so groove out blocks of about 12 inches cube?

The President delivered the following address:

PRESIDENTIAL ADDRESS.

By W. ARMSTRONG.

My first duty is to thank you cordially for the great honour which you have conferred upon me in electing me President of this now venerable Institute for the coming year. Conscious of the responsibilities of the position and the important duties which it confers upon its holder, and which are inseparable from it, I can assure you that I fully appreciate the confidence you have reposed in me, and you may be assured that I will endeavour to the utmost of my ability to uphold the prestige of this Institute and further the objects of its foundation as they were enunciated 46 years ago. I ask your assistance and forbearance during my term of office.

After the able and comprehensive addresses of my immediate and remote predecessors on the past history and recent improvements in the coal-trade, so completely narrated and carefully discussed, there seems, at first thought, little left to discourse upon. It has occurred to me, however, that instead of wearying you with debatable and unproved technicalities, I might more profitably occupy your time in reviewing the present position of the coal-trade, particularly with regard to the many difficulties looming in the future, and venture, if possible, to indicate that line of action by which they may be most advantageously met and overcome.

A thorough grasp of any single subject, be it scientific or industrial, cannot be obtained without taking cognizance to a greater or less extent of many collateral subjects. As the title assumed by this Institute embraces mechanical as well as mining engineering, I feel that I am justified in considering any branch under these heads which, in its technique, may be utilized for the efficient and successful working of a colliery.

The success of every industrial concern is to be measured by its dividend-paying results. These are affected:

1. By trades union organizations shortening the working hours and increasing the price of labour, thereby cutting down profit to a minimum.
2. Foreign competition offering products of an equal or better quality or at a lower price;
3. Legislative interference, by insisting on more costly appliances and processes to secure greater safety where risk to life or limb is concerned, often, though not always, beneficially. These processes must be combatted if our manufacturers are to hold their own in the trade of the world, and upon the success or failure of this hangs the fate of the coal-trade also.
I may safely venture to predict that, far from diminishing, these opposing and disturbing forces are more likely to increase, and the question which I propose to consider is how they are to be met.

Counter-legislation and combination on the part of capital is suggested by many, but political economy teaches us that this policy is short-sighted, and eventually futile, because unscientific.

The struggle is not between capital and labour, where the resources on either side are limited and the results, in whichever way it may end, suicidal; the struggle is between brain-power and the forces of nature, where on each side the resources are unlimited, and the result, as proved by all past processes of evolution, a certain victory. This victory can be obtained only by persistently keeping before us economies in the processes of production.

In passing, permit me to express the opinion that legislation, when exercised beyond its legitimate sphere (the maintenance of order and protection of life and property), far from being a panacea for the ills of life, has generally a retarding effect on progress, and in no instance is this better illustrated than in its application to trade.

Scientific engineering in all its branches has advanced in late years by such leaps and bounds that further improvement, at first sight, seems to be well nigh impossible. Examination of the more modern tools and machines discloses the fact that not only do they turn out work more quickly and cheaply, but the quality of the work is better, and that with a diminished use of skilled labour. The highly paid and skilled workman is gradually being displaced by an almost intelligent machine, the various operations requiring only the attention of boys. In the face of this, it is astonishing to see in the shops of many of our leading engineering firms the antiquated and costly processes still at work. Unquestionably, and especially in this country, many hesitate before consigning to the scrap-heap the machinery, well kept and in good working order, with which their shops are equipped. Nevertheless, with the continued pressure from trades union organization and competition by foreign nations adopting the latest and most improved forms of machinery, our manufacturers will be compelled either to follow suit or, by nature's inexorable law of the survival of the fittest, go to the wall.

The same arguments apply to coal-mining. Higher wages, shorter hours competition from foreign coal-fields, and legislation increase costs and diminish profits with tenfold force.

Improvements in the direction of winning, laying out, and ventilation, coal-getting, haulage, winding, and preparing the produce for sale have been effected in recent years, though not by any means commensurate with that in the mechanical trades, and for obvious reasons. A workshop may be laid out in any situation and to any design, but the laying out and equipping of a coal-mine depends upon the peculiarities and exigencies of the coal-field. An error in a workshop may be amended, but much of the work done in a coal-mine, whether underground or on the surface, cannot be undone. Hence the greater necessity for care and foresight in all mining operations, and the immense difference between the schemes for laying out a new colliery in virgin coal, proved or unproved, and the reconstruction of one already established and in operation.

Here comes, first of all, the great question of recent improvements in sinking operations, which, being a vast subject in itself, I do not intend further than to mention in passing.

Another important item is the arrangement of the mechanical department, both underground and on the surface, making use of the most recent and best approved appliances, and so arranged that, when future necessity requires it, they may be replaced by improved devices, and so keep pace with the times. This is a matter of almost daily increasing importance.
In old establishments, with wasteful boilers, antiquated and in some cases obsolete machinery, involving a heavy consumption of fuel for purposes of production, which fuel it is the duty of the management to convert into cash, there is much scope for improvement, without which the ultimate object, profit, must materially suffer. Each decade brings with it modifications and improvements on old methods with increasing rapidity, which in the business of to-day, so different from that of a generation ago, cannot be ignored. I will now briefly summarize some of these:

Prime Movers.—These afford in themselves an abundant field for consideration and discussion as to structure, steam-raising and distribution.

Boilers.—These and the methods of firing them have been the subject of much controversy, attended by many important improvements; but there is yet room for more. High pressures, varying from 100 to 160 lbs. per square inch, and even higher, are being adopted, and in boilers of the Lancashire type with most satisfactory results, the obsolete and condemned egg-ended type being, and very properly so, thrust aside. Where high pressures are adopted, abundant capacity both for water and steam space are important factors in economical working. Twenty years ago the bare mention of the probability of boilers one day being worked on such a load, and especially at collieries, was flouted and ridiculed. Improvements in construction brought about by improved tools and the adoption of steel instead of iron have made this possible. The questions of economical firing and dealing with impure feed-water, especially when charged with lime, salts, etc., afford a considerable field for useful thought.

Although the bogey of a declining coal-supply does not, thanks to modern discoveries, disconcert our economists as formerly, the increased cost of coal-production and consequent increase in value, however convenient, places us in the same dilemma. When this is fully appreciated, as great care will have to be observed with colliery-boilers as obtains in factories where fuel has to be purchased. Where there is an abundance of waste-heat from coke-ovens which may be utilized, the importance of these matters is considerably minimized.

Engines.—Much has been achieved of late in improvements of engines, especially those used for winding. The application of high-pressure steam with automatic cut-off valves has brought this class of machinery to as near perfection as possible. I cannot think that compounding these will be successfully and safely worked, as it must involve complications, which should be avoided above all things; nor do the continual interruptions in running point to the economy claimed for it. I am strongly in favour of condensers being applied wherever possible; those of the evaporative type, into which all or most of the engines on a colliery may exhaust, are well worthy of careful study; and it is unnecessary for me to enlarge upon the economy gained by such an appliance, even though the first cost be high.

In all new mines, and I may also include those in present working, mechanical coal-getting should be looked forward to as an indispensable requisite. This points to the adoption of the longwall method of working whenever practicable, as it is the only system to which it can be successfully applied. A matter of no little importance is that of improving the saleable value of inferior coal by washing. It has yet to be determined which is the most efficient and economical apparatus, and information is still required in this direction.
Electricity.—Electricity as a force has been so extensively used in recent years that it has exceeded the expectation of its most sanguine advocates. Mr. Hippolyte Fontaine, in a paper read by him before the Institution of Mechanical Engineers in June, 1878, states in his opening paragraph that:—"The number of industrial applications, which was 4 in 1874, and 12 in 1875, was raised to 85 in 1876 and to 350 in 1877; whilst at present there are upwards of 500 applications of the light, amounting in intensity to more than 1,500,000 candles."*

It is now 20 years since this was written, and we have only to look at the immense strides which the adoption of electricity has made everywhere. This is chiefly due to the invention of the incandescent system of lighting as compared with the arc system, which was the only one in vogue in 1878. And our author goes on to state that:—"The electric light does not interfere with gas light, nor with oil light, nor with candle light." It will not revolutionize, as has often been averred, the question of lighting, destroying what is now in use and monopolizing every industrial application, domestic and public. The electric light has its place marked out for it under many circumstances; but, far from diminishing the consumption of other lights, it will lead to their further development by demonstrating the advantages of a more powerful and more complete illumination."†

These prophetic utterances have been borne out, and upon a scale which was in all likelihood beyond the writer's most sanguine hopes, and I venture to think in almost every detail. We have only to look at the enormous extension in the gas-factories of our large towns to have this fact conclusively demonstrated.

I am strongly of opinion that the same utterances will apply to its use for motive purposes. As such it is becoming better understood, and its distribution from central-power stations in some of the more important factories at home and abroad, in every instance with a marked saving in labour and fuel, points to its more extended adoption. The chief factor against it has been the high initial cost of its installation, and in some cases of its upkeep. This was owing sometimes to errors in estimating the work which it was to perform, sometimes to false economy in cutting down first cost. These mistakes are fatal to success in any exploitation. I think that I am correct in saying that most electricians are agreed that a margin of 50 per cent. above the work required from a generator is necessary for economical working. The great convenience of its application is a considerable factor in the argument for its almost universal adoption at collieries and other industrial concerns in the near future.

* Proceedings, 1878, page 529.
† Ibid., page 529.

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In considering the future of any industrial concern, it is not sufficient to assume that because everything is laid out, constructed and worked on the latest principles, it will be a permanent success. It must be borne in mind that in machinery there is constantly at work an evolutionary process abreast of which every business must keep or fail. The usual depreciation fund for wear-and-tear of machinery is not sufficient, the producer must not content himself with the renewal of a machine when it is worn out, but must immediately supplant it by a better. This implies that in future industrial economics will require the matter of a depreciation fund, securely invested, to be considered on a much broader basis than that to which we have been accustomed. If Great Britain is to keep her place as mistress of the world, this all-important factor must be reckoned with.

To students I would say, cultivate careful and accurate observation, associate with this intelligent reasoning on scientific principles, and upon this base the practice by which means only can the desired end to which your labours are directed be
attained. Be not dismayed by difficulties, rather court them. The experience gained in battling with them will be of undoubted advantage to you.

To the working-man seeking shorter hours, higher wages, and less laborious occupation, I would say, bear in mind that these cannot be got by fruitless agitation against the capitalist, beholding him as an enemy, but by joining him as an ally and friend and welding against the forces of nature his only successful weapon, education. When the scales have fallen from the working man's eyes and he recognizes his vantage ground, trade disputes with their concomitant miseries will have become ancient history.

If by these somewhat discursive and speculative remarks I should succeed in supplying to those engaged in colliery practice subject-matter for serious thought, I shall feel satisfied that these my feeble efforts have not been in vain.

Mr. G. B. Forster said that, after hearing the President's very able review of the conditions and prospects of their staple industries, the members would agree that between the law, the foreigner, and the workman, it behoved them to set their houses in order, and make the best they could of existing circumstances. He was present at the first meeting of members of this Institute, which had for its object the effecting of improvements, first of all, in matters of safety, and, secondly, in matters of working, and he thought, on the whole, that the Institute had fully discharged its duty. Addresses, such as that given by the President, were of great advantage to the members, as they pointed out fields in which their explorations should go and points to which their attention should be directed. He had great pleasure in proposing a hearty vote of thanks to Mr. Armstrong for his address.

Mr. William Cochrane, in seconding the vote of thanks, said that Mr. Armstrong had so experienced a knowledge of what had been done in the past that he was sure the members would reap great advantage therefrom during his tenure of office.

The President briefly acknowledged the vote of thanks.

The following paper by Mr. S. J. Becher on "The Nullagine District, Pilbara Gold-field, Western Australia," was taken as read:

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THE NULLAGINE DISTRICT, PILBARA GOLD-FIELD, WESTERN AUSTRALIA.

By S. J. BECHER.

The Pilbara gold-field, although perhaps the least known of the Western Australian gold-fields is, with the exception of the Kimberley and Yilgarn fields, the oldest in the colony, having been proclaimed in 1889, while the others were respectively proclaimed in 1886 and 1888, gold having been found in all at much earlier dates. It occupies a total area of 45,600 square miles, being now subdivided into the Pilbara gold-field (35,100 square miles) and the West Pilbara gold-field (10,500 square miles), the two abutting on the north-western coast for a distance of about 200 miles. Nullagine, as will be seen on the accompanying map (Fig. 1, Plate III.), is situated on the Pilbara gold-field about 180 miles by road south-south-east from Condon, and 300 miles by road east-south-east.
from Roebourne; Marble Bar, the head-quarters of the Warden of the Pilbarra gold-field, being situated on the Condon road about 100 miles from the coast. Taking this road as a base-line inland, the main geological features observable, until Marble Bar is reached, are restricted in variety to the occurrence of belts of diorites, schists and limestone, forming broken hill-ranges, often crested by a backbone of jasperoid quartzite, which traverse the otherwise prevailing granite-plains in a northerly direction, varying slightly a few points east or west of north, and dipping universally westwards.

After passing Marble Bar, leaving the Coongan river on the west, the road winds for some 10 miles through broken ranges of diorite and schistose rocks, whose sides are scarred with innumerable quartz-reefs,

[Photograph] Fig. 5. — Portion of Hill, shown in Fig. 4.

the most noticeable feature being a range of actinolite-rock, views (Figs. 4 and 5) of a portion of which are appended hereto. In the vicinity of this range, the surrounding schists assume a similar structure, and even so the quartz (superficially) of the reefs. For some miles again, after leaving this belt of country, the traveller journeys over a vast granite-plain. Beyond this plain, one sees the last of the granite, and the road immediately commences to rise into the heart of an apparently extremely rough country, which, however, is really less forbidding than one anticipates. The former characteristic features of the landscape give place to higher ranges of broken hills, which preserve no very systematic trend. They consist of trappean and basaltic rocks, and huge weathered boulders hang on their rough flanks in a threatening manner, while the gorges and creek-beds are strewn therewith.

Occasionally the country opens out, and the road passes over lower and flatter ground, traversed by creeks and sparsely timbered. As one approaches Nullagine, the features again alter, and the sections exhibited in the gorges and on the hill-sides show well-defined formations of grits, slates, sandstones and conglomerates, having a general strike to the north-east, and dipping at low angles to the north-west. The rugged broken crests of the ranges give place to long round-backed heights and table-topped hills; these latter are mostly isolated hills capped with thick masses of ironstone, cement and conglomerate, covering a substratum of kaolin. These hills are characteristic of this district of the Pilbarra gold-field, and they will be referred to hereafter.

In the immediate vicinity of Nullagine township or mining camp, range upon range of conglomerate-hills lie to the north-west, while on the eastward as one approaches the township (and the characteristic galvanized-iron buildings, tents and bush-huts come into sight), there is a reach of undulating country, dotted with isolated flat-topped hillocks and low ranges, extending some miles beyond the bed of the Nullagine river, whose course is marked by a wide belt of timber and scrub.

The river runs only after a flood, but the pools left therefrom and shallow wells have provided an abundant water-supply for the small population. The quality of the water is very good.

Far away across the low-lying country, with its low, broken ranges, may be seen the Ripon Hills, which form the water-parting between the Oakover and Nullagine rivers. The course of the river, as indicated on the accompanying locality sketch-map (Fig. 2, Plate III.), follows the outskirts of the conglomerate country, keeping on the further
side of the slate country and its quartz-reefs, and forms a marked line of division, as it were, between the characteristic topographical features of the district. In the township, about 1/4 mile from the western bank, a well-shaft was sunk through 33 feet of clay-slate, below which sandstone was met with carrying a good supply of water. There are several other good wells. At the side of the road, going thence towards Beton's Hill, the clay-slates are seen in a section on a creek-bank to be folded sharply in

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anticlines of only a few feet in height. This is the only spot in this neighbourhood where the writer noticed anything of the kind, the country generally appearing to be much less disturbed than that lying north and west towards the coast. Beton's Hill forms one of a group of the abovementioned flat-topped hills or hillocks situated in a bend of the conglomerate country, the river forming hereabouts a chord of the arc. Another hillock of note is Cook's Hill, named after Nat Cook, the explorer and prospector who was the first to find gold in the district some 12 years ago. The former hill is named after Beton, who at a later date, when the Nullagine "rush" was at its height, traced alluvial gold from the adjoining flat into the kaolin at the base of the hill, and followed the run by tunnelling and took out a very considerable quantity of gold.

This kaolin, varying in thickness from 10 to 50 feet, has been highly coloured in places by the action of percolating mineralized waters, and probably too during the original process of decomposition. Capping the kaolin, in a flat bed varying in thickness from 1 to 10 feet, is a mass of highly ferruginous matter, mostly very hard. Much of it is either a compact body of ironstone-conglomerate, or nearly pure haematite; some however is vesicular and offers less resistance to denudation. The writer may add that the same ironstone-formation may be seen in many places throughout the whole length of the colony, sometimes merely capping hills or ranges, and sometimes forming the surface of a tableland extending for many miles.

On the flats, between these isolated hills and below the main conglomerate-ranges, an immense amount of work has been done by alluvial diggers. The ground, where the alluvium attains any depth, is all turned over and over and heaped up afresh, while up the gullies regular walls of the larger stones, originally lying in the creek-bed, may be seen heaped up on either side of the watercourse. Then again the gold has been traced up the hills, and the curious sight may be seen of whole hillsides, and even the very tops too, dotted with little heaps of stones and the rest of the ground swept bare to the hard surface. The alluvial material has been treated for gold by roughly screening, and then puddling and sluicing in hollowed-out tree trunks at a pool in the river, or merely by dry blowing.

Here and there, on these flats, outcrops of clay-slate and sandstone occur. Coming then to the conglomerate-ranges, which average in height about 100 to 150 feet above the level of the river-flat, we find that the

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hills in the forefront, upon which the chief mine workings are at present situated, appear to be mostly round-backed and strewn with rounded boulders and pebbles (Fig. 3, Plate III., series β, and view reproduced in Fig. 6.) On closer examination, one finds that they consist of bed upon bed of conglomerate, merging into intermediate layers of kaolin. The beds dip universally to the north-west, and strike northeast and south-west. The dip is flat, averaging perhaps 15 degrees. Therefore as one approaches from the south-east the hill-sides exhibit longitudinal sections of the country, and in some cross gorges very complete studies may be made of cross-sections; whilst, where the
[Photograph] Fig. 6.—View of Series β. in Fig. 3. Plate III., showing Adit levels on a slight Incline, with Dip of Conglomerate-bed.

rounded weathered hill-sides slope to the flat, one may notice somewhat regular lines of round boulders and pebbles roughly marking the outcrops of the conglomerate-beds. By these indications, and also by following up the runs of alluvial gold until they stopped all along certain horizontal lines, the auriferous conglomerates were originally located and worked by prospectors by means of drifts and tunnels. Some of the conglomerate-beds contain boulders up to 3 or 4 feet in diameter, while others carry nothing bigger than a man's head. These boulders consist of rounded masses of fragments of quartz, trap-rocks,

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and other conglomerates. A peculiar feature about the shape of these is that they are very often somewhat flattened like curling-stones. This flattened shape might suggest glacial action, but the writer saw no striae. An accompanying illustration (Fig. 7) shows the section of a very massive bed, as exposed in a gorge. These have, the writer understands, proved to be less auriferous than the other beds whose component particles are small. The best gold seems to be obtained from ferruginous veins. The ore now being crushed by the mining companies varies in value, the writer believes, from 10 dwts. to 2 ounces per ton, the treatment being by battery and amalgamation alone. The gold is worth

[Photograph] Fig. 7.—Portion of a Conglomerate-bed of the Coarser Order.

£3 17s. 6d. to £4 per ounce. At the time of the writer's visit, in the year 1896, only the decomposed portions of the beds had been worked, but he is given to understand that a vertical shaft has since cut a bed in depth below the zone of decomposition, and that the character of the rock is a very hard greenstone-conglomerate, carrying much iron pyrites, samples of which have yielded returns by assay up to 13 dwts. per ton.

Behind these round-backed series of hills, to the westward, the topographical features vary again, and the conglomerate-ranges assume an appearance of being terraced, the reason of which becomes evident

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upon examination. Following up into these ranges an affluent of what is known as the Main creek, one enters a gorge with precipitous sides rising to 50 feet in height, and here a very fine cross-section of the country may be examined. Here it may be seen that, interbedded conformably with the beds of conglomerate, there are indurated slates and grits. The former, where long exposed to the action of the atmosphere and water, split off into flags.

Compared with the abovementioned series, little or no decomposition has taken place beyond surface-weathering, which accounts probably for the fact that no free gold (to speak of) has been obtained in the gullies, and that the terraced series is not at present recognized as auriferous. Time may prove this. The terracing is due to the unequal effect of weathering on the exposed longitudinal edges of these otherwise undecomposed beds of varying durability.

As to the age and origin of these interesting Nullagine beds, nothing-definite is yet known. Beyond a cursory examination some years ago by the late Government Geologist of Western Australia, Mr. H. P. Woodward, at which time, the writer believes, no work had been done upon them, no geologist has thoroughly studied
them. In some samples brought down by the writer, the mineralogist of the present Geological Survey Office recognized the occurrence of volcanic bombs.

A curious fact in connexion with the composition of these conglomerate-beds is that when cleaning up after battery-crushings, small diamonds have on several occasions been washed from the residual sand and stone taken from the battery-boxes; and, in many instances, diamonds have also been obtained by men when washing the alluvial from the gullies and flats for gold. Few stones, however, of sufficient size to be of commercial value have been obtained. Tradition states that the local test for their authenticity has been to put the stone on an anvil and strike it a blow with a sledge-hammer!

The writer has before mentioned that the course of the Nullagine river marks roughly the outline of the above-described country in this neighbourhood, and that on the eastern side of the river very diverse conditions are noticeable. The country is generally almost flat, but is crossed by fairly parallel belts of low outcrops forming ranges of slate-hills, while about 1 mile from the Nullagine township two low, much weathered, and broken ridges of igneous rock protrude above the surface for a distance of 2 miles.

The flats themselves consist of the same slates as the ranges, though naturally in a soft decomposed state, being liable to submergence at flood-time, and carrying the drainage-waters from the hills. These slates apparently also dip to the north-west and lie somewhat flatly. They are traversed by a network of quartz-reefs and leaders. The main reefs, however run with the country, striking north-east. The surface is strewn with their debris and dry-blowers have gathered good harvests therefrom. About 3 years ago, attention was attracted to the reefs themselves by the discovery of several very rich patches of stone on their outcrops, and since then a considerable amount of mining has been done and many good crushings have been taken out.

The character of the quartz in the big reefs is mostly very white and vitreous, and in this kind of stone the gold is generally coarse and occurs in bunches. While in smaller reefs, and sometimes in certain splices of the big ones, a more kindly-natured stone is found, showing perhaps fine gold and prospecting well all through. Smaller reefs vary not only in strike, but in dip very much. Some lie somewhat flatly with the country-rock, while others are practically vertical. Some dip eastward, and some westward.

The writer was shown some much-decomposed calcite, carrying wonderfully rich gold in a very fine powdery form, taken from a small vein, but could gain no information about the locality of the find as the prospector had left the district.

No fossils have yet been found in this district.

Mr. H. M. Cadell (Bo'ness, N.B.) said that he had visited the Pilbarra gold-field in 1895, and had heard of the Nullagine district and seen specimens of the diamonds from the conglomerate in that part of Western Australia. The value of the gold-field had of recent years been greatly exaggerated by interested people desirous of making money by selling mining properties to British investors. There were no doubt gold, antimony, copper, tin, lead, manganese, and magnetic and hematite iron-ore deposits of some value in various parts of the district which at other places might be
workable at a profit. But he did not think that any mining company would continue operations very long in that inhospitable and remote tropical region. The author of the paper wisely said little about the prospects of successful mining. The climate was such that no white man could be expected to survive many years of exposure to it, and the mining laws of Western Australia prohibited the employment of Asiatic or coloured labour, capable of enduring the

heat. In summer, the temperature in the shade often reached 1200 Fahr. For many months there was little or no rainfall, and the region was a terrible dry wilderness parched with scorching heat. The drought was varied at times by terrific storms of wind and rain locally known as "Willie Willies." One of these occurred some mouths ago and blew down nearly every house over a wide region, while rain fell in torrents and devastated the country far and near. At one mine, the only place of shelter was found under the boilers, and the manager was driven even out of that wretched retreat by the water rising to the level of the furnace-bars. It was unpleasant to speak the truth at times, but he (Mr. Cadell) considered it his duty to warn mining engineers at home against that part of Western Australia. Gold was no doubt to be found on the surface in quantities sufficient to dazzle the eyes of inexperienced people. The natural drawbacks, however, were so great in the way of cost of living, excessive difficulty and cost of transport, absence of fuel and severity of climate, that nothing but the very richest of mines could be worked at a profit. For thousands of miles there were no safe and adequate natural harbours on the coast where heavy machinery could be safely landed, and this geographical drawback would never be satisfactorily overcome. He had followed the history of the Pilbarra gold-field with some interest, and it was a history of successive defeat and disappointment. Geologically the district was interesting, as there was a great variety of rocks and minerals, and Mr. Becher had done well in adding to the very meagre information that had been published on the rocks of the Pilbarra gold-field.

DISCUSSION OF MR. FRANK REED'S PAPER ON "HYDROTHERMAL DEPOSITS AT PEAK HILL, WESTERN AUSTRALIA." *

Mr. FRANK REED, replying to Prof. H. Louis' remarks, wrote that the title of his paper conveyed the meaning he intended; and by thermal crater, he meant the orifice of a fissure, originally caused by volcanic activity and afterwards used as an outlet for thermal waters


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The following gentlemen were elected, having been previously nominated :-

MEMBERS-
Mr. Thomas William Turner Atherton, Chief Mining Engineer, Mijnbouw Maatschappij, Bwool, Celebes.
Mr. Harry Foster Bain, Assistant State Geologist of Iowa, Des Moines, Iowa, United States of America.
Mr. Theodore Breidenbach, Mine Manager, Mikado, Rat Portage, Canada.
Mr. James Carroll, Manager of Brilliant and St. George Gold-mine, Charters Towers, Queensland, Australia.
Mr. William Clark, Colliery Manager, Cranbury Lodge, Park Lane, Wigan.
Mr. A. J. Colquhoun, Mining Engineer and Assayer, Vancouver, British Columbia.
Mr. Alfred S. Edgecombe, Mining Engineer and Metallurgist, Rossland, British Columbia.
Mr. John James Constant Fernau, Mining and Civil Engineer, Nenthead House, by Alston, Cumberland.
Mr. Henry J. A. Herrman, Mechanical Engineer, Cranleigh, Woodford Green, London.
Mr. Thomas Jaffrey, Engineer and Mill Manager, John Bull Gold-mine, Limited, Ravenswood, Queensland, Australia.
Mr. G. F. Monckton, Mining Engineer and Assayer, Lytton, British Columbia.
Mr. George Arthur Pingstone, Analytical and Consulting Chemist, P.O. Box 212, Bulawayo, Rhodesia, South Africa.
Mr. John Archibald Pringle, Mining Engineer, Blakeney, Newnham, Gloucestershire.

Mr. John Satterthwaite, Mining Engineer, Garbham Mines (Vizianagram Mining Company, Limited), Chipurnpalle, Vizagapatam District, India.
Mr. Alfred Godden Smith, Mining Engineer and Manager, Golden Valley Ochre and Oxide Company, Wick, Bristol.
Mr. John Southern, Colliery Manager, Heworth Colliery, Felling, R.S.O., Co. Durham.
Mr. T. Trevaille-Williams, Mining Engineer, P.O. Box 271, Johannesburg, South African Republic.
Mr. Walter Francis Ainslie Wadham, Civil and Mining Engineer, Millwood, Dalton-in-Furness.
Mr. Johannes Westphal, Bergreferendar, Eichenallee 23, Westernd, near Berlin.

Associate Members—
Mr. A. A. Blow, The Sheba Gold Mining Company, Limited, Eureka City, Barberton, South African Republic.
Mr. A. R. Boyle, Melbourne and Metropolitan Board of Works, Rialto, 501, Collins Street, Melbourne, Australia.
Mr. Charles J. Collopy, P.O. Box 1212, Johannesburg, South African Republic.
Mr. William J. Gilbert, Monarch Gold-mining Company, Gullewa, via Yalgoo, Murchison, Western Australia.
Mr. Albert J. Hill, New Westminster, British Columbia.
Mr. Thomas Snowball Innes, Crown Chambers, Side, Newcastle-upon-Tyne.
Mr. Joshua Jeffries, Greta Collieries, Greta, New South Wales.
Mr. G. Bentley Poore, P.O. Box 149, Johannesburg, South African Republic.
Mr. John Rosen, 28, St. Charles Square, North Kensington, London, W.

Associates—
Mr. Thomas Danskin, Deputy-overman, Springwell Colliery, Gateshead-upon-Tyne.
Mr. William Rochester, Jun., Overman, Emma Colliery, Ryton-upon-Tyne.

Students—
Mr. Charles Arthur Crofton, Mining Student, Peases' West Institute, Crook, Co. Durham.
Mr. William Denham Harbit, Mining Apprentice, 32, High Street, Wallsend-upon-Tyne.
Mr. Richard Nash Pearson, Mining Student, Tamworth Colliery, Alvecote, Tamworth, Warwickshire.

The following paper by Mr. H. Foster Bain, on "The Western Interior Coal-Field of America," was read: —

[55]

THE WESTERN INTERIOR COAL-FIELD OF AMERICA.
By H. FOSTER BAIN, Assistant State Geologist of Iowa,

Classification of American Coal-fields.
The coal-fields of the United States of America underlie an area variously estimated at from 200,000 to 300,000 square miles. The extent of many of these fields is yet unknown, and detailed knowledge of the stratigraphy of almost all of them is lacking. Their location and general outline, so far as known, are laid down upon the accompanying map (Fig. 1, Plate VI.). The data for this map were collected for, and first published in, the Eleventh Census.* The outlines of the various fields as far west as the Missouri river are accurate within the limits of the map; but west of that the spots coloured indicate points at which coal is known to occur, more often than they give the full extent of the fields.
In a general way it may be said that the eastern fields are in the Carboniferous, while the western belong to the Mesozoic system, but this statement has exceptions to be noted later. For statistical purposes, the coal-fields have been classified by the U.S. Geological Survey into the following groups, which, as will be readily seen, agree in most instances with geographical and geological units. The production of each field in 1897 is given below:—

<table>
<thead>
<tr>
<th>Classification</th>
<th>Tons of 2,000 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthracite</td>
<td>52,500,839</td>
</tr>
<tr>
<td>Triassic</td>
<td>116,950</td>
</tr>
<tr>
<td>Appalachian</td>
<td>97,291,187</td>
</tr>
<tr>
<td>Northern</td>
<td>223,592</td>
</tr>
<tr>
<td>Central</td>
<td>26,414,127</td>
</tr>
<tr>
<td>Western Interior</td>
<td>13,164,059</td>
</tr>
<tr>
<td>Rocky Mountains, etc.</td>
<td>8,854,182</td>
</tr>
<tr>
<td>Pacific Coast</td>
<td>1,639,779</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>200,204,715</strong></td>
</tr>
</tbody>
</table>

The anthracite-production includes small amounts from Colorado and New Mexico, from coal-fields not marked on the map. The major production is, of course, derived from the Pennsylvania coal-field. The New England beds are not now producing. As will be noted, the largest
amount of coal mined comes from the Appalachian coal-field. It was the southern portion of this field which was described recently by Mr. Jeremiah Head.* The Central coal-field stands second in production among the bituminous fields, the Western Interior is the third. It is the latter coal-field which it is the especial province of this paper to describe. The production of this coal-field for 1897 is given (by states) below. The total 13,164,059 short tons, constituted 8.9 per cent. of the whole production of the United States for the year, and was an increase of 29.1 per cent. over the output for the preceding year.

<table>
<thead>
<tr>
<th>States</th>
<th>Tons</th>
</tr>
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<tbody>
<tr>
<td>Iowa</td>
<td>4,611,865</td>
</tr>
<tr>
<td>Missouri</td>
<td>2,665,626</td>
</tr>
<tr>
<td>Nebraska</td>
<td>645</td>
</tr>
<tr>
<td>Kansas</td>
<td>3,054,012</td>
</tr>
<tr>
<td>Arkansas Indian Territory</td>
<td>856,190</td>
</tr>
<tr>
<td>Texas</td>
<td>1,336,380</td>
</tr>
<tr>
<td>Totals</td>
<td>13,164,059</td>
</tr>
</tbody>
</table>

Location and Extent of the Western Interior Coal-field.
This coal-field stretches in a long irregular belt for a distance of approximately 900 miles north and south, and has a maximum width of 300 miles east and west. As much of it has not been accurately surveyed, its exact area cannot be stated. It includes portions of Iowa, Missouri, Nebraska, Kansas, Arkansas, Indian Territory and Texas. The active mining operations are largely confined to Iowa, Missouri, Kansas, Arkansas and Indian Territory. The estimated area in each state is as follows:—

<table>
<thead>
<tr>
<th>States</th>
<th>Square Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>20,000</td>
</tr>
<tr>
<td>Missouri</td>
<td>23,000</td>
</tr>
<tr>
<td>Nebraska</td>
<td>3,200</td>
</tr>
<tr>
<td>Kansas</td>
<td>17,000</td>
</tr>
<tr>
<td>Arkansas</td>
<td>14,700</td>
</tr>
<tr>
<td>Indian Territory</td>
<td>12,000</td>
</tr>
<tr>
<td>Texas</td>
<td>6,000</td>
</tr>
<tr>
<td>Total</td>
<td>95,900</td>
</tr>
</tbody>
</table>

These estimates include both barren and productive beds. The really valuable ground would of course be much smaller. For example, Dr. J. C. Branner † in 1892 estimated the known coal-bearing territory of Arkansas at 1,620 square miles. This has since been increased of course by detailed prospecting, and there are still extensive reserves of unproven value. In Iowa, about one-half of the coal-measures are

underlain by what are called the productive measures. Within the area of the latter diamond-drill work shows variable amounts of mercantile coal. In prospecting one field of about 5,000 acres, approximately 12 per cent. was found to include workable coal. In Polk county, with a total estimated production up to date of 10,000,000 (short tons of 2,000 lbs) tons but 3 per cent. of the total area of 375,200 acres has been prospected and less than 0.6 per cent. has been worked out.* In Missouri, Mr. Winslow suggests† 10 per cent. as a possible measure of the proportion of field which will produce coal. Hardly sufficient data exist for making a trustworthy estimate for the whole field, but it may at least be stated that not only is the Western Interior field the largest known coal-field in the United States, but so far there is no reason to doubt that it will yield approximately as much coal as any.

General Stratigraphy.
The Western Interior coal-field occupies a portion of the western half of the Mississippi valley. In its major extent the region is a vast level plain sloping very gently from the Rocky Mountains on the west to the Mississippi on the east. This plain is diversified by certain areas of uplift which jut out into the coal-field from the east. To the northeast is the area of pre-Carboniferous rocks of the Lake Superior region. This doubtless in Carboniferous times, as now, formed an elevated land-mass which then drained south-west into the sea. Between the main mass and a long arm from this area stretching off to the south-west a bay was formed, and in the latter is the present northern limit of the coal-field. South from the Wisconsin area, there was probably a ridge of land dividing, at least partially, the basins in which were accumulating the beds now making up the coal-measures of the Western Interior and the Central coal-fields. At present, the erosion of the river Mississippi and its tributaries is the main factor in the separation of the fields. There is not wanting, however, certain evidence in the beds themselves to indicate that the dividing-line marks as well an original shore-line. It seems accordingly that the Central and Western Interior fields, if not originally separate, were at least connected only by occasional lagoons and arms of the sea.

To the south-east, it will be noted that the western border of the field shows a great embayment. This is due to the Ozark uplift,

* "Geology of Polk County" by Mr. H. F. Bain, Iowa Geological Survey, 1897, vol. vii., page 359
extreme south-eastern border of the field, are composed of Paleozoic strata, mainly of pre-Carboniferous age. The Coal-measures have been caught up in this folding which is post-Carboniferous, and in Arkansas and Indian Territory, they show its influence; but the core of the mountains consists of earlier beds.

To the extreme south-west is the bituminous coal-field of Texas, which is usually considered to be the prolongation of the main field. There are, however, some reasons for believing that it has had a separate history. The detached areas indicated on the map east of the main Texas field; as well as the area in Central Kansas, and the smaller area in south-eastern South Dakota mark lignite-fields belonging to the Mesozoic. The western border of the coal-field is everywhere formed by the overlapping edges of later strata. In a general way, the dip of the whole series is to the west, though there are important exceptions, and the beds after passing under the great plains are brought to the surface again along the eastern edge of the Rocky Mountains. They are not, however, coal-bearing in the latter region, nor, so far as we now know, far under cover of the latter beds. In general, the workable areas are the areas of outcrop of the productive series only.

In discussing in greater detail the stratigraphy of the region, it will be convenient, for many reasons, to consider separately the areas north and south of the embayment made by the Ozark rocks. The northern portion may be called the Iowa-Missouri coal-field, though the term is occasionally made to cover the entire field, and the southern may be known as the Arkansas-Indian Territory.

The Iowa-Missouri Coal-field.
The first geologist who visited and reported upon this field was Dr. David Dale Owen, who, in his report issued in 1852,* made known the general outline of the field and many of the essential facts of its stratigraphy. Since then it has been studied by Messrs. Swallow, Broadhead, Marcou, Geinitz, Worthen, St. John, White, Calvon, Keyes, Winslow Haworth, and many others.

The formation consists of two main portions, an upper or barren, and a lower or productive series. To this upper division has recently given the name Missourian, while the term Des Moines has been applied to the lower. The Missourian series consists of a number of distinct formations beginning with the Bethany limestone, and extending up to, and including the Cottonwood limestone. It is made up in Iowa and Missouri mainly of thin limestones, with intercalated argillaceous and calcareous shales, and contains very little sandstone with only thin seams of coal. The Nodaway bed, mined in southwestern Iowa and the adjacent portion of Missouri, is probably, the most important. It is from 15 to 22 inches thick, and has a known north-and-south extent of something over 40 miles. It is worked along the outcrop mainly by drifts, and supplies the local market with household coal. The mines are small, poorly equipped, and usually run only in the winter season. It is not improbable that the coal mined in Nebraska comes from the same bed, as it occupies the same general position in the series on the western side of the syncline, that the Iowa mines hold to the east. In these states, the Missourian formation can never be expected to become a large producer of coal, and in the future, as now, the main supply must come from the lower beds. In Kansas, the Missourian includes certain shaly members, individually reaching a thickness of 600 feet and carrying thin seams of coal, which, from their position, well towards the western limit of the field, have considerable importance. Here, as elsewhere, however, the great bulk of the coal comes from the lower beds. The Des Moines series includes three formations, which are unequally developed. The uppermost division is formed by the Pleasanton shales, which in Kansas attain a thickness of 200 feet. To the north, they thin until in central Iowa the shales are hardly to be separated from the next lower member. Below the Pleasanton comes the middle member of the
series. It passes under various names in different parts of the field. In Kansas, it consists of two well-marked limestones, known as the Oswego and Pawnee, with an intercalated shale-bed. In south-western Missouri, the latter becomes unimportant, and the limestones come together so as to form a single escarpment. This is known as the Henrietta, and is well displayed near Hume in Pates county. The great bulk of the coal is mined in the area between this escarpment and the outer edge of the Coal-measures. In northern Missouri, the Henrietta limestone breaks up into a number of thin beds separated by shales and carrying important but thin coal-seams. This phase of the formation has been called the Appanoose. In Schuyler, Putnam and Adair counties, Missouri, and Appanoose and Wayne counties, Iowa, the formation is very regular; it carries an important seam of coal known variously as the Mystic, Centreville, Mendota or Stahl coal. This bed has an areal extent of at least 1,500 square miles, and an average workable thickness of about 2 1/2 feet. It thins very gradually, with a dip to the west, and passes below the later beds. The main openings are along the outcrops, where drifts are, of course, largely employed. There are no important mines much more than 15 miles back from the edge, where the coal is found at a depth of about 250 feet. A section of this bed has already been given, and the general methods employed in mining it have been mentioned.*

North of the region of outcrop of the Appanoose formation there are equivalent beds, though exactly the same sequence does not prevail. The thin coal-seams found are only mined for local consumption, and do not influence the general market.

Below the middle member is the formation which Dr. Haworth has called the Cherokee shale,† from the county in Kansas, where it supports so large a mining industry. It crops out over a crescent-shaped area following the outer line of outcrop of the Coal-measures from Kansas to north-central Iowa. In general, the beds throughout the area dip toward the centre of the circle, which would be formed by the prolongation of the horns of the crescent. The general dip is, however, so slight that mining operations are wholly uninfluenced by it, and except for occasional local dips the beds are apparently horizontal. The region is an open plain, and the surface-inequalities are only those due to river-erosion. The country is well supplied with railways, and has an important population. The Cherokee shales vary in thickness between 200 to 600 feet along the outcrop of the next higher formation, and thin to nothing at their own outcrop. The formation is made up largely of shale and sandstone, and carries numerous important coal-beds. The individual strata vary in thickness and character from point to point, so that it is impossible to construct a general section of more than local value. In the southwest, especially in south-eastern Kansas and the adjacent portions of Missouri, the beds are apparently more regular than elsewhere, and the irregularities found farther north serve to mark this as an exceptional portion of the field.

In Iowa and much of Missouri, the coal-beds have been cut out in a variety of ways. In the first place, the beds are practically horizontal while the streams have cut 200 to 250 feet below the upland. As a result a considerable amount of coal has been cut


out. Since, however, these deep valleys afford ready means of tracing and opening the coal seams, they are probably more advantageous than detrimental. There is, however, another series of valleys which cause a good deal of loss and have no corresponding value. The region as far south as the Missouri river is covered by the till or boulder clay laid down by glacial agencies. In the period immediately preceding the advent of the glaciers, the region stood high and was much cut up by the streams. The valleys cut at this time being later on filled by glacial debris, are now entirely concealed and often seriously affect mining. In one case, a drift had to be driven in soft water-bearing material more than 300 feet, in crossing such a valley. Fortunately the present streams seem to follow very largely the courses of their older prototypes, so that with a little care in selecting ground these buried valleys may be usually avoided.

The most serious limitation to the workable coal is the fact that the beds of the northern portion of the field do not maintain a constant thickness. They thicken and thin rapidly, varying from nothing to 7 feet in a few feet. The usual variation is from about 18 inches to 6 feet. The thicker, workable beds lie in basins or troughs of very irregular outline. The coal varies a little in elevation, differences of 20 to 30 feet being common, and as much as 60 feet of local dip being observed in a single mine. Usually the coal thins to the rise, and it seems that irregularities are a result of the original irregularities of the bottom. In the case of the lower coal worked near What Cheer in Keokuk, Iowa, the inequalities can be referred to the irregularities of the old erosion-surface of the St. Louis limestone upon which the Coal-measures rest unconformably.* This condition is paralleled by the outlying pockets of very thick coal found in Missouri along the borders of the field,


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and described by Mr. Arthur Winslow.* In some of these pockets, coal 70 feet thick has been found, but its extent is very limited. The coal occurs in narrow channels eroded in the earlier rocks. In one instance, such a channel is known to be 100 feet wide, and has been followed for 500 feet. These pockets have attracted much attention, but are really of small value. Their exploitation has entailed the loss of considerable sums of money.

In the Iowa mines no such thick deposits have been found, but corresponding irregularities in the beds worked are common throughout the field. The beds thicken and thin so rapidly that it has so far proved impracticable to construct a general section of the formation, or to make any extended correlations between the coal-beds. The following records of certain diamond drill-holes, all reaching the same coal and being within 2 miles of each other, will illustrate these variations:—

[Table omitted]

As may readily be supposed, this uncertain character of the coal-beds influences largely the methods and cost of prospecting and opening. The very general covering of boulder-clay of a thickness varying from 50 to 250 feet also adds to the difficulty of locating a mine. The prospecting is nearly all done by drilling. The extent of a given coal-basin is so uncertain that monkey-shafts are very little used. In order to locate the coal with sufficient accuracy to warrant opening, it is sometimes necessary to put down ten drill-holes on a single square mile. When the depth is less than 100 feet, and there has been work enough in the region to make the strata pretty wellknown, the common churn or percussion-drill, driven by horse or steam-power, is used. This work is cheap, the cost being from 25 to 75 cents (1s. to 3s.) per foot, but the results are
uncertain and the extended use of this type of drill cannot be recommended. The best work, and all the large contracts, are done with the diamond core-drill. As carried on in this field, this work probably costs about $1 (4s.) a foot for average depths and conditions. One extended job has recently been finished at a cost of 72 cents (3s.) per foot, but the work was done there with exceptional economy. The total cost of prospecting depends of course on the area and the difficulties. In general it costs from $5,000 to $10,000 (£1,000 to £2,000) to locate enough coal for a big shipping-mine. One company leased 5,000 acres, put down 20 diamond drill-holes, and located about 600 acres of coal for 17,000 (£1,400).

A majority of the mines are opened by shafts. These are oblong in cross-section, usually having two compartments, each used for hoisting, and are ordinarily 7 by 14 feet in the clear. They are timbered with 4 to 12 inches timbers, and are frequently sunk by contract. An ordinary shaft costs about $12 (£2 10s.) per foot for sinking, plus the timber, etc.

[Photograph] Fig. 3.—Pekay Coal-mine, Mahaska County, Iowa.

The inequalities of the thickness of the beds limits the amount of coal which may be advantageously mined from one shaft. The fact that none of the mines are deep, the deepest mine now operating in Iowa reaching about 250 feet, makes it cheaper usually to sink a new shaft rather than drive through thin coal and make a long underground haul. These natural conditions, coupled with the high rate of interest and the desire for quick returns also influence the methods of working. The mines are frequently capitalized inadequately, and cheap installations with smaller returns ate the rule. The life of an individual mine is short, 10 to 20 years, and after the immediately adjacent territory is worked out, the plant is moved to a new site. Comparatively little of the area is adapted to longwall and various forms of room-and-pillar work are adopted. A very common form is that shown in Fig. 2 (Plate VI.), where the cross-entries are driven 350 feet apart, and the rooms after being driven in 14 feet are widened to 30 feet. They are then driven until they meet the rooms from the next cross-entry. The pillars between adjacent rooms are then mined back, and the work is closed up. All the work is advancing, so that the last coal mined has a long haul through old workings. Sometimes the rooms are worked in panels, but usually not. Ventilation is accomplished in most instances by fans. There are no explosive or dangerous gases, and under normal conditions there is very little water to contend with. Tramming is done by mule-power in the smaller mines, and on the cross-entries of the larger ones. For the main hauls, tail-ropes and continuous ropes are usually used, though electric motors are occasionally put in. The tail rope system seems to be the favourite. The mine-cars are ordinary wooden boxes with iron frames and loose wheels. They hold, as variously built and loaded, from 1,200 to 2,200 pounds. The small country-mines raise the coal by horsepower, but steam-hoists are almost universal.

The coal is nowhere cleaned, except by a certain amount of hand-picking in the mine. It is sized by being allowed to fall over fixed grizzles with an occasional trommel-screen for the smaller sizes. It is usually loaded directly into cars which stand on track-scales, the coal being weighed as it is loaded. When box-cars are being loaded, the coal is thrown to the ends of the car by an ingenious machine
known as a box-car loader, which is driven by an independent engine set on the opposite side of the car from the coal-shoot. This engine is attached, by means of an eccentric or crank-shaft, to a pivoted beam working in a horizontal plane. The free end of the beam is armed with a shoe against which the stream of coal falls. As the beam is given a rapid vibratory motion, it knocks the falling lumps of coal first to one end, then the other of the car.

The shaft-house and all top-works are usually built of wood, though in some cases brick boiler-houses or corrugated iron sheeting is used. There is, of course, danger of fire with wooden structures and several disasters have resulted from it. A separate escape-shaft is, however, required by law, so that the loss of life has fortunately never been great. The big coal-mining camps of Iowa are situated in a line across the state following the Des Moines river. Fort Dodge, Boone, Des Moines, Oskaloosa and Ottumwa, are found in succession following down the valley, and each mark the crossing of the river by an important east-and-west railway. From Ottumwa westward, along the line of the Chicago-Burlington-Quincy railway, there has always been considerable mining. The Cleveland mines of the Whitebreast Fuel Company, in Lucas county, were long the largest in the state, and at present the Heitman mines of the Wapello Fuel Company, in Monroe county, are the most important west of the Des Moines valley. South of Ottumwa, the line of active mining-camps swings west, including Mystic and Centreville in Iowa, and Mendota, Stahl and Milan in Missouri. It is at these points that the upper bed, already mentioned, is mined. The lower measures cropping out east of this latter group of mines are not now producing much, though in earlier years they yielded important supplies of coal. South of Milan, the line sweeps in a semicircle to the south-west, keeping relatively close to the edge of the coal-field, and passing through Macon, Randolph, Ray, Lafayette, Bates and Vernon counties. The important mining towns of Bevier, Huntsville, Richmond, Higginsville, and Rich Hill, each mark the crossing of the productive zone by important railways. The latter have not only been the chief agents in the development of these coal-fields, but afford the largest market for the output. In Iowa, in 1897, 49 per cent. of the total output was used by them, and they carried 43 per cent. to market. The relations between the railways and the coal-companies are naturally very intimate. In a large number of cases, the two properties are owned by the same parties though the business is in most cases carried on under different company names. In any event, it is the policy of the railway as much as any other factor which determines the advisability or non-advisability of opening a mine. In many cases, the coal-companies own in fee the land mined. Most of the country is farm-land, and large tracts can be purchased in favourable locations at from $20 to $40 (£4 to £8) per acre. It is customary to option an area, agreeing before prospecting to purchase the land at a stated price or to pay royalty at a fixed percentage for all coal mined under the land in question, in case the prospecting proves favourable. The royalty varies greatly with the thickness and character of the coal and the demand for leases. It usually runs from 4 to 15 cents. per ton, though some old leases at 20 cents. per ton are still running. It is frequently agreed that the royalty shall be paid at the rate of a certain number of dollars per month, whether the

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[Photograph] Fig. 4.—Anchor Coal-mine, Centreville, Iowa.
coal be actually mined or not, the coal-company reserving the right to mine later. Occasionally, the mineral rights are directly purchased, but it is usually cheaper to buy land in fee, and then as opportunity offers to sell the surface rights.

In Vernon and Bates counties, Missouri, and the adjacent portion of Kansas, the conditions are slightly different from those farther north. This region, which is known as the Pittsburg field (from its chief city Pittsburg, Kansas), has many of the resources which have made the older district of the same name in Pennsylvania so famous. It is situated at the edge of the richest American lead and zinc-field, and has important smelting interests. The coal mined comes from the Cherokee beds. In contrast with the irregular, pocketed nature of the beds mined farther north, the Cherokee coal is known to extend over a very considerable area. A general section of the strata in the vicinity of Scammon, Kansas, would be as follows:

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.</td>
<td>Surface-drift and slate, 0 to 30 feet.</td>
</tr>
<tr>
<td>5.</td>
<td>Coal, Top Vein, 6 inches.</td>
</tr>
<tr>
<td>4.</td>
<td>Black and white slate, 4 to 5 feet.</td>
</tr>
<tr>
<td>3.</td>
<td>Coal, Middle vein, 16 to 21 inches.</td>
</tr>
<tr>
<td>2.</td>
<td>Black and blue slate, 6 to 30 feet.</td>
</tr>
<tr>
<td>1.</td>
<td>Coal, Cherokee Seam, 3 to 10 feet.</td>
</tr>
</tbody>
</table>

The strata have a gentle dip to the north-west and the underlying Lower Carboniferous beds crop out a few miles to the south-east. As a result, the depth to the lower coal, the bed principally worked, varies considerably. At Scammon, the mines range in depth from 50 to 90 feet. Near there, the beds crop out, and coal is mined by stripping.*

The upper bed is mined at No. 8 mine of the South-western Coal and Improvement Company, located at Mineral, Kansas. At this point, the seam is about 2 feet thick, and has been opened up by longwall workings. It is covered by 8 to 15 feet of black slate, over which is 36 feet of surface-dirt. The coal was originally opened up with room-and-pillar work and independent mining-machines were used. The rooms were driven 50 feet wide, and the under-cut made 5 inches below the coal in the fire-clay. It was found that to make a 4 feet undercut, about 12 feet of clear room at the face was needed. In so thin a bed the movement of the machines from one part of the mine to the other entailed considerable expense, and the ready separation of the coal from the fire-clay also gave some difficulty. It was decided to change the work and a Link-belt longwall machine was being installed at the time that the writer visited the mine. This machine consists essentially of a steel box enclosing a motor and suitable gearing, and arranged to slide forward on a movable track. The motive power is applied by means of a drum and a wire-rope attached to a post ahead. The cutting is done by a horizontal arm projecting at right angles. Around the end of this

* The Coal-measures and mining methods of Kansas have been recently described by Messrs. Haworth and Crane in Univ. Geological Survey, Kansas, vol. iii., 347 pages, Topeka, 1898.
is run a chain armed with picks similar to those used in the ordinary mining-machine. With machine-work, this upper seam yields only 10 per cent. of fine sizes, while the lower bed, as ordinarily worked by shooting off the solid, makes but 50 to 60 per cent. of lump coal.

In this district, the coal is usually paid for as mine-run, and is weighed in the mine-cars before hoisting, or just before dumping into the screens. The coal passes, first, over a 14 feet grizzley placed at an angle of 28 degrees, and set with 7/8 inch bars. The fine coals from these bars drop upon a series of perforated iron-plates, which receive a gentle vibratory motion from a small engine, so that the coal passes through the system. This type of screen is common throughout the district.

The mine-work is room-and-pillar, with cross-entries at intervals of 300 feet, rooms 22 feet wide, 8 feet between rooms, and with 12 feet pillars along entries. The coal lies very even, and the work is very regular. The highest roll noted was 4 feet, and in one mine a single mule pulls 7 tons per trip on a 1/2 mile haul. Most of the tramming is accordingly done by mule-power, about 22 mules being needed for an output of 900 tons per day. The cars are the usual wooden boxes, with a capacity of 1,300 to 2,000 pounds, running with loose wheels on a 36 inches gauge railway, with about 12 pounds rails.

The mines are opened by means of 7 by 14 feet shafts, and the top works are about the same as those seen farther north. In some of the mines of the Central Coal and Coke Company and other large operators, first-motion hoisting engines are used, though the second-motion engine is more common. At No. 7 shaft of the Southwestern Coal and Improvement Company, a first-motion engine hoists from a 110 feet shaft in 6 seconds, with 6 1/2 revolutions of the drum. This shaft has an automatic dump, but has rather awkward arrangements below, the coal being weighed in the mine. Two cagers, two boys, and a weighman work below, while one man is stationed on the top. The Nelson mine of the Central Coal and Coke Company has a second-motion engine, and four cars per minute are hoisted. One of the Weir City mines, with the same hoist, takes out twice as many cars with a first-motion engine. This is of interest, because of the contention that first-motion engines do not have any great advantage in shallow mines, and the fact is significant, despite the differences in top arrangement, etc., which contribute somewhat to the results. In general, the mines of the region hoist from 450 to 2,000 tons per day, the average mine having a daily output of about 900 tons, and working out about 160 acres per shaft. Here, as farther north, shaft-sinking is cheaper than long underground hauls.

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There is little water to contend with, regular pumping being rare, and no gas in dangerous quantities is found. An exceptionally small amount of timber is used, and no extensive faults or rolls are encountered. Aside from clay-slips, which are very common and occasionally carry water there is nothing to hinder the most extensive development.

There are a large number of Italian miners in the region, some negroes and some Slavs. Anglo-Saxons are few, and yet there are some large mines which employ them entirely.

While close competition has in recent years reduced considerably both the price of coal and the profits of mining, it is still a paying field. The low cost of mining may be inferred from the facts that entry work costs from $1.40 to $3.20 (5s. 10d. to 13s. 4d.) per yard, the latter price being paid only for work in barren ground, and last summer the miners were being paid 87 cents (3s. 7 1/2d.) per ton for lump coal, or 52 cents (2s. 2d.) for mine-run. It is easy to place contracts for coal at 25 cents (1s. 0 1/2d.) per ton more than the mining rate, from which the low cost of general expenses may be estimated. Some coal has been sold recently at even lower rates.
The Arkansas-Indian Territory Coal-field.
The southern portion of the Western Interior coal-field differs in many important particulars from the northern portion. The great limestone member which is so important in the latter region has not as yet been positively recognized to the south of Kansas. Even in the latter state, the Missourian includes, as compared with the region to the north, a relatively small amount of limestone, and in Arkansas and Indian Territory the limestones are practically absent, at least, so far as the coal-field has been studied. The Coal-measures of the region include a great thickness of sandstones and shales. The hard sandstone beds are quite persistent, and in weathering stand up above the shales, forming a series of "hog-backs" which are of considerable aid in unravelling the stratigraphy of the region. The beds have been thrown into a series of east-and-west folds, of increasing intensity to the south-east. The recent erosion has cut out a relatively well developed grade-plain, above which the mountain-ridges rise 1,200 to 1,600 feet. A considerable number of these mountain-masses are detached, and they include both anticlines and synclines. To the south-east, the folds are closer and more compressed, and faulting becomes important. To the north and west, the folds are broader and shallower, and faulting is practically absent. The region has never been mapped in detail, and all the knowledge that we have of its geology has been derived from various reconnaissances. It is obvious that no very certain correlations can be made until more careful studies have been carried on.

Omitting the mention of briefer papers, the most satisfactory information may be obtained from Mr. Winslow's report on the Arkansas coal-seams,* a paper by Mr. Chance on the "Geology of the Choctaw Coal-field,"† and a recently issued paper by Dr. N. F. Drake giving the results of a reconnaissance of the coal-fields of Indian Territory.‡

Mr. Winslow's report was preliminary to a fuller paper which was never published. He gives a map of the greater portion of the Arkansas field on a scale of 4 miles to 1 inch, and the various cuts with the descriptive matter make the main features of the field clear.
Without attempting to correlate his divisions with those found elsewhere, he has mapped the Upper or Western coal-bearing division and a Lower or Eastern coal-bearing division with an Intermediate Barren

[Photograph] Fig. 6.—Bonanza Coal-mine, Arkansas.

The more important mines are found in the area covered by the Upper division, and are situated from 15 to 30 miles south-east of Fort Smith. The Huntington, Hackett, and Jenny Lind mines are among the older and better-known mines. The Bonanza mine of the

† Transactions of the American Institute of Mining Engineers, 1889-90, vol. xviii., pages 653-661.
‡ Proceedings of the American Philosophical Society, vol. xxxvi., No. 156.

Central Coal & Coke Company is working on the western extension of the Jenny Lind coal-seam, and may be more specifically described, since in equipment and general methods of working it is quite representative of the larger mines of the region.

The Bonanza mine is located in the extreme western portion of Sebastian county, Arkansas, about 10 miles south of Fort Smith on the St. Louis and San Francisco
railway. The coal is delivered to the Pittsburg and Gulf railway at Poteau, 20 miles south-west, by the Choctaw and Arkansas railway, which has running powers over the St. Louis and San Francisco railway, but is owned by the coal-company. The field is the western extension of the Jenny Lind, and its position with reference to the general geology of the region is excellently shown on the map accompanying the report by Mr. Winslow already referred to. The coal occurs near the base of the Upper or Western coal-bearing division of the Coal-measures as defined by him: it is a semi-anthracite, and in appearance is clean and glistening, showing on fractured surfaces a sub-metallic lustre. A section measured in the mine gave the following details:

<table>
<thead>
<tr>
<th></th>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Roof-shale, hard, grey, siliceous</td>
<td>2</td>
<td>+</td>
</tr>
<tr>
<td>4. COAL, Upper Bench</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>3. Clay, parting</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2. COAL, Lower Bench</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1. Shale, grey, hard</td>
<td>8</td>
<td>+</td>
</tr>
</tbody>
</table>

The thickness of the roof and bottom-shale was not measured, but is known to be considerable. At points, its upper portion is bituminous, and is known as "black jack." The clay-parting is uniform, and is the only dirt-band in the coal. There are no sulphur balls or bone coal, so that with ordinary care very clean coal can be loaded. The bed varies but little in thickness. At one point, it decreases to barely 4 feet and at another it is over 6 feet, but the average of 5 feet is well maintained. There are no rolls or swamps such as are common further north, and there is very little faulting. One small slip with a throw of a few feet was observed. The bed has a regular dip to the north of about 10 feet per 100. It crops out south of the shaft along the flank of the anticlinal ridge between Bonanza and Jensen, and was originally worked along the outcrop by stripping. It has been traced by diamond drilling over an area of about 1,500 acres, and is known to extend to a distance of 3/4 mile from the outcrop where it lies at a depth of 887 feet. It probably extends much farther, but under present conditions deeper working would hardly pay.

The mine is worked by means of a double-compartment hoisting shaft with a second escape and air-shaft a short distance east. The coal is shot from the solid. The mine-cars are collected by mules, of which there are fourteen in the mine, in trips of two cars each. They are taken to the gravity or engine-planes, according as the entry is worked to the rise or the dip. The work is room-and-pillar, double entry with 8 feet of coal between the rooms and the entry-pillars are 14 by 18 feet. The rooms are narrow, less than 25 feet wide, and the work is all manual. About 230 miners are employed, and with a second-motion engine 1,100 tons a day were being hoisted at the time the mine was visited. The coal is dumped by hand and weighed in a hopper. From the latter, it is dumped a second time to the screens, first passes ordinary 7/8 inch grizzles, yielding about 75 per cent. of lump coal. The fine coal is passed over shaking-screens with perforated iron bottoms, driven by a separate engine under the screen. The mine is ventilated by a 15 feet fan, driven by a third engine placed in the fan-house. The three engines and boilers are cared for by one engineer and two firemen. There are four cagers below and four top men. By putting in an automatic dump, it should be possible to decrease this number, and with a first-motion engine at least 100 tons a clay more could be hoisted. As it is, however, the mine falls but a few tons below the Arkansas record for daily output.

In the region immediately west of the Arkansas boundary line, there is not just at present much mining. Coal occurs in Sugar Loaf and Cavaniol (or Kavanal) mountains, as well as on the lowland plain between. The most ambitious attempt to
open up the beds was that of the Kavanal Coal and Railway Company. This corporation built a track from Poteau up the side of the mountain to the mouth of their slope, and opened up a mine. The coal lies about 300 feet above the lowland, and pitches into the mountain with a dip of 5 degrees. The mountain is a syncline, and the outcrop of the coal has been traced entirely round it. The bed is from 3 to 4 feet in thickness, clean and of excellent quality. It could be easily mined, and there seems no good reason for the financial reverses which forced the closing of the mine.

The main mining activity in Indian Territory is in the vicinity of McAlester and Krebs, about 70 miles west of the state boundary line. This region has been studied by Mr. H. M. Chance, and his results will be found in the paper already cited. The Coal-measures of the region consist of shales and sandstones which, according to his measurements, have a minimum thickness of 8,500 feet. The Mayberry, Secor,

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Norman, McAlester and Grady coal-seams were distinguished and partially mapped. The Mayberry, McAlester and Grady beds have a wide distribution, a good thickness and are considered economically important. The Grady group of coal-seams is found immediately above the basal sandstone. The McAlester coal-seam lies about 1,200 feet above the Grady. The coal-bed lies in a series of synclinal basins, with moderately steep dips at the outcrop and flat coal near the centre. The beds are 4 to 6 feet thick, the coal is of excellent quality, and the mining conditions are favourable. The Mayberry coal-seam is the one mentioned as having been mined in Cavaniol or Kavanagh mountain, and Mr. Chance considers it to be the equivalent of the Huntington-Jenny-Lind coal. Dr. Drake on the other hand believes that the latter is the equivalent of the Grady coal-seam. In the absence of detailed maps and sections, it is hard to make sure of these correlations, though the writer's own brief experience in the region leads him to believe that the Arkansas coal-seams were certainly lower than the Mayberry horizon. Change of dip and even slight faults may, however, prove so easily deceptive that it is perhaps best to reserve opinion until more is known.

With regard to the age of the Coal-measures and their correlations with the divisions noted farther north there is also room for considerable question. The beds are almost entirely sandstones and shales, and are but sparingly fossiliferous. Between them and the Missouri-Kansas field is the western end of the Ozark series, here an area of open gentle foldings. The Arkansas measures themselves have been rather sharply folded and show some faulting. Under these circumstances, correlation by stratigraphical evidence alone is uncertain, until more detailed work has been done. Lithologically the rocks near Bonanza resemble the Des Moines beds of the northern coal-fields. Their relations to the Lower Carboniferous rock's separating the two areas are apparently such, as to at least not forbid the correlation of the two divisions. Dr. J. C. Branner* has considered the beds as probably Permo-Carboniferous. Dr. Drake has divided the series into two groups, the Poteau and the Cavaniol, both being considered to lie below the Permian. The Cavaniol is believed to be the equivalent of the Missourian formation of Kansas. These correlations are based largely upon the evidence derived from fossils, but a little experience with the Carboniferous-measures of the interior quickly shows that the fossils alone are of rather uncertain value in the correlation of minor divisions over wide areas. It is not difficult to find most of the common Missourian forms well down in the Des Moines beds.


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wherever limestone occurs. There is rarely sufficient difference in the fauna of the separate divisions to make certain the correlation of widely separated beds. Dr. Keyes* considers the whole of the Coal-measures of the Arkansas-Indian Territory field to be the thickened southern extension of the Des Moines series. It is certainly difficult to find in the region anything similar to the Missourian as developed in the north. This absence of all rocks of the Missourian type, despite their usual great persistence, and the difficulties, in view of the present known distribution of the Missourian, in conceiving a distribution which would reconcile this correlation with the known facts, mitigates against the view that any portion of the beds is Missourian. While the matter is still open, it seems not improbable that eventually the Arkansas measures will be found to be southern equivalents, greatly thickened, of the Des Moines productive formation of the Iowa-Missouri-Kansas field. The dynamic action which the beds have suffered, but more especially the differences in the conditions of deposition, evidenced by the greater thickness of the measures, are sufficient to account for the change in the character of the coal.

The Carboniferous area in Texas has been supposed to be a portion of the Arkansas-Indian Territory coal-field. Mr. Robert T. Hill, who is quite familiar with the region, thinks, however, that it is quite distinct. He states that the merchantable coals of the territory do not outcrop south of the great folded east-and-west axis of the Ouachita mountain system, which extends across southern Indian Territory and constitutes a complete barrier between the natural features of the Missourian and Texan regions. South of this system, the Coal-measures occur under entirely different structural conditions, having been submerged during subsequent geological epochs, which submersion seems to have charged them with certain impurities that render them of less commercial value than the coals of similar age from the unsubmerged areas.† The coals of the Texan area are not of such quality as to compete seriously with those immediately north. They come into competition rather with lignites, which occur throughout the region. In 1897, 395,927 short tons of bituminous coal were produced and 211,514 short tons of lignite. The bituminous mines are located in Erath, Montague, Palo Pinto, Parker and Webb counties. The mines are small, and the output is absorbed by the local trade.


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Character of the Western Interior Coal-seams.

As might be expected from the great extent of the field and the wide variation in the original and present condition of the beds found in it, there is a considerable variety in the quality of the coal found. All grades from semi-anthracite to free-burning non-coking coal, including gas-coal, cannel and coking-coals, occur. Representative analyses are given in the table on the following page.

It will be noticed that the coals of Iowa and northern Missouri are relatively low in fixed carbon and high in volatile matter. They would in many cases make excellent gas-coal if it were not for the sulphur which is uniformly high. The percentages of ash and moisture are also high. In appearance, they are usually laminated and show a dull fracture-surface. They are fair steaming-coals, and are acceptable for local manufacturing and domestic use. It is, however, obvious that they can never compete with the better coals to the east and south in outside markets. The simplicity of the mining conditions which allows them to be easily and cheaply mined, has been the main factor in promoting their development.

The Mystic coal is a glance coal, breaking with a clear conchoidal fracture, and showing little lamination. It is brittle and must be carefully handled. It is a favourite for
domestic use, though not quite so good a steaming-coal as the others. Several of the coals of the region give indications of coking, but none could be coked to advantage without preliminary washing to reduce the sulphur and ash. Trade conditions are such, that no coal is coked in Iowa or northern Missouri. A small amount is made in the Pittsburg (Kansas) region for use by zinc-smelters. The Indian Territory coal ranks still higher, having lower sulphur and ash, and being higher in fixed carbon. The analysis of the Mayberry bed quoted is exceptionally high in ash and sulphur, other determinations being: ash 3.15, 2.11 and 9.57, and sulphur 1.21 and 0.87. This analysis is given, as it is the only one at hand of coal from Cavaniol mountain. The fault is probably in the sample. Indian Territory coals are quick firing, clean and easily handled. They are, at most points, good coking-coals, and are, undoubtedly, the most satisfactory steaming-coals for general purpose in the entire field. The cost of mining is a little higher than elsewhere, as royalties average higher than in the states.

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[Table of analyses of Coals from the following mines, omitted]

Collins 6, Craig "Cannel", Dalby, Gibson, American, Forbush, Rich Hill, Johnson County Coal-mining Co., Lexington Coal-mining Co., Osage Coal and Mining Co., Cherokee coal, Grady coal, McAlester coal, Mayberry bed, Huntington, Hackett, Petty (Jenny Lind), Bonanza.

[77]

The absence of any important local demand, and the difficulties and expense incident to mining in a wild and thinly settled area, have hindered the development of the mines. The Arkansas coals are semi-bituminous and semi-authracitic. Their high fixed carbon, low sulphur, ash and moisture, stamp them as coals of great efficiency. In appearance they are clean and glistening, and show little lamination. They are more fragile than is usual with coals of their class. They are practically smokeless, and with care in handling make excellent locomotive coals. They must, however, be burned over a special grate with large air-space and strong draught. The coal must be spread even and thin, and frequently raked. The Kansas City, Pittsburg and Gulf railway burns the Bonanza coal on its southern division, and the Stahl, Missouri coal on the Omaha line. Mr. I. C. Hubble, fuel-agent of the road, states that Bonanza coal has about 50 per cent. greater efficiency than the northern coal. The St. Louis Sampling and Testing-works found, as a result of tests made for the Arkansas Geological Survey, that for Huntington coal, the ratio of heating-surface should be about 5.3 times the square root of the height of the stacks. For Jenny Lind, this ratio should be about 6, and for Coal Hill, 4. With these properties and fairly clean flues, these coals should evaporate 8.5, 8.4 and 7.0 pounds of water per pound of coal respectively. The following table shows the number of pounds of coal in each case equal to one cord of standard oak-wood as determined by the U.S. Quartermaster-Genera. It will be useful for comparison, even though it be recognized that all coals are not equally efficient under the same conditions, and that by varying the type of grate one may often largely increase the efficiency of a poor coal.

Table IV.—Government Tests of Certain Coals in comparison with 1 Cord* of Average Oak-wood.

[Table omitted]
A cord of wood measures 4 feet by 4 feet by 8 feet, and has a volume of 128 cubic feet.

Markets.
Throughout the western interior coal-field, the railways are the chief users of coal. The area is mainly within the great farming and grain-producing region of America, and railway traffic is a relatively important industry. Manufacturing is as yet but little carried on, though certain classes of goods are made in quantity, and other lines of manufacture are bound in time to develop. In the northern portion of the field, the winters are severe and domestic consumption is important. Towards the south, the shorter, less severe winters, the greater amount of timber, and the decrease in the density of the population, all tend to reduce the output of the mines so far as they are dependent upon domestic trade. The chief export trade of the Iowa coal-operators is with the states lying to the north and west, where the coal is the main staple for domestic and locomotive use. It is well adapted to this work, can he produced cheaply, and has geographical advantages which assure it a future in the trade. The Missouri and Kansas mines ship west and south-west into the prairie region, the coal being adapted to the same uses and having the same advantages that Iowa mines enjoy in the north-western trade. It might be thought that, in view of the presence of the Mississippi and its tributaries and the cheapness of water-transportation, this northern portion of the field should be able to reach some of the distinctly lower river-markets. It should be remembered, however, that the states of West Virginia, Pennsylvania, Ohio, Indiana, Illinois and Kentucky enjoy the same advantages, and furthermore, have better coal and frequently lower mining costs. A cheaper class of labour is employed in these eastern states, the operations are usually on a larger scale, and the trade is following lines already established. All these facts make it hopeless to expect any important eastward movement of these coals.
The coals of the Arkansas-Indian Territory field, as already suggested, do not have much of a domestic trade. Portions of the country are well adapted to certain lines of manufacturing, and in time the growth of local industries will considerably increase the demand for coal. At present, however, the mines are even more dependent than elsewhere on the railways. There has been recently some activity in railway-building in the region, and an effort is being made to build up the Gulf ports. The direct exportation of the great grain crops of the prairie states and the importation of foreign goods through, the new but geographically nearer ports on the Gulf rather than the old-established ports of the Atlantic seaboard has long been the dream of the region.

There have been railways built to accommodate this traffic, but sooner or later they have passed into the hands of interests better served by maintaining the status quo, and goods have continued to be shipped via the eastern routes. Recently, the Kansas City, Pittsburg and Gulf railway has been built from the first-named city to Port Arthur by Holland capitalists to occupy this field. The railway has shortened the distance from Kansas City to the sea by 300 miles, and has at the same time brought the coal-fields much nearer to the docks. Previous to the completion of this road the McAlester coal had been 590 miles from the Galveston docks. With the completion of a short connecting road, now ready for the rails, the distance to Port Arthur will be 500 miles. The distance from Poteau, at which point the Bonanza coal is delivered to the Kansas City, Pittsburg and Gulf railway, and at which point the Mayberry coal is mined, is 460 miles. The new road accordingly cuts off more than 100 miles of the distance which coal had previously to travel to reach tide-water. It seems probable
that as a result of these changes the mines of this coal-field will soon be able to enter
the tidewater trade. Alabama coals are now hauled 276 miles to reach Gulf ports,
and Pocahontas coals travel 350 miles to Norfolk. With the completion of the
contemplated coal-docks at Port Arthur, there can be no doubt that these western
coals will become an important factor in the Gulf trade. The western Arkansas coal is
well adapted to marine use, and already it is found that steamers seek this coal.
Analyses of Bonanza and Pocahontas coals are placed side by side below to call
attention to their close similarity. The analysis of the former is the one already given
as made for the Empire Zinc Company, and that of the latter is by Mr. E. V.
d'Invilliers.

<table>
<thead>
<tr>
<th></th>
<th>Bonanza</th>
<th>Pocahontas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>0.50</td>
<td>1.011</td>
</tr>
<tr>
<td>Volatile and combustible matter</td>
<td>18.37</td>
<td>18.812</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>78.02</td>
<td>74.256</td>
</tr>
<tr>
<td>Ash</td>
<td>2.25</td>
<td>5.191</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.83</td>
<td>0.730</td>
</tr>
<tr>
<td>Totals</td>
<td>99.97</td>
<td>100.000</td>
</tr>
</tbody>
</table>

In view of the fact that Pocahontas is the standard marine coal of America, and has
been shown by repeated tests to be the best coal for ocean-going vessels, the
comparison is wondrously significant. The western Arkansas coals are rather more
fragile than is altogether desirable in a bunker coal. Since, however, in order to get
the best results they must be fed fine, this is not so serious a matter. After the stokers
learn to handle the coal, and grates fitted to its use are put in, the

results will be found very good indeed. With so many favourable conditions there is
undoubtedly an excellent opportunity for the development of a coaling trade. Whether
or not a considerable export trade can be developed is more open to question. It will
depend largely upon the means adopted, but it is fair to suppose that, with careful
organization and close attention to costs, the feat can be accomplished, as the
superior character of the coal is bound to influence results in the long run.

[Plate VI. Fig. 1: Map of the Coal-Fields of the United States. Fig. 2: Plan of a Portion
of the Pekay Coal-mine.]

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THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL
ENGINEERS.

GENERAL MEETING,
Held in the Wood Memorial Hall, Newcastle-upon-Tyne,
February 11th, 1899.

Mr. WILLIAM COCHRANE, Past-President, in the Chair.

The Secretary read the minutes of the last General Meeting, and reported the
proceedings of the Council at their meetings on January 28th and that day.

The following gentlemen were elected, having been previously nominated:—

Members—
Mr. William Lawton Goodwin, Director of the School of Mining, Kingston, and Professor of Chemistry, School of Mining, Kingston, Ontario, Canada.
Mr. N. Maurice Griffith, Mining Engineer and Colliery Manager, Broughton and Plas Power Coal Company, Limited, Wrexham.
Mr. James Radcliffe, Consulting and Manufacturing Engineer, 124, Victoria Street, Westminster, London, S.W.
Mr. Edward Charlton Scott, Mining Engineer, 20, Henrietta Street, Swansea.
Mr. Henry Livingstone Sulman, Metallurgical Chemist, 60, Gracechurch Street, London, E.C.
Mr. Francis Symons, Mining Engineer, Ulverston, Lancashire.
Mr. Richard Thomas, Colliery Manager, Brown's Duckenfield Collieries, Minmi, Newcastle, New South Wales.

Associate Member—
Mr. John Thomas Luxton Searle, 58, St. George's Avenue, Tufnell Park, London, N.

Associates----
Mr. James Howe, Jun., Deputy, East Cross Street, Langley Park, Durham.
Mr. Thomas Morland, Back-overman, 24, Langley Street, Langley Park, Durham.

Prof. P. Phillips Bedson read the following "Results of the Analysis of Samples of New Zealand Coal and Ambrite, and of Barbados Manjak": —

[82]

RESULTS OF THE ANALYSIS OF SAMPLES OF NEW ZEALAND COAL AND AMBRITE, AND OF BARBADOS MANJAK.

By P. PHILLIPS BEDSON.

New Zealand Coal and Ambrite.
The samples were supplied by Mr. E. S. Wight, Kiripaka, New Zealand. The analyses have been made by Mr. B. Dodds, A.Sc., a student of the Durham College of Science; in the estimation of the carbon and hydrogen the method employed is that proposed by Messrs. F. Haber and S. Grinberg.*

Coal.—The proximate analysis of the coal gave : —

<table>
<thead>
<tr>
<th></th>
<th>Per Cent.</th>
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<tbody>
<tr>
<td>Moisture</td>
<td>4.66</td>
</tr>
<tr>
<td>Ash</td>
<td>1.10†</td>
</tr>
<tr>
<td>Volatile hydrocarbons</td>
<td>47.80</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>46.44</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.54</td>
</tr>
</tbody>
</table>

The coal gives a non-coherent sandy coke.
† The ash is light in colour, and consists chiefly of alumina and silica.

The results of the estimation of the carbon and hydrogen expressed in terms of the dried and ash-free coal are :—

<table>
<thead>
<tr>
<th></th>
<th>Per Cent.</th>
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</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>74.32</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>5.67</td>
</tr>
<tr>
<td>Oxygen and nitrogen</td>
<td>20.01</td>
</tr>
</tbody>
</table>
These numbers, and the proportion between the oxygen and hydrogen, show this coal to be most nearly related to the "dry coals burning with long flame" of Prof. Gruner's classification.

Ambrite.—The analysis of this brown transparent resin, found in association with the coal, showed it to contain 0.59 per cent. of moisture and 0.18 per cent. of ash, and the estimation of the carbon and hydrogen gave results, which, when expressed as above, are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>80.95</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>9.87</td>
</tr>
<tr>
<td>Oxygen</td>
<td>9.18</td>
</tr>
</tbody>
</table>

This substance resembles very nearly in composition a resinous body met with in association with coal, and described by Dr. Stanek as reussinite.* In Dr. Thorpe's Dictionary of Applied Chemistry "ambrite" is described as:—

Brittle, semi-transparent, and of yellowish-grey colour. Its specific gravity is 1.034, and its hardness, 2. It is insoluble in most solvents, but dissolves partly in carbon bisulphide. It is said to have the composition C₁₆H₂₆O₂.†

Barbados Manjak.
The occurrence and mining of this material in Barbados has been dealt with by Mr. Walter Merivale in a paper recently read before this Institute.‡ Mr. R. L. Treble, A.Sc, a student of the Durham College of Science, has analysed the samples. His results are contained in the following tables. The proximate analysis gave:

<table>
<thead>
<tr>
<th></th>
<th>Per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash</td>
<td>1.58</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>36.52</td>
</tr>
<tr>
<td>Volatile matter</td>
<td>61.90</td>
</tr>
</tbody>
</table>

It leaves a coke which is much larger in volume than the manjak.

Stating the results (as before) in terms of ash-free manjak, we have the following ultimate analysis, representing the proportion of carbon, hydrogen and oxygen:

<table>
<thead>
<tr>
<th></th>
<th>Per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>81.18</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>8.43</td>
</tr>
<tr>
<td>Oxygen</td>
<td>10.39</td>
</tr>
</tbody>
</table>

Prof. Dunstan, of the Imperial Institute, some time ago sent the writer a specimen of manjak, the proximate analysis of which shows it to be very similar to that described by Mr. Walter Merivale in the paper already referred to. Manjak in appearance closely resembles albertite, analyses of two different specimens of which are given in Dr. Percy's Metallurgy.§ Albertite appears to contain a larger proportion of carbon and of hydrogen than manjak. Despite this close resemblance in appearance, the writer has found these materials to differ markedly in their behaviour with regard to the solvent pyridine. Pyridine is a nitrogenous base obtained from coal-tar. It is a colourless liquid, of characteristic odour, and boiling at 115° Cent. It is possessed of remarkable solvent properties, and in it manjak is completely soluble, forming a dark-brown or blackish-brown solution. Albertite, from Sutherland, is not completely dissolved by
pyridine, but only to a slight extent, and gives a yellowish solution with a slight green fluorescence. New Brunswick albertite is partially dissolved by pyridine, forming a solution like that of manjak.

In this connexion the writer may be allowed to mention some experiments on the solvent properties of pyridine. As is wellknown, many solvents, such as ether, benzene, chloroform, light petroleum-oils and phenol, dissolve some constituents out of coals. From some investigations of pyridine which were being carried out in the laboratory, the writer's attention was directed to the solvent powers of this substance, and he determined to try the action of this material on coal. Mr. F. Hooper, of the Wear Fuel-works at Sunderland, kindly placed a considerable quantity of the rectified material at his disposal, and by experiments on brown coal, a Durham coal, a specimen of anthracite and also the New Zealand coal the writer has found that pyridine dissolves out a greater proportion from some of these coals than any solvent hitherto used.

Experiments with anthracite show that neither cold nor hot pyridine dissolves any portion of the coal, while from a sample of Durham coal from 16 to 18 per cent. of the coal was dissolved by a pyridine boiling at 117 to 125° Cent., and in the case of the New Zealand coal the pyridine extracted from 10 to 13 per cent.

For some years, the investigation of the proximate constituents of coal has engaged the writer's attention, and he has sought in many ways to approach the solution of a problem as interesting as it is illusory; but he is hopeful, by the application of this solvent pyridine, that he will be able to secure some information as to the nature of some of the compounds which enter into the composition of coal.

Prof. Bedson, after reading his paper, exhibited and described the Haber-Grinberg apparatus used for the purpose of the analyses.

Mr. E. S. Wight (Kiripaka, New Zealand) said that coal-gum or ambrite occurs in all the coal-seams of the North Island of New Zealand in an elongated nodular form, the longest diameter varying from 1/2 inch to 9 inches. It is also found in the strata immediately over and under the seams. It is of a yellowish-brown colour, sometimes very clear, varying much in quality. It is of no commercial value, being sent away with the coal, which it helps considerably in burning, being ready to ignite; and by using a little in kindling, a fire is quickly made. It is capable of taking a high polish, and ornaments could be made from it. It evidently originated from the vegetation which had formed the coal-seams, being similar to the gum of the kauri-tree, allowing for the pressure and other agencies which it had undergone. The coal-gum was found of the best quality, and of the greatest thickness, and as a most regular stratum in the semi-bituminous coal-seam worked at the Kiripaka mine, in the Ngunguro district of the North Island. This coal-seam varies in thickness from 3 1/2 to 8 feet.

The Chairman (Mr. W. Cochrane) said that the illustration of the simplicity with which important chemical analyses of coal could be made would be valuable to the members, and they were indebted to Dr. Bedson for giving them an opportunity of
seeing so concentrated an appliance. He asked whether ambrite was found anywhere else than in New Zealand. Was reussinite, mentioned by Prof. Bedson, found in New Zealand, and was it also found in Germany? The character of ambrite seemed to be similar, if not actually the same as that of kauri-gum found at the base of ancient forest-trees in New Zealand, and largely used for the manufacture of the finest varnishes. Did Prof. Bedson think that ambrite was of the same origin, and thus account for its being found under similar conditions?

Prof. H. Louis said that, as the Chairman had pointed out, ambrite had distinct analogies with kauri-gum, but the latter was practically a fossil substance. In the Malay peninsula, the natives found a resinous substance known as dammar, which occurred in pieces, sometimes as large as one's fist and sometimes as large as a man's head, close to the surface, in the midst of decaying vegetation, and it seemed to him that they were thus brought a step nearer to the origin of ambrite: (1) there was a fossil ambrite, lying in the midst of coal, in the roof or floor of the seams; then (2) the more recent kauri-gum, and lastly, (3) the dammar in the freshly decayed vegetation, and this seemed to complete the chain of evidence showing how these bodies had been produced. He suggested for Prof. Bedson's consideration the interest of analyses of these different substances. In the Malay peninsula, the climate closely resembled that generally supposed to have existed in Carboniferous times, and also was very similar to that of New Zealand, where ambrite and kauri-gum were found.

Mr. A. L. Steavenson asked whether ambrite was found in sufficient quantity to have a commercial value.

Prof. Bedson said that reussinite was one of the resinous bodies found in the lignite near Aussig. In the earlier examinations of lignites in Devonshire, resinous bodies were found, and an analysis was given. Resinous bodies were occasionally found in the coal-seams of Northumberland, and a few years ago he had picked up pieces on the screens at one of the Cramlington collieries. He had also had a few samples of coal brought to him, from time to time, containing resinous substances. He would not venture to compare kauri-gum with ambrite but no doubt Prof. Louis' suggestion as to its formation was a true one. The reason for which he had preferred not to speak of manjak as coal was that he called to mind a case of litigation as to whether shale was coal or not, and he did not want to commit himself to saying that manjak was coal.

Mr. George J. Binns (Duffield) wrote that the sample of New Zealand coal appeared to be of very inferior quality, except in respect of its low percentage of ash, and resembled somewhat the analysis of a coal from Hikurangi mentioned in a paper by himself. As regards ambrite, he might refer to the same paper,† where it was mentioned on the authority of Sir Jas. Hector as a characteristic of the "brown coal" of New Zealand, that it "contains resin in large masses," and of the "pitch coal" that it "contains resin disseminated throughout its mass." The same authority is quoted as stating that the Mataura lignite contains "abundance of ambrite (derived from a coniferous tree closely allied to the kauri of the North Island, but which has long since disappeared from the South Island)."‡ Some details are also furnished of this fossil gum, and two analyses are given containing less carbon than that made by Mr. R. Dodds. §

Ambrite occurs not only in the North Island of New Zealand, but, as stated in his paper, very commonly in the South Island in minute specks, as well as in the masses described. He had some beautiful, though minute, stalactitic specimens from the pitch-coals of Reefton.
Prof. Louis had apparently been misinformed as to the climate of New Zealand. To quote the remarks of Sir Jas. Hector, who is in charge of the Meteorological Department:—

† Ibid, page 33.
‡ Ibid., page 32.
§ Ibid., page 77
‖ Handbook of New Zealand, 1886, page 60.

The climate resembles that of Great Britain, but is more equable. The extremes of daily temperature only varying throughout the year by an average of

20°, whilst London is 7° colder than the North Island and 4° colder than the South Island of New Zealand. The mean annual temperature of the North Island is 57° and of the South Island 52°, that of London and New York being 51°.

As the Malay Peninsula lies between the isotherms of 80° and 70° in January and 80° and 90° in July, there cannot be any close similarity; in fact, a glance at the map would show an obvious discrepancy.
Ambrite undoubtedly occurs in sufficient quantities to be commercially valuable, and some years ago he communicated on the subject with the Colonial Treasurer of New Zealand, who was then in England, at the request of a large firm of varnish manufacturers, but no result was arrived at.
As the kauri-pine is named Dammara Australia, and as dammar appears to be a generic name for many kinds of fossil and sub-fossil gums, there appears to be some connection between the two words, but he was unaware of the exact relation.

The Chairman (Mr. W. Cochrane) proposed a cordial vote of thanks to Prof. Bedson for his paper and experiments. His investigations were original, and the Institute was honoured in having the record printed in its Transactions.

The following report of the Institute's delegate at the "Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, Bristol, 1898," was taken as read:

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CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, BRISTOL, 1898.

The report of the proceedings of the Corresponding Societies Committee of the British Association for the Advancement of Science was read, and also that of Mr. T. Forster Brown, the delegate representing the Institute, as follows:

Guild Hall Chambers, Cardiff,
December 13th, 1898.

To the President and Council of The North of England Institute of Mining and Mechanical Engineers.
Gentlemen,
The British Association for the Advancement of Science meeting at Bristol extended from September 7th to September 14th, 1898.

Sir John Wolfe-Barry, in his presidential address before Section G, read an interesting paper on the Bristol and other docks, and pointed out the very large increase in the size and number of ships, due to improvements in the science of shipbuilding, necessitating larger docks, and consequently longer quays and larger warehouses. These improvements and increases, he said, have come upon us very suddenly, and were largely due to the cheapness of steam navigation and various economic causes, and within the last decade a sum of about £35,000,000 had been expended on the docks and harbours of this country. In his opinion, docks were more or less "stations" and links in the chain of transport between sea and land. He inferred that the old idea that a dock should not be held by a railway company was to some extent exploded, and pointed out the great and recent improvements at the Southampton and Hull docks which are now held by the powerful railway companies serving them, but suggested that in the amalgamation of docks and railways proper safeguards should be provided against monopoly, and protection should be given to other railways serving the docks. He also touched upon the fact that Bristol was the birthplace of the Great Western Railway, and that their famous engineer, Mr. Isambard Brunel, designed the Clifton suspension-bridge with a span of 702 feet, and it was here that the Great Western steamship of 2,300 tons was launched and ran regular voyages for 20 years across the Atlantic Ocean. Sir John also referred to Dr. Lardner's assertion at Bristol in 1836, before a meeting of the British Association, that it was impossible to construct a ship of this dimension to successfully trade between Bristol and New York, on the basis that the resistance to the progress of the ship varied according to its capacity, and that no ship, however large she might be, could carry sufficient fuel. He also referred to certain statements made by scientific men who did not base their calculations on sound principles, as, for instance, the doubt cast upon the stability of the Forth bridge on account of the wind-pressure, and on this account, and owing to the failure of the Tay bridge, the Board of Trade required provision against a wind-pressure of at least 56 pounds to the square foot, whereas the actual pressure on the Tower bridge is from 6 to 9 pounds per square foot only. This excessive precaution is directly due to the untrustworthiness of experiments made on small surfaces. The writer, while not wishing to decry statements made by scientific men or of reviving ancient controversies, thinks that it is desirable that the true facts in relation to physical conditions should be ascertained before generalizations are made, and the importance of having a public physical laboratory was dilated upon, and he was strongly in favour of a Government institution of this kind.

An interesting paper, from an antiquarian point of view, was read on the "Newcomen Engine" at Long Ashton, by Mr. W. H. Pearson. This engine appears to have been erected so far back as 1750, and is still doing practical work. The original cost was £70. The piston is packed with rope, and has a covering of water on the top to make it steam-tight. The engine is of course worked by the vacuum formed through the injection of water into the cylinder. In the discussion which followed, Dr. Ryan calculated that it would use at least 400 pounds of steam per horsepower per hour, so that the consumption of coal for the work done must be enormous.

Mr. A. Siemens read a paper on the subject of "Electric Power in Workshops." The author stated that in 1879 Dr. Werner Siemens first introduced electric engines in
Berlin. In his (the author's) opinion, electric motors will supersede horse and steam-power tramways. In electric traction 84 to 90 per cent. of useful effect was obtained, and installations were now in use employing currents of 10,000 volts, whereas a short time ago 2,000 volts was considered to be the limit. The author described the great saving in using electricity in the works of Messrs. Siemens Brothers & Company. The total cost in 1897 was 2d. per Board of Trade electrical unit and l.71d. per brake-horsepower per hour exerted by the motors.

Mr. A. H. Gibbins read a paper on "The Application of the Electric Motor to small Industrial Purposes, and its Effects on Trade and on the Community generally," in which he pointed out the difficulty under which Great Britain especially laboured in respect to the objection to innovations which characterized the industrial world. Then there was the difficulty of first cost, which small tradesmen could not afford. The author suggested that private companies or public corporations should be instituted for the purpose of letting out small motors on hire. This system is being recognized in France, Germany, Switzerland and the United States.

A paper was read on "Electric Power and its Application on the Three-phase System to the Bristol Waggon and Carriage Works" by Mr. W. Geipel, who showed the considerable loss entailed by the use of small, scattered steam-engines. The author suggested the erection of three-phase electrical installations in preference to the direct-current system, as by the former system the motors can be left for a long time without supervision, and there is less possibility of breakdown. The discussion which followed turned chiefly on the question of continuous as against alternating currents.

Prof. Sylvanus P. Thompson read a contribution on the subject of "The Economic and Social Effects of Electric Traction," which was devoted chiefly to observations made in 1897 at Toronto, of the change made in 1893, from a very complete system of horse-tramways to a still more complete electric service. The author further stated that in Boston, U.S.A., there were 400 miles of electric tramway which would have necessitated 29,000 horses, and the gain in cleanliness was immense,

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The writer (Mr. T. Forster Brown) read a paper on "The Mechanical and Economic Problems of the Coal Question." This paper had reference to the exhaustion of the more valuable and thicker seams of coal in the United Kingdom. He pointed out that at the rate of 220,000,000 tons per annum, there would in 50 years be exhausted about eleven-fifteenths of our best coal-seams. There would however, still be thinner and inferior seams of coal left, which at an output of, say 250,000,000 tons per annum would last about 250 years. This large residuum of thin and inferior seams would, on account of the greater depths at which they would be wrought, undoubtedly cost considerably more to work than the thick and superior seams at present in operation, notwithstanding all the skill which the mining and mechanical engineer can bring to bear upon the question. The result would be that the price of coal sold would be so increased as to raise the cost of seagoing transport, with the result that the price of our exports would naturally be higher as well as the price of the raw imports, and thereby hamper our commercial progress and prosperity, to the benefit of other nations.

The author then proceeded to show what might be saved in the cost of production by improvements in mechanical and mining appliances, etc., and to show how the higher cost above-mentioned would be to our disadvantage. With regard to Germany, although no doubt the cost of working the seams would increase in the same manner perhaps as that of our own, still this might in a certain sense be neutralized by the cheaper transit over railway and canal owing to their being in the hands of the
Government. In respect to the United States, where the coal-fields are possibly twenty times the size of the British, the cost of production is now less than it is in this country. The output in that country has increased by leaps and bounds, which the following figures will show:—In 1883, it was 102,868,000 tons, in 1890 it was 140,883,000 tons, and in 1896 it was 171,416,000 tons.

In America, the railway-waggons are better adapted to coal-transport and carry less dead-weight, and consequently more profit-weight in proportion, at a cheaper rate per mile. The cost of transit on American coal is about a quarter of that charged in England. No doubt some improvement could be made in this direction by enlarging the size of the waggons.

The writer also adverted to the probable competition in the Eastern markets likely to arise through the opening-out of the vast coal-fields of China, and more especially Formosa, which is under Japanese rule, neither of which have so far been exploited to any extent.

In summarizing the several points, the writer said that no doubt the increased cost of the thinner seams might be somewhat neutralized by improvements in coal-cutting machinery, and in winding-, hauling- and pumping-engines; by checking the increase of temperature due to depth, by raising larger quantities from each shaft and by a partial readjustment of the cost of labour and royalties, the last-named even now being dealt with to a certain extent, when the conditions required it. He also reiterated his views expressed before the British Association in 1891, that the nation should acquire the railways and docks so that in case of urgency the cost of transit might be reduced to the bare working expenses. He further stated that all capital expended in drainage, water, lighting, schools, parks, etc., should be repaid within the next 60 or 65 years to admit of a permanent reduction in rates and taxes. Assuming that this country was in the same position as, say, the Continental states in regard to the railways belonging to the Government, and that the capital on the above-mentioned public works had all been repaid, then the State could reduce the cost of carrying passengers, goods and minerals by nearly 50 per cent. In addition, the rates and taxes would be greatly reduced and the cost of living would be consequently much less. The author said that the present scheme of paying off the National Debt was no doubt a good one, but he thought that there would be ample opportunities of doing this after the above economies had been effected, which were, in his opinion, imperative.

Looking at the reverse side and assuming that the nation did nothing to guard against the contingencies he had mentioned, they would have the prospect of commercial collapse which would take place upon the exhaustion of the cheaply worked coal-seams, and they would be saddled with the burden of railways, docks, and public works, the capital of which he estimated at the sum of £1,500,000,000, with no opportunity of paying it off. The cost of manufactures would increase, with consequently a curtailment of foreign markets, resulting in a large proportion of the industrial population being thrown out of work, our income and the means of supporting our army and navy would rapidly decrease, and Great Britain would ultimately sink to the position of a secondary power.

Existing and immediately succeeding generations would therefore do well to adopt some well-matured plan for dealing with the question, and the future difficulties indicated, with the great object in view of extending the duration of the prosperity of the nation far into futurity.

Prof. O. C. Marsh, of Yale University, read a paper on "The Comparative Value of Different Kinds of Fossils in Determining Geological Age." The author said that the value of all fossils as evidence of geological age depended upon their degree of
specialization. Recent forms of the same or allied genera have no distinctive characters sufficiently important to mark geological horizons, but in some cases it is totally different. From the earliest appearance of certain families the members have been constantly changing, and are thus especially fitted to assist the geologist, as each has distinctive features and an abiding-place of its own in geological time. All fossils are valuable in geology, but the comparative value of different forms needs further and fuller investigation.

The Rev. J. F. Blake read a paper on "Aggregate Deposits and their Relation to Zones." The peculiarities of certain bands he considered as evidence that the deposit was a tumultuous one, in which the material was drifted rapidly by strong currents in a horizontal direction. They were in fact the sweepings of the bottom of the sea, from the places where the fossils originally lay. For this reason the fossils belong to various dates, the actual deposit itself being necessarily at least as young as the latest fossil it contained. Such deposits may thus be distinguished as "aggregates."

Mr. R. Etheridge read a paper on "The Relation and Extension of the Franco-Belgian Coal-field to that of Kent and Somerset." The author pointed out that the coal-fields of France and Belgium occupied an extended and sinuous east-and-west line ranging through about 150 miles. In his opinion, there was little doubt that the Belgian coal-fields extended westwards to Valenciennes, Conde and Bethune, and to Calais, thence under the Straits of Dover to the recently--discovered coal-fields of South-eastern Kent. The author also referred to the Present borings at Pluckley, West Brabourne, and Penshurst, the latter being 25 miles west of Dover and 1,700 feet deep. The Brabourne trial had passed through 1,875 feet of sedimentary rocks, but the bore-hole had reached a red conglomerate of probably Old Red Sandstone age, nevertheless the boring would probably be continued. The Dover bore-hole was 2,225 feet deep, and had proved eight seams of coal, the lowest seam being 4 feet thick. This, the author pointed out, was thicker than any known seam in the Belgian coal-field.

In the course of the paper Mr. Etheridge pointed out the common characteristics of the respective coal-fields. The Bristol coal-field, he said, was 26 miles in extent from north to south, and was divided into two sections at Kingswood. The thickness of the coal-measures at Radstock was no less than 8,000 feet ; the Welsh were 11,000 feet, and on the Continent they varied from 7,000 to 8,000 feet in thickness.

Mr. L. J. Spencer, in a paper on "Leadhillite, in Ancient Lead-slags from the Mendip Hills," said that lead-ores had been worked in Eastern Somerset ever since the time of the Romans, but that during the present century operations had been chiefly confined to the reworking of the old waste-heaps of slags and slimes. From these heaps upwards of 9,000 tons of lead were extracted during the 10 years ending with 1880.

Yours faithfully,
T. Forster Brown.

The Chairman (Mr. W. Cochrane) proposed a vote of thanks to Mr. T. Forster Brown for his interesting report.
Mr. M. Walton Brown seconded the vote of thanks, which was cordially approved.

DISCUSSION OF MR. S. J. BECHER'S PAPER ON "THE NULLAGINE DISTRICT, PILBARRA GOLD - FIELD, WESTERN AUSTRALIA."
Mr. Frank Owen (El Peru, Venezuela) wrote that additional interest was given to Mr. Becher's excellent paper on the Nullagine district by the fact that his official connexion with the Western Australian Department of Mines had afforded him opportunities for observation not available to many. He (Mr. Owen) had not been quite so far inland as the Nullagine district, but in 1895-96 he was in and around Marble Bar, which is some 50 or 60 miles distant, where the economic (or rather, uneconomic) conditions of mining were very similar. After the heat, what impressed him more than anything on the Pilbara gold-field was the inefficiency of the miners available, due, no doubt, to the fact that really competent workmen could obtain much the same wages (£4 per week) on the southern gold-fields, where the climate was not nearly so severe and food was both cheaper and better. Of course if the developments of the mines warranted it, a railway would, to a great extent, do away with these disadvantages. When he (Mr. Owen) was in the colony, the chief obstacle to the construction of the railway was the determined opposition to the more direct route from Port Headland to Marble Bar (see map accompanying Mr. Becher's paper)* by the inhabitants of Roebourne and Cossack, who feared the diversion of trade which this would involve. From bitter personal experience, he (Mr. Owen) could fully substantiate Mr. Cadell's pointed and candid remarks on the drawbacks to successful mining in the Pilbara district. Hitherto, with respect to the unfortunate shareholders in mining-enterprises in that district, the old saying, "Sic vos non vobis nidificatis, aves," had applied, and the local publicans and storekeepers have been the principal gainers. A genuine north-western "willy-willy," as described by Mr. Cadell, was an experience which one must go through to fully appreciate, and with large sheets of galvanized iron skimming along, end on, in all directions, no one need complain of feeling dull! He ventured to suggest that the value of Mr. Becher's paper would be enhanced by some description of the recent finds of diamonds in the Nullagine district, of which sensational accounts had been appearing in some of the mining papers.


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* Vol. xvi., Plate III., page 52.

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THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
Held in the Wood Memorial Hall, Newcastle-upon-Tyne,
April 8th, 1899.

Mr. Wm. ARMSTRONG, President, in the Chair.

The Secretary read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on March 25th and that day, and of the Council of The Institution of Mining Engineers.

The following gentlemen were elected, having been previously nominated:—

Members—
Mr. Henry Clark, Engineer, Cowper House, Norton, Stockton-upon-Tees.
Mr. John Coulthard, Certificated Colliery Manager, Brunnerton, Greymouth, New Zealand.
Mr. Hugh Llewellyn Gill, Mechanical Engineer, c/o Messrs. Bennie, Teare & Co., Woodward Street, Coolgardie, Western Australia.
Mr. Henry Wallace Gregory Halbaum, Certificated Colliery Manager and Journalist, 12, Kelvin Grove, Gateshead-upon-Tyne.
Mr. Paul Mellors, Copper-mine Manager, Locksley House, Sherwood Rise, Nottingham.
Mr. George Bentley Poore, Mechanical Engineer, P.O. Box 149, Johannesburg, Transvaal, South Africa.
Mr. John Southern, Colliery Manager, Heworth Colliery, Felling, Co. Durham.
Mr. Frederick T. Snyder, Metallurgical Engineer, c/o The William Hamilton Manufacturing Company, Peterborough, Ontario, Canada.

Associate Member—
Mr. Arthur Kidson, Argyle House, Sunderland.

Associate—
Mr. John Thomas Melville, Surveyor, Coxlodge Colliery, near Newcastle-upon-Tyne.

Mr. John Rogers, Mining Apprentice, Cornsay Colliery, Durham.

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AWARDS FOR PAPERS.

The Secretary read the following list of papers communicated during the year 1897-98, for which prizes of books had been awarded by the Council to the authors:—

"Pyritic Smelting." By Mr. W. Lawrence Austin.
"Experiments with the Shaw Gas-tester." By Messrs. P. P. Bedson and J. Cooper.
"Notes on Rearer Workings." By Mr. John Cadman.
"Occurrences and Mining of Manjak in Barbados, West Indies." By Mr. Walter Merivale.
"The Siliceous Iron-ores of Northern Norway." By Mr. H. T. Newbiggin.
"Hydrothermal Gold-deposits at Peak Hill, Western Australia." By Mr. Frank Reed.

DISCUSSION ON MESSRS. J. L. HEDLEY AND W. LECK'S PAPER ON "TIMBERING IN THE IRON-ORE MINES OF CUMBERLAND AND FURNESS."

Mr. T. E. Forster (Newcastle-upon-Tyne) remarked that, in the discussion which followed the reading of the paper, exception was taken to the Cumberland practice of timbering, some of the speakers thinking it a bad system to put a round balk on a fork-prop. It might be wrong in theory, but from what he had seen of the iron ore-mines in Cumberland props were very rarely split. Although the system of square timbering had not been followed up in the Cumberland district, he thought it would be interesting to have a description of that method. He would like to know to what extent the ore was taken out of the vein-like deposits, which were described in the paper, and the space between, standing on chocks or setts. Did they find the hanging-cheek come in at any time? It appeared to him that it would only go so far, and then there would be a crush.
The President said that each district adopted the system which suited it best, and he thought that any application of timbering in one district would not entirely suit another. Mr. G. B. Forster (Newcastle-upon-Tyne) said that in Cumberland the props were generally set with the thin end downwards, and it was found that putting a balk on the top did not split the thick end so much as the thin end.


Mr. J. L. Hedley, replying to the discussion, said that the American system of square timbering was tried at the Hodbarrow mine, but had been discarded because it was not profitable. In this system, the timbering was begun from the bottom of the deposit. In many of the mines in the Furness district, it was necessary to work from the top downwards, and therefore the American system could not be used to advantage. The system had, however, been recommenced on a smaller scale, and with additional experience gained by previous trials, the results would be specially interesting. The question of timbering was one which required very much consideration, and it was necessary to adopt many and various systems. It would be readily understood that it was necessary to adopt a system of timbering in the Furness deposits different from that in use in Cumberland, where they had deposits of a different character. There were scarcely two mines in his district in which a similar method of timbering was used.

Mr. W. Leck remarked that the timbering of vein-like deposits was among the most difficult of the mining problems with which they were called upon to deal, and no doubt it sometimes did happen that falls took place from the hanging side. The sides of the veins were very irregular, and occasionally they came close together and then widened out again. Where the vein became very narrow, the timbering was sometimes filled in with "deads," and thus there was practically a solid mass between the two sides. A few years ago, they had a very striking example in connexion with these veins, when there was a sudden collapse of surface, and a locomotive engine disappeared, which had not been recovered. The veins varied in thickness from 2 or 3 feet at one point to 30 or 40 feet at another.

Few persons had better opportunities of going through these mines than himself, and he found that whether their method of connecting the fork-prop and cap was right or wrong in theory, as a matter of practice, which, after all, was but the result of experience, the actual effect was satisfactory, and few fork-props were split. This particular system was universally adopted in the Furness and West Cumberland mines, including Hodbarrow, to which mine many of the miners had migrated from Cornwall.

DISCUSSION ON MR. W. T. GOOLDEN'S PAPER ON "COAL-CUTTING BY MACHINERY."

Mr. A. L. Steavenson (Durham) said that one point which struck him on reading the previous discussion on this paper was the very great divergence of opinion on the part of electrical engineers and mining engineers with reference to electrical coal-cutters. One recommended 300 volts, another 350, and a third 500, and so on, and those who were not electricians were rather confused. They were told by Mr. Goolden that he had received a shock of 600 volts without injury—that might be so; but he had read of a case in Scotland where a man was lifting a tub on the rail, and when his bare head touched the conductor—carrying 200 volts—he fell dead. He had been using currents of 300 to 350 volts for many years. Another thing to be
considered, not only in regard to destroying a man's life, which was sufficiently serious, was that if the men received shocks they might refuse to work with electricity, and the plant would be thrown on one's hands.

Another point on which there was considerable difference of opinion was with regard to the multiphase system. One electrician would recommend the multiphase system for certain purposes, and another would say that they must not adopt it on any account. In such cases, he thought that each should ascertain for himself as far as he could what was the best system.

Mining engineers also differed in regard to the use of the cutters:— One said that they were only useful in thin seams; another said that they were useless in seams above 3 feet; and somebody else averred that they could be worked with advantage in seams 4 or 5 feet thick. No doubt if they were to save money at all by coal-cutting, it would prove more effective in thin than in thick seams. The percentage of undercut was twice as great in a 2 feet seam as in one of 4 feet, and therefore if machines would not pay in a 2 feet seam, they were not likely to do so in thicker seams.

There was a considerable difference in the manner in which costs were compared. He thought that there was only one fair way of doing this, and that was to take a case where both systems had been adopted and to take a fortnight's pay-bill, at different times, say in 1896, when the entire cost was for hand-labour, and another pay-bill, say for 1899, when practically all the work was done by coal-cutting machines.


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Electricians complained that slow progress was being made in regard to the introduction of coal-cutting machines; and the United States of America were quoted in comparison; but it was pointed out by other speakers that if the total coal produced in America was compared with the quantity produced by machines, the latter amounted to only 7 per cent. He thought that, after all, they were not very far behind the Americans or their friends on the Continent.

The efficiency of electric plants was so much a matter of opinion, that he might state his own experience in Cleveland with electricity, as compared with compressed air. For 20 years, compressed air had been used in mines about 2 miles from one end to the other, with numerous machines, so that it was impossible to make a direct test, and say that they would start at a given hour and indicate every engine. He had managed to obtain a result by taking diagrams over several hours with each system of engines at bank, and these showed that with compressed air 111 horsepower was required for 8 drills. With electricity, about 17 horsepower was required for the same work. The great loss with compressed air arose from the leakages of some 8 or 9 miles of pipes, whether the drills were cutting or not.

There were certain conditions where he thought every mining engineer was agreed that they would not adopt electricity; and some would say that they would not take electricity where candles could not be used. To meet this difficulty, he would suggest: Supposing the coal-cutters were 5,000 feet in-bye; at say 4,000 or 4,500 feet, they might place an air-compressor and work it by an electromotor. They would thus get the advantage of the saving between the shaft-top and the 4,500 feet, and the safer conditions of using compressed air at the face.

In using electric machinery, it was essential that a responsible person should be appointed to attend to it, else the manager or under-manager would find it troublesome, and in time it would be relegated to the scrap-heap.

Mr. J. L. Hedley said that if danger arose from touching an exposed cable, it was questionable whether electric wires should be used down the pit. There was also the liability to sparking, and the question arose whether these sources of danger could be removed.
Mr. C. C. Leach (Seghill) said that, even when a cable became damaged, there was no more danger than from a damaged steam pipe, and both would be at once repaired. He had taken hold of cables, without danger, carrying a current of 460 volts. He did not agree with

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Mr. Steavenson with regard to the difficulty of ascertaining the useful effect. If they took the indicated horsepower of the engine and compared it with the useful work, the useful effect of the electric-plant at Seghill colliery was 32 per cent.

Mr. T. E. Forster asked what voltage an average man could take without danger.

Mr. H. W. Appleby (Bradford) thought that mining engineers were themselves to blame for the different voltages adopted by the various makers, who, in the present competition in the electrical trade, adapted their goods to the people whom they supplied. He had generally found, with coal-cutting machines, that there was a saving of 10d. per ton in working a 2 feet seam as compared with hand-holing. A similar result was obtained at Lidgett colliery, near Barnsley, where a large number of machines were at work. He was of opinion that all cables should be properly insulated and covered. He thought that the difficulty of broken cables could be overcome by laying the cables on the ground in preference to attaching them to the roof. The dangers arising from a broken cable were much greater in a fiery mine than the sparking from the commutator—the latter danger was very much exaggerated, as most motors used in mines were enclosed and gas-tight.

The working of a 3 or even 2 phase-system did away with the commutator, but it necessitated more cables and thus increased the danger to a greater extent than it lessened it by doing away with the commutator.

With reference to the danger from high pressure, he had received a shock of 500 volts without injury, but this could not be done by any man in a weak state, or whose hands were moist, and, under such conditions, 250 volts might prove dangerous.

Mr. T. H. Barr stated in his paper that the amount of power required depended upon the class of holing and the depth of the cut, and might vary normally from 12 to 20 horse-power.* He thought that 50 or 60 horsepower would be more nearly correct. Of course it must be understood that this over-load was only for short periods. He did not intend to state that 50 horsepower was the constant load of the machine, but that they had to work up to that power very frequently for a few minutes at a time. Motors designed for 23 horsepower were nearly always run at more than double, but the load never came down so low as was estimated by Mr. Barr. He had tried a 14 horsepower motor, but it was always burning out and breaking down, and it was replaced by a larger one of 23 horsepower designed to run at double load if necessary. This worked excellently, and seldom gave any trouble. With reference to the Hurd coal-cutter, he would like to ask Mr. Goolden, who made a machine of the same type, whether it did not happen, when it came to a hard place in the coal, that it cut up above it or ran below, choosing the easiest part.

Mr. W. T. Goolden, referring to Mr. A. L. Steavenson’s interesting remarks, wrote that it was much the same with electricity as with steam. The particular voltage or particular steam-pressure at which an engineer would prefer to work must depend on the special circumstances of the case, and no hard-and-fast rule could be adopted to meet every condition. Economy in space, and in some degree in first cost and working expense, tended to high pressures both in electricity and in steam.


[101]
Considerations of convenience and of safety might tend the other way, and generally some compromise was arrived at. As regards the thickness of seam in which it was most profitable to work a coal-cutter, here again no hard-and-fast rule could apply. It was naturally more difficult to work in a very thin seam either by machine or by hand than in a place where there was plenty of room. The yardage would in general be much greater where there was plenty of headroom, and the machinery could be more thoroughly and expeditiously overhauled and repaired than in a cramped situation. Another consideration, which was generally overlooked in estimating the comparative advantages of machine-cutting and hand-cutting, was the value of the product. If a machine of ample power and strength of material was used, so that the face could be quickly worked, the coal produced was generally of so much better appearance that an enhanced price could be obtained for it. Therefore not only the pay-bills, but the invoices, should be compared in the two periods suggested by Mr. Steavenson. He (Mr. Goolden) was preparing a full and detailed account of the costs actually incurred in a number of pits where machines had been working during the last 6 years, which he hoped to be able to lay before the members at a no distant period.

The comparative efficiency of compressed air and electricity experienced in the Cleveland mines yielded so remarkable a result that it was well that it was given on the authority of so trustworthy and independent an observer as Mr. Steavenson. The suggestion made by Mr. Steavenson of using a motor-compressor [102] for great distances in-by is a plan that he (Mr. Goolden) had advocated for some years past, and the figures given by Mr. Steavenson fully justified it. It was not, however, necessary to engage an electrical expert to look after electric mining-machinery, provided that the plant was well made and had a sufficient margin of power. There were several mining-plants which had been running for many years under the care of colliery-engineers, without any trouble or technical assistance whatever. The repairs were easily made by the ordinary colliery staff, and his (Mr. Goolden's) experience compelled him to state that as a rule they were better done than when they were sent away to the manufacturers' repairing shops. It was not a difficult matter to rewind an armature; it simply required care, and that care was more likely to be given by the workman who was responsible for running the machine, than by a workman who never saw the machine again after it left his hands. In reply to Mr. Appleby's question whether a bar-machine when it came to a hard place in the coal, chose the easiest path above or below the obstruction, it was a fact that with a light machine this did occur, and a machine had once or twice been lifted completely off the rails in this manner, but with the heavier machines now used, this did not occur. If the rotation of the bar was reversed, the tendency was to go below an obstruction. In this case there was less chance of getting the machine off the rails, and the cutting was often much steadier and more regular.

Mr. T. H. Barr was correct in his statement of the lower limit of power required by a coal-cutter. A good deal of work with a bar-cutter had been done with 35 amperes and less than 300 volts, that was, absorbing 12 to 14 horsepower; on the other hand, the power had frequently risen to 37 horsepower, and would no doubt have exceeded this but for the fuses blowing. A disc-cutter, working on a material which a bar-cutter could not tackle at all, might exceed this higher limit considerably.

Mr. T. L. Elwen read the following "Notes on the Glacial Deposit or 'Wash' of the Dearness Valley." [103]
NOTES ON THE GLACIAL DEPOSIT OR "WASH" OF THE DEARNESS VALLEY.

By T. L. ELWEN.

The river Dearness rises near Tow Law, some 10 miles west-southwest from the city of Durham, and flows for 10 miles in an easterly direction, to its junction with the river Browney near Langley Bridge. It has a total fall of about 700 feet, or from 900 feet to 200 feet above sea-level, and a mean width of about 12 feet. In its course it is fed by several small streams, which also form "washes" on a smaller scale, for a short distance up the side of the valley. After its confluence with the river Browney, at a further distance of 3 1/2 miles, occurs the confluence of the river Browney with the river Wear near Croxdale. The "wash" described in these notes may therefore be regarded as a tributary of the larger or principal wash of the Team valley.

The Dearness valley is well-developed laterally, being enclosed by well rounded hills rising to a height of 400 feet above the present level of the river at its lower reaches, and having a width between the summits of about 2 miles.

Geologically, the valley is situated in the Upper Coal-measures, with the exception of the recent deposits of clay, sand, etc. The coal-seams, which are continuous throughout, have a total rise of 1,100 feet, which is in excess of the surface-rise by 400 feet. The proved workable coal-seams in the strata at the termination of the valley, from the top of the series, are: —The Hutton, Harvey, Busty and Brockwell. The Hutton and Harvey seams outcrop naturally, apart from glacial action, in their order up the valley.

A deposit of Boulder Clay, near the surface, is present all along the valley. It rests on the Coal-measures, and is overlain by thin beds of sand and gravel. It is an irregular, unstratified and very compact deposit, having a maximum thickness in the lowest parts of the valley and thinning out towards the summits of the hills.

Proceeding in the direction of the valley, the base of this deposit is seen to be of an undulating character, and consequently variable in thickness. It thus lies in depressions, the river flowing generally over

the top of this deposit, but at some places where the deposit is absent in the bed of the valley, the river has cut its way down several feet into the solid rocks. Between the confluence of the Dearness and the Browney rivers and the junction of the Browney with the Wear near Croxdale, the bed of the original valley rises 80 feet.

Just before reaching the "wash-out," the coal-seams become softer and of a red colour in the cleavages. The burning qualities are also reduced, the deterioration becoming more pronounced as the wash-out is reached. Approaching the wash-out, the seam first thins out and afterwards detached streaks of coal occur at intervals; and the underclay or seggar is also softer. At the sides, the edge of the deposit lies against almost vertical cliffs near the bottom. The maximum thickness is about 100 feet.

The clay is of a dark blue colour, very stiff at the bottom and in the centre, and becoming softer at the sides near the top. In some places it is dry, and strong enough to stand for a considerable time without timber; and in other places it is wet and apt to swell where sandy partings are present. The boulders are thoroughly embedded in every variety of position in the clay, and are more rounded, smaller and

more striated near the bottom, the shales especially being smooth and finely striated. The direction of the striae is found generally to be in a line with the longitudinal direction of the stone, but no arrangement is observed with regard to the stones

[Diagram] Fig. 1. - Section showing "Wash." Horizontal scale, 660 feet to 1 inch. Vertical scale, 200 feet to 1 inch.
themselves and their position in the clay. The proportion of boulders to clay is about equal in the upper part of the clay, and less frequent in the lower parts. Many of the boulders are found to be of material not belonging to the locality, such as calc spar, blue limestone, and ironstone; the remainder being principally shale and sandstone. The writer has not found any fossiliferous remains in this deposit. Resting on the top of the clay is a bed of sand, gravel and large boulders, with pieces of decayed wood, and it is full of water. Beds of sand and boulders with water intercalated in the clay are present in some parts of this deposit.

The period during which the faulting occurred in the coal-seams appears to have been antecedent to this deposit, as no trace of them has been found in the clay. The effect of this Glacial Drift, primarily, in cutting out large areas of workable seams, and secondarily in subjecting the adjacent areas of coal to deteriorating atmospheric agencies is considerable. To what extent separately, the effect of glacial action and that arising from other natural agencies, is a matter of conjecture. A considerable thickness of strata with the enclosed coal-seams must have been scooped out of the valley by ice. An additional effect has been the subjection of the lower seams to the deteriorating action of atmospheric agencies by removing part of the natural cover. The coal-seams under this deposit, which are situated less than 100 feet from the surface, are found generally to be deteriorated, though the same seam will resume its normal quality where the thickness of older rock-cover increases, found by following the contour-lines to the rise and by approximating—if the information is not at hand from the lower seams—the levels of the strata, and also by an examination of the surface to discover whether the Boulder Clay exists there or not. Thus, a coal-seam considered useless in the lower parts of the valley may exist in good condition in small areas higher up. This reasoning is complicated somewhat by the fact that the Glacial deposit lies in hollows: for where the Drift is developed, the bottom of the deposit (for all practical purposes) may be considered the surface,—such it would be during the Glacial period—and, consequently, the upper coal-seams would be deteriorated in quality.

The drainage-level also must be taken into consideration. The average inclination of the seams up the valley is 1 in 48, and being considerably in excess of the surface-rise, brings the top-seams successively above the drainage-level. Water would consequently percolate through the joints of the coal, reducing the quality by removing the enclosed gases, and leaving behind sand- and dirt-partings of a red colour. Thus in the same seam approaching this deposit the coal is deteriorated on each side of the wash-out to a greater width higher up the valley, where the coal has remained above the river-level, than lower down the valley, where the seam would be above the drainage-level during the Glacial period only. This process would be assisted by the gulley nature of the upper strata, which would form both water-channels and outlets for gas from the coal. To some extent to the action of alternating extreme colds during the Glacial period maybe attributable the broken-up character of the strata surrounding the deposit.

Mr. A. L. Steavenson (Durham) said that about 35 years ago they had a paper on the Team valley wash by the late Mr. E. F. Boyd and Mr. Nicholas Wood. This paper gave a very excellent account of the Team valley wash, and was illustrated with
A similar wash extended into Weardale, where they were cutting it with a steam navvy, when baring the limestone.

Mr. Philip Kirkup (Cornsay) said that he did not quite understand the statement as to the total rise of the strata being 1,100 feet. On a line between Stanley pit and Hedley Hill colliery, the Brockwell coal-seam outcrops at about 50 feet above the bed of the stream, on the south side of the valley. The base of the "wash" at this point is approximately 100 feet below the bed of the river Dearness, so that the ancient river or glacier had really scooped out rooks below the Coal-measures, in fact 150 feet into the Ganister series. All the coal-seams deteriorated in quality as the "wash" approached them. The red colour in the cleavages was caused by oxide of iron. He would like Mr. Elwen to produce some of the striated stones which he believed must be more common in the lower portion of the valley than in the upper. He had found boulders of basalt, greenstone, sandstone and blue limestone in the clay.

Mr. T. L. Elwen said that he arrived at the rise of strata as 1,100 feet by taking the depth of the Brockwell seam, 600 feet in the lower reaches of the river, and adding to this the natural rise at the surface, 500 feet, obtained from the Ordnance survey-maps, he obtained a total rise of 1,100 feet. He would exhibit some of the striated stones at the next meeting.

The President moved a vote of thanks to Mr. Elwen for his paper. Mr. P. Kirkup seconded the resolution, which was cordially approved.

Mr. F. Reid's paper on "The Felling of a Chimney" was read as follows:

THE FELLING OF A CHIMNEY.
By FRANK REID.

The following is a short account of the felling of the large chimney at Wallsend on January 14th, 1899.
This chimney was built in 1879, and being no longer required, the present owners of the ground (The Parson Steam-turbine Company, Limited) decided upon its removal. The chimney was 266 feet high, at the ground-level the outside diameter was 21 feet, and the inside 14 feet; and at the top the outside diameter was 14 feet, and inside 12 1/2 feet; making the brickwork 3 1/2 feet thick at the bottom and 9 inches at the top. On examination, the writer came to the conclusion that he could fell the chimney in a nearly due south direction, where the ground was clear of all buildings.
On January 9th, 1899, the workmen commenced cutting out the walls on both sides of the chimney, about 3 feet from the ground, working towards the point of direction of the fall, and as the brickwork was removed it was replaced with large wooden blocks 18 inches high, 15 inches wide, and 12 inches long, carefully wedged up with thin hardwood wedges. The wooden blocks consisted of three deal boards, each 18 inches long, 3 inches thick, and 12 inches wide, and each board was separated by two pieces of deal 7 inches by 3 inches by 12 inches, in order that tar and sawdust might be filled into the interstices and afford a larger burning surface (Fig. 1.). About 40 feet was cut out, and the chimney being at this point 66 feet in circumference, about 26 feet was left at the back.
The blocks being saturated with tar and paraffin, wood was then built for a fire all round the circumference of the chimney where the brickwork had been removed, the firing-material being much larger at the point of direction of the fall of the chimney. For about 1 minute after the fire was lit, workmen were employed throwing paraffin on the portion where

[Diagram] Fig. 1.—Elevation of a Wooden Block.
the blocks were required to burn most rapidly, and 6 minutes after the lighting of the fire, the chimney fell exactly on the line marked out for it on the ground. The cost of felling the chimney was only half of that involved in its removal by ladders and throwing the material down, working from the top; and moreover many thousands of the bricks were recovered for further use.

The President moved a vote of thanks to Mr. Reid for his interesting paper, and it was cordially approved.

The meeting then terminated.

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THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

Held in the Wood Memorial Hall, Newcastle-upon-Tyne, June 10th, 1899.

Mr. J. B. SIMPSON, Past-President, in the Chair.

The Secretary read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on May 20th and that day, and of the Council of The Institution of Mining Engineers.

The Secretary read the Balloting List for the election of officers for the year 1899-1900.

DEATH OF MR. A. M. POTTER.

The Chairman (Mr. J. B. Simpson) said that he had the melancholy duty of asking the members to pass a vote of condolence with Mrs. Potter on the death of her husband, who had passed away since the last meeting of the Institute. He felt sure that all of them who knew him would very much regret his loss.

SYLLABUS OF THREE YEARS' COURSE OF LECTURES FOR COLLIERY-ENGINEERS.

The Chairman, in drawing the attention of members to the syllabus of the course of instruction at the Durham College of Science for colliery-engineers, remarked that the requirements of coal-mining nowadays were of a highly scientific character, and it was absolutely necessary that the colliery-engineer of the future should have the knowledge to be attained by a scientific education. He hoped that engineers, and especially young engineers and others, would take advantage of this important course of lectures.
The following gentlemen were elected, having been previously nominated:—

Members—
Mr. Edwin Stanley Clark, Colliery Proprietor, Oak Alyn, Cefn-y-bedd, near Wrexham.
Mr. Thomas Parker, Colliery Manager, Wellington Pit, Whitehaven.
Mr. John Walter Pearse, Technical Translator, 1, Avenue Pescatore, Luxembourg-Ville.
Mr. Francis Holborrow Glynn Price, Mining Engineer and Estate Agent, Longlands Place, Swansea.
Mr. George Robinson, Colliery Manager, Harton House, Harton Colliery, South Shields.
Mr. William Smyth, Director of Mines, Gympie, Queensland, Australia.
Mr. Arthur P. Wilson, Mining Engineer, 11, Queen Victoria Street, London, E.C.

Associate Members—
Mr. John Fairless, Mineral Manager, North Eastern Railway, Newcastle-upon-Tyne.
Mr. James M. Gummerson, 9, Albury Park Road, Tynemouth.
Mr. Colin Ochiltree Macdonald, Gowrie and Black House Collieries, Limited, Port Morien, Cape Breton, Nova Scotia, Canada.
Mr. Douglas Stuart-Spens Steuart, 51, St. Ermin’s Mansions, Westminster, Loudon, S.W.; and P.O. Box 154, Pretoria, South African Republic.
Mr. Oswald Thompson, Hendon Lodge, Sunderland.

Students—
Mr. Robert William Glass, Mining Student, Axwell Park Colliery, Swalwell, R.S.O., Co. Durham.
Mr. Thomas Easton Rutherford, Mining Student, South Derwent Colliery, Annfield Plain, R.S.O., Co. Durham.

The following paper by Mr. D. Murgue on "The Murgue Recording Volumetric Anemometer" was read as follows: —

THE MURGUE RECORDING VOLUMETRIC ANEMOMETER.*

By D. MURGUE.

The regulations regarding fiery mines, enforced in the collieries of the Departement de la Loire, France, since September 1st, 1895, have compelled mining engineers to provide ventilators with a speed-recording apparatus and with an automatic pressure-gauge for recording depression or compression. It is easy to follow the train of thought which led up to this enactment: each apparatus, taken by itself, furnishes only an incomplete record, but the two check one another, and the comparison of the diagrams traced out by them enables the observer to decide, for instance, whether a given depression is due to an acceleration in the speed of the ventilator or to an accidental constriction of the underground airways. Nevertheless these two records do not give the mining engineer that piece of information which is for him the most interesting of any, namely, the volume or the number of cubic feet of air passing through the workings in a given time. Imagine for a moment that the return-airway is suddenly blocked by a fall of rock: the speed-recorder will still continue to record the speed, and what is more, a constant speed (if
the engine be provided with an automatic cut-off gear), the pressure-gauge will go on recording a depression differing but little from the customary average - and yet not a cubic foot of air will be passing through the workings. Bearing this fact in mind, and guided by the writer's former researches, he had endeavoured to construct a recording volumetric gauge such as would of itself suffice to take the place of the two gauges prescribed by regulation. The state inspectors of mines had been good enough to approve of this method of attacking the problem—that is, taking the ventilation as the fundamental datum; and with the help of his colleagues of the Compagnie de Montrambert, he had succeeded in producing the apparatus, a type of which was now before the members, which had been at work for 2 years in connexion with five mine-ventilators.

* Translated by Mr. L. L. Belinfante, M.Sc.

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The instrument which really measures the intensity of the air-flow, if he might so express himself, is the Pitot tube, well-known to all, and itself the subject of a highly interesting paper by Mr. Rateau.* Before describing, however, the particular arrangements which he had adopted, he thought it well to set forth certain principles but dimly apprehended by many of his colleagues, principles with which he had only recently become acquainted.

In order to appreciate thoroughly the effect of a ventilator exhausting air from the mine which it ventilates, we must imagine it preceded by a vast chamber into which the air coming from the mine expands and remains stationary for a time before rushing into the inlet of the fan (Fig. 1, Plate V.). In this chamber prevails a certain pressure $H$, necessarily lower than the atmospheric pressure. The difference revealed by the water-gauge is what mining engineers are accustomed to term the depression. The writer calls this pressure $H$ the static pressure, so as to emphasize the fact that here we are concerned with air that has no speed. In practice, the supposed chamber exists but rarely. In most cases the air, exhausted from the mine, travels direct to the ventilator by an airway of moderate cross section wherein the air maintains a high speed (Fig. 2, Plate V.). Now, the pressure $H'$ which prevails in such an airway is no longer the static pressure. The former is inferior to the latter, in virtue of the Bernoulli theorem, by the quantity $-\frac{v^2}{2g}$.

$$H' = H - \frac{v^2}{2g}$$

$v$ being the velocity of the air at the point, where the depression is measured by the tube $a$.

But, if we wish to determine the true static pressure—and to this point the writer desired to direct the earnest attention of mining engineers—it will, suffice to curve the above-mentioned tube into the form of a Pitot tube facing the current. The shock-pressure $+\frac{v^2}{2g}$ destroys the negative term $-\frac{v^2}{2g}$, and we have finally on the water or mercury of the manometer, the statical pressure $H$, that is

$$H - \frac{v^2}{2g} + \frac{v^2}{2g} = H$$


[115]

That such is the fact the following experiment, which the writer had performed over and over again, will show (Fig. 1, Plate V.). Place a Pitot tube $b$ in the constriction
which precedes the inlet of a Kateau ventilator, and a straight tube a in the wide part of the air-drift, where the speed of the air is comparatively very low, the differential gauge with which both tubes communicate will be found to record an equality of pressures.* Without being considered guilty of too great presumption the writer may, therefore, lay down the following proposition:—The Pitot tube, so arranged as to face the current, transmits the static pressure. As a corollary, he may be allowed to answer a question which is often put:—How should the orifice of a tube be arranged which is intended to transmit to a pressure-gauge above bank the pressure prevailing in an airway? The static pressure being alone that which possesses any interest, the orifice must be placed facing the current. Let us return from this digression to the apparatus which forms the main subject of the present communication.

The foregoing pages have made it clearly apparent that if a straight tube a (Fig. 2, Plate V.) be fixed beside a Pitot tube b, in an airway through which passes a current of considerable intensity, and if these two tubes be brought into communication with the two branches of a differential gauge, this gauge will indicate for the air-current that strikes the orifice of the straight tube the function of the speed $v^2/2g$.

In point of fact this is an anemometric method which has been known for some time and is often used, as, for example, by the Prussian Firedamp Commission.†

In order to utilize this arrangement for the measurement of air-volumes it would evidently be sufficient to place the orifice of the straight tube at that point of the cross-section where an average speed prevails, the volume being simply equivalent to the product of the area of the section multiplied by the speed. But even that is not necessary, as numerous experiments made by the writer at the Besseges colliery had shown that when the average speed of a current in an airway is made to vary, the form of the curves of equal speed remains unchanged. Whence we may conclude that the speed at any point of the section bears a constant relation to the average speed.

*This experiment has also been performed by Mr. Rateau under slightly different conditions, Annales des Mines, 1898, series 9, vol. xiii., page 335, and Trans. Inst. M.E., 1899, vol. xvii., page 126.

† Mr. Rateau advises that the extremity of the straight tube should be furnished with a small screen p (Fig. 2, Plate V.), bevelled off on the side of the current, in order to prevent the eddy produced by the tube from disturbing the parallelism of the trajectories in front of the orifice.

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It may then be affirmed that the change of level $h$ of the differential gauge is in all cases a function simply proportional to the square of the volume:—

$$h = Kv^2$$

As to the coefficient $K$, which sums up all the constant factors, section, density, etc.,* it will be sufficiently determined by means of a preliminary measurement carried out in the customary manner.

Such is the very simple principle upon which the recording volumetric gauge, herein described, has been based. Before proceeding to discuss its applications, however, mention must be made of one difficulty in particular which it was found necessary to overcome.

The speed which usually prevails in the return-airways being 800 to 1,000 feet per minute, the change of level $h$ of the differential pressure-gauge, expressed in terms of a water-column, would not exceed 0.050 inch, a load which, although it might deflect a recording apparatus, would not suffice to give reliable readings. It was, therefore, indispensable to induce an acceleration of speed at one point in the
gallery, which could only be done by narrowing or constricting the cross-section thereof. Theoretically, this procedure is quite permissible for, if the gradual transition is properly arranged, to the rise and to the fall of pressure between the original cross-section and the constricted cross-section (dotted outline in Fig. 2, Plate V.), the vis viva produced during the period of acceleration is wholly restored during the period of slackening, and thus everything takes place as if there had been no constriction at all. It would appear that practical experience corroborates these theoretical assumptions. Nevertheless, in the absence of confirmatory experience it is hardly probable that we should have agreed to place such obstacles in the road of the ventilating-currents, being naturally reluctant to do anything which might weaken them.

It was, therefore, very satisfactory to meet with the desired constriction in the ventilators themselves. These are of the Rateau type: the air-admission canal at the inlet narrows gradually to a minimum of 1.68 of the diameter, and then widens out to connect with the spiral diffuser. At the narrowest point, a speed of 2,000 to 2,500 feet per minute prevails, corresponding in the differential pressure-gauge to water columns of 0.24 to 0.32 inch. These loads seemed to the writer quite sufficient to be self-recording, reliable, and capable of suitable amplification.

* The density of the air is not absolutely a constant; but it varies within limits so narrow, that in practice it may be considered a constant.

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Therefore the two measuring-tubes, the straight and the Pitot tube, were fixed permanently in the narrow portion, and then joined up by means of leaden piping* with the two branch-pipes of the differential pressure-gauge which remains to be described. As generally happens, the writer did not at the first attempt hit upon exactly the arrangement which is described to the members, and the original type of apparatus has now been discarded. Nevertheless it may be as well to describe in the first instance the original type, as it will help to explain the apparent complications of the later type.

The two branches of the pressure-gauge were represented by the unequal compartments of a rectangular zinc box or holder dipping into a cast-iron tank filled with water (Figs. 3 and 4, Plate V.). At the top of each compartment, two taps (a and b) communicated with the pipes coming from the measuring-tubes, the straight tube corresponding to the small compartment and the Pitot tube to the large one. A third tap allowed of communication between the two compartments, and it was therefore possible to equalize the pressures in them, an equalization which is indispensable from time to time, in order to test the zero of the instrument.

The small compartment was occupied, as now, by a cylindrical float, immersed up to its horizontal diameter. This float was connected to a long lever formed by a hollow tube, light and yet rigid, which ran along the bottom of the tank, and issued therefrom at its two ends: at the rear, it was joined to a shaft whose pointed extremities turned in two small screw supports, s, fixed to the tank, and at the forward end, it commanded, by means of a short crank m, the lever of a Richard recorder.

It will now be easy to understand how the apparatus works. Under the influence of the various pressures transmitted by the measuring-tubes the water rises in the small compartment, carrying the float with it. The water falls in the other, but proportionately less in consequence of the greater surface. It is advisable to extend this surface as much as possible, in order not to diminish too much the amplitude of movement of the float. The motion of the float is transmitted by levers, with suitable amplification, to the recording pen, which traces out on a diagram ordinates proportional to the square of the volume.
* The pipes communicating with the gauge must be laid with a gradual rise, so as to avoid bends wherein condensed water might accumulate and block the passage.

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But a very serious defect was soon discovered in this first type of apparatus. In the narrow channel e, which separated the zinc box or holder from the inside wall of the tank, the water remained subjected to atmospheric pressure, and fell there while it rose slightly within the holder. Now, given the same volume, that is, the same alteration of level within the two compartments, the position of the float was influenced by this unmeasured fall, and transmitted sensibly different readings according as the equivalent orifice of the mine was large or small, that is, according as the change of level in the channel e, equal to the depression, was more or less marked.*

With the view of avoiding this difficulty and yet of preserving the system of the pneumatic trough, the author modified slightly the shape of the compartments, making the larger one form a continuous jacket around the smaller one (Figs 5 and 6, Plate Y.). Moreover, around and outside the tank a deep and narrow cast-iron trough has been placed, wherein the larger holder dips on all sides, while the smaller holder continues to dip into the inner tank.

The water in the outer trough alone is exposed to atmospheric pressure and is completely shut off from the water in the tank; therefore the disturbing action previously described ceases to take place, and in this respect no further fault can be found with the apparatus.

Unfortunately, however, this modification necessitates the introduction of some complications into the lever. It has been found necessary to give the lever some extraordinary bends, in order to enable it to issue from the tank and pass through the trough by its two ends without interfering with the hydraulic seal. As a matter of fact, however, not much harm is done thereby: the lever having only very light work to do, the necessary rigidity is ensured by strengthening the bends as shown in the drawings.

The recording-cylinder is duplicated by a reserve cylinder, which takes a strip f paper 3 feet long. This strip, unrolling at the rate of 0.20 inch per hour, lasts for a week, and is renewed every Monday. It is ruled with curvilinear ordinates plotted at one-hour distances, and with horizontal lines graduated in cubic metres, and arranged farther and farther apart according to the law of the squares of the volumes (Fig. 7, Plate V.).

*To note only one point, the zero position lost all fixity. When pressure was equalized in the two compartments, the zero rose or fell at the same time as the depression. The new arrangement ensures absolute fixity of the zero, whatever may be the equivalent orifice of the mine or the speed of the ventilator.

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As the writer has previously said, the ruling of the paper is done very simply by means of comparative measurements. The difference between the real volume of air and that given by the graduated strip is easily corrected by allowing the little sliding-sockets, m and n, at the ends of the connecting-link to run as far as may be necessary on the corresponding levers.

The checking, and, if necessary, the correction of the zero must be made, at least, every time that the paper-strip is changed. A small funnel, c, going down nearly to the bottom of the tank (thus ensuring hermetrical automatic closure), and a small waste-tap, v, allow of the necessary amount of water being added or removed, as desired,
to bring back the instrument to the zero-point, if any deflection chances to have taken place.

Finally, the whole apparatus is enclosed within a glass case.

Such is, in its essential aspects, the apparatus which the writer has invented. He had laid upon himself the following conditions which appeared to him indispensable for the achievement of permanent success:—

1. To have at one's disposal more than sufficient motive-power, by making use of a float of large dimensions.
2. To reduce the passive resistances to a minimum, by restricting them to the friction of two points in two supports, which are easily lubricated.
3. To have everywhere a water seal or hydraulic closure, the only true hermetical closure.
4. To bring into play large masses of water and air, so as to diminish oscillation.

Save and excepting the last-named condition, the foregoing desiderata seem to the writer to have been fairly well achieved. The apparatus is extremely sensitive, and so soon as an artificial block is produced in the airways, the pen is seen to go down. If, on the other hand, a separation-door is opened, the pen rises immediately. The writer may remind members that the depression-recorder would have given inverse results. If the ventilator be stopped, the pointer continues to mark the flow due to natural action alone, and in order to make sure that one is not labouring under some delusion it is sufficient to bring the instrument back to zero. The difference between the ordinates, however insignificant it may be, is plainly attributable to the mere effect of the circulation of air.*

* It is a pity that the apparatus cannot be utilized for the measurement of the re-entering currents which are produced in warm weather. To do this, the measuring-tubes would have to be arranged differently.

But this very sensitiveness is the cause of a serious defect: the pointer is in a state of continuous oscillation, and as the speed of travel of the strip is perhaps too low, the result is that smudgy diagrams are sometimes produced. The writer may say at once that better diagrams are produced in shafts used exclusively for ventilation than in those which serve both for that purpose and for sending timber, packing material, etc., down into the mine. It will be easily understood that the frequent opening of doors, however carefully closed, will cause much oscillation of the pen. The writer endeavoured to meet this difficulty by interpolating, between the measuring-tubes and the apparatus, enclosed spaces of a cubical content of about 175 cubic feet, with the hope of deadening the oscillation, but the endeavour was not very successful. It is possible, as someone remarked to the writer, that the measuring-tubes are placed too close to the inlet of the ventilator. If perhaps they were fixed further off in a constriction or narrow place arranged in the return-airway, diagrams of a less tumultuous character would be recorded. This is a supposition which the writer has not verified in practice.

It may be, too, that the oscillations are due to periodic displacement of slow or fast currents, oscillating around their mean position, in such wise that if a certain number of measuring-tubes were spread over the cross-section, a less oscillatory mean result would be recorded on the diagrams. This experiment would be worth making. Perhaps, too, the diagrams would be better if the fan-engines were provided with good regulators, keeping up a constant speed. In practice, the regulators just keep the engine from running away in case of a belt slipping.
However that may be, the apparatus described in the foregoing pages, with all its imperfections, appears to the writer destined to furnish useful records to mining engineers.

Mr. J. B. Simpson moved a vote of thanks to Mr. Murgue for his paper describing an interesting appliance. The resolution was cordially approved.

Mr. M. Walton Brown read the following description of the "Davey-Bickford-Smith Safety Shot-igniter" ;—

[Plate V: - Diagram of the Murgue Recording Volumetric Anemometer.]

DAVEY-BICKFORD-SMITH SAFETY SHOT-IGNITER.*


On December 10th, 1897, the Minister of Public Works forwarded to the French Fire-damp Commission for examination and report a new system of safety-igniter for firing shots in gaseous mines, which had been submitted by Messrs. Davey, Bickford, Smith & Co., manufacturers of dynamite and detonators at Rouen. Samples of these igniters and of the firing apparatus were submitted on December 11th by Mr. Harle, engineer of the above company, who showed their mode of operation and handed them to the writer in order to carry out tests with them in explosive media. It is wellknown that when a fuze is lit, a jet of hot gas is evolved during several seconds, accompanied by the projection of granules of powder in a state of ignition and capable of igniting fire-damp. Several arrangements have already been proposed in order to avoid this ignition by confining the gaseous products of the burning fuze either in an entirely enclosed space or within a safety-lamp, from which the fuze is only to be withdrawn when the combustion of the powder-core is advanced sufficiently to prevent the projection of any incandescent particles. This occurs after about 4 inches (10 centimetres) of fuze has been consumed. A considerable number of appliances of this order used in coal-mines have been described in the Annales des Mines.† Some of these ignite the fuze by means of a percussion-cap (Lens shot-firing pistol), others by means of a safety-lamp (Johnson, Howatt and Petit safety-lamps) ; others, again, by making use of the heating of air by abrupt compression (Bourdoncle pneumatic igniter). With all of these different pieces of apparatus, it is always necessary to wait for some seconds before passing from one shot to the next, a fact that limits considerably the number of shots that can be fired at once, and entails the employment of fuzes of considerable length. Messrs. Davey, Bickford, Smith & Co., of Rouen, have already attempted to avoid these objections by means of a chemical igniter.‡

‡ Ibid.

A little glass bulb, containing sulphuric acid surrounded by a mixture of potassium chlorate and sugar, is placed in a copper tube, and the fire due to the heating produced on crushing the bulb by means of a special pincers, is communicated to the
fuze attached to one end of this tube, while the gases escape by the other end, which is closed by means of discs of wire-gauze. This igniter, tried successfully in several coal-mines, had given numerous miss-fires in others. Among other objections, it was found to be rather too delicate to be placed in the hands of workmen, and the possibility of the tube splitting while the glass bulb was being crushed, also presented itself.

The new igniter devised by the same firm and submitted to the French Fire-damp Commission allows, as in the case of the last appliance, the fuze to be lit in a fiery atmosphere, and to be immediately left as soon as it has been lit, while it is much more simple to use, and avoids the danger of splitting the tube that encloses the igniter. This result is obtained by employing a special igniting-cap, which on a small scale resembles in construction a Davy safety-lamp. It is constructed as shown in the annexed sketch (Figs. 1 and 2),

[Diagram: Fig. 1., Fig. 2.]

and consists of:—A fulminating-cap, A, into which is inserted a spiral, B, of brass wire, carrying a small quantity of powder. C is a brass tube into which the fuze is inserted as far as the constriction D. E is a gauze-tube of very fine brass wire having 1,089 meshes to the square centimetre, which prevents any direct contact between the heated products of combustion and the external atmosphere, just as in the case of the safety-lamp. It is firmly attached to the cap, A, at one end, and to the tube, G, at the other, uniting these two parts. The wire spiral, B, prevents the wire-gauze from being crushed in while the igniter is in use or is being transported. There is a longitudinal seam in the wire-gauze, which is closed by an overlap of about a semi-circumference.

In order to fire the shot, the fuze is pushed as far as possible into the tube, C, its end being tightly pinched by means of a special tool, which is also employed for cutting the fuze to the required length. The igniter is then placed in a pistol which carries the igniter, fires the cap by percussion, and allows the igniter to be liberated very rapidly. With a little practice, it is possible thus to fire a series of shots in a few seconds. With this object the igniter is placed in the pistol, as shown by the sketch (Fig. 3). A groove, a a, takes half the thickness

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of the igniter, whilst a cover, G G, movable on a hinge, b b, and with a semi-cylindrical groove, b₁ b₁, holds the igniter in place when the cover is closed on its hinge until the projection H, with which it is furnished, is caught in the spring-catch, I.

[Diagram: Fig 3.]

It is then sufficient to pull the trigger, K, of the pistol, to lift the hammer, L, which drops upon the cap and fires it. The tube, c c, allows the fumes to escape. The moment the cap has been fired, pressure on the button, M, frees the projection, H, and the lid or cover, G G, moved by an opposing spring not shown in the figure, rises automatically, thus allowing the igniter to be removed, and leaving the pistol in readiness for the firing of the next shot. In Fig. 8, the cover, G G, is shown lifted up. We have worked this apparatus in explosive mixtures at their highest degree of inflammability, consisting of mixtures either of air and marsh gas or of air and illuminating gas, employing the conditions which should be most favourable to the propagation of an explosion through the wire-gauze. In order to do this, we have fired the igniters attached to fuzes placed in an explosive current without replacing the cover or lid G, taking care to keep the igniter in its proper place. Under these
conditions, we have not succeeded in causing ignition of the explosive mixture in 80 trials made with marsh gas and in 80 trials with illuminating gas.* It may, therefore, be admitted that the Davey-Bickford-Smith igniter presents a very high degree of safety.

At the moment when the fulminate explodes, the passage may be noted through the wire-gauze of a dull red light lasting for an exceedingly short time, but too rapid and already too far cooled to ignite an explosive mixture. Neither the combustion of the powder covering the wire spiral nor the spitting of the fuze project any incandescent particle through the wire-gauze.

It may be asked whether it would not be possible to replace the wire-gauze, E, by a plain metal tube sufficiently strong to withstand

* We had proved that the spitting of the ignited fuze, when unprotected, fired illuminating-gas every time but marsh gas very rarely. Experiments in the former mixture are therefore particularly conclusive. The fuze employed had been manufactured with especial care.

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without bursting the compression of the products of combustion; which would evidently be a much simpler and less expensive construction than the wire-gauze cylinder; but although there is after all a very small quantity of explosive matter employed, its force would be sufficient to project the fuze from its place, even if the former were fairly well secured, seeing that the material of which the fuze is made is tolerably plastic. We have, in fact, found that if the fuze is not squeezed firmly into the tube, C, of the Davey-Bickford-Smith igniter, it is thrown out with a certain amount of violence, notwithstanding the passage of the products of combustion through the meshes of the gauze. In no case, however, has the fuze been detached from its place when it has been properly secured.

We may summarize the experiments which we have performed by saying that they have brought us to the conclusion that the safety-igniter of Davey, Bickford, Smith & Co. presents the very highest degree of safety; at the same time it allows shots to be rapidly fired, and, like several of the other forms of similar apparatus previously described in the Annales des Mines, it deserves to be brought to the attention of those engaged in working fiery mines.

II.—Opinion of the Fire-damp Commission.

The Commission has adopted the conclusions of this report, and gives the opinion that it is justified in proposing to the Minister of Public Works to insert Mr. Chesneau's report in the Annales des Mines.

Mr. M. Walton Brown said that the use of this pistol form of shot-firer had been approved by the French Government, and they had been in general use for about a year.

The Chairman (Mr. J. B. Simpson) said that this shot-firer seemed very simple, but no doubt would require further experiments before they were inclined to adopt it for use in British mines.

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DISCUSSION ON MR. W. T. GOOLDEN'S PAPER ON "COAL-CUTTING BY MACHINERY."

Mr. H. W. Appleby (Bradford) wrote that many colliery-engineers always desired to use armoured cables, but this, he thought, was quite unnecessary, and it certainly
added very greatly to the cost. Where the cables are carried along main roads, the ordinary insulation is quite sufficient. At the working-face, where loose cable is lying about or dragged over the ground, he certainly thought that armoured or protected cable should be used. If the mine is very damp or the cables have to pass through water, lead-covered cable would be necessary, as the leaden sheathing saves the insulation from rotting away. Cables, if slung from the roof, should not be stretched too tightly, but allowed to sag so that, if any part of the roof falls, the cable will not be broken, but will give way and allow the fallen part to drop clear of the cable. He had heard of several cases of this kind occurring recently in a mine. Where cables have been stretched tight, the fall of roof cuts through them, but in places where they were slung loosely, they simply came down with the roof and no damage was done to them.

It is most important where several electrically-driven machines are depending on one source of supply that this should not be interrupted, and it will easily be seen that the fixing of cables, so that the chance of fracture may be reduced to a minimum, is very necessary. In addition, the rupture of a cable carrying a current at high pressure generally causes a big flash, and this is a source of danger against which provision has to be made. He would like to make a few more remarks, but as he hoped to have the pleasure of submitting a paper bearing on this subject to the Institute at some future date, he would defer his remarks till then.

The following paper by Mr. H. G. Stokes on "The Ore-deposits of the Silver Spur Mine and Neighbourhood, Texas, Queensland," was read as follows :—


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THE ORE-DEPOSITS OF THE SILVER SPUR MINE AND NEIGHBOURHOOD,
TEXAS, QUEENSLAND.

By H. G. STOKES.

Introduction.

Introductory.—In preparing these notes the writer has endeavoured to give a detailed account of the mode of occurrence of the ore-bodies at the Silver Spur, which have been constantly under his observation since they were first opened, in the hope that the information may be of use as a reference, and serve as a supplementary report to another paper dealing with the mine when further developed. The plans and sections accompanying the paper will help to throw light on the geology of the ore-bodies, and the diagrams represent as nearly as possible the natural appearance of the ore-sections.

General.—The ore-bodies of the Silver Spur are located on Gunyan lease, 3 1/2 miles north of the Dumaresq river, the border between New South Wales and Queensland, and about 7 miles east of Texas, and 54 miles south-west of Stanthorpe, in the Darling Downs district. The area in which they occur is situated near the base and western slope of the main range, on the divide between the waters of Warroo and Pike creeks. The passage from the hills to the narrow valleys extending to the Dumaresq river is somewhat abrupt, consisting for the most part of steep sloping ridges and spurs, rising into dome-shaped hills. Owing to the conformation of the country the numerous creeks which drain the area and fall into the Dumaresq river are mostly dry during the summer.
The country is open forest-land, the timber consisting of ironbark, box, apple-tree and cypress pine with some currajong and brigalow.

Geology.—The predominating rocks of the area covered by the sketch-maps (Figs. 1 and 2, Plate VI.) are sedimentary, and belong to the Permo-Carboniferous period. They consist for the most part of grey and buff shales, sandstones and conglomerates, and lenticular masses of un-fossiliferous limestone, with quartzites on some of the ridges and hills. These beds have a variable strike, ranging a few degrees east and west of north, the general trend in the neighbourhood of the ore-bodies being north 10 degrees to 40 degrees east, and the dip is easterly at angles varying from 40 to 80 degrees. The shales generally present an uniform appearance at the surface with the same lithological characters; in depth they change to a dark bluish-grey and appear to merge into beds of compact sandy clay-stones. They contain rounded, flattened pebbles of quartz and quartzite and occasionally large and small pebbles and fragments of granite. The granite-fragments appear to be confined to certain beds: they have been met with at a depth of 90 feet below the surface in the Silver Spur mine (No. 1 shaft). A large block, weighing about 15 cwt.s., was exposed in a trench near the surface, in Lease No. 66, of a coarsely crystalline variety containing muscovite. Similar fragments of granite have been noticed in the Gympie Beds by Mr. W. H. Rands, the assistant government geologist.

Sandstone-beds are rarely met with, and appear to pass by insensible gradations into shales; they occur as narrow bands of local extent, of a red or yellow colour, friable and fine grained in texture. The conglomerates are claystones, with numerous circular and oval discs of siliceous shale, sandstone and quartz: granite has not been noticed in these beds. The limestones occur as large and small isolated patches, mostly lenticular masses between the bedding-planes of the shales. They project as much as 20 feet above the surface and have been scored and grooved by weathering. They do not appear to contain organic remains, and have very irregular outlines. The writer may mention that some of the shale-beds are saliferous, marsupials and the cattle on the run forming "licks" where they are exposed in the creeks. The alluvium in the flats along the base of the hills, formed from the detritus of the sedimentary rocks, where it is exposed by the creeks running through it, has been undermined by these "licks."

Igneous Rocks.—Diorite is the only intrusive rock that occurs hereabouts; it belongs to the quartz-diorite variety and contains abundance of hornblende. It is a moderately-coarse crystalline rock, and occurs in dykes having a general strike of north 80 degrees west, and varying in thickness up to 40 feet.

The Ore-deposits.

Several small deposits of copper and argentiferous lead-ore have been worked intermittently for some years past in the district, but have not yielded remunerative results.

Silver Crown.—The only ore-deposit now being worked, other than the Silver Spur lease, is the Silver Crown, distant about 4 miles east of the Silver Spur and south of the old mail-track to Glenlyon. The shales here strike east-north-east and dip east-south-eastward. The ore occurs as small detached pockets of ferruginous copper
gossan, outcropping to the east of a sandy shale, containing numerous quartz-veins, from which it is distant some 30 feet. The joints in the shales, dipping north-north-eastward at varying angles, contain small veins of ore; where these are intersected by other joints dipping north-north-west and west, the ore makes, forming pockets and lenses occasionally opening out to 30 inches wide by 4 to 5 feet in length, tapering out along the strike of the joint dipping north-north-east. At a depth of 50 feet below the surface, the ore presents the same characteristics, but contains both galena and copper-pyrites. It assays from 5 to 40 ounces of silver per ton and up to 11 per cent. of copper.

Silver King.—This mine is situated about 2 miles north-north-west of the Silver Spur. It is located in the same belt of country as the Silver Spur, and is 1,600 feet above sea-level. The shales in the neighbourhood contain lenses and pockets of limestone which present a brecciated appearance on the weathered surface, owing to the inclusion of fragments of shale. Veins and nests of quartz also occur in the limestone. The ore-body corresponded in strike and dip with the bedding of the enclosing shales: the line of strike being north 10 degrees east, and of dip west 10 degrees north at a steep angle. The outcrop consisted of carbonates of lead and copper with some quartz and argentiferous iron-oxides, its length was over 30 feet and greatest width 5 feet. The lode consisted for the most part of shale which had been impregnated and partly replaced by metallic minerals, the replacement having taken place without materially altering the appearance of the rock. There were no defined walls, the ore-material gradually disappearing, until at a depth of 30 feet small pockets of carbonate of lime with some galena were met with; it thinned out at the northern and southern ends also. At the northern end, in sinking the shaft, numerous large and small pockets of spongy cellular material were passed through; they consisted of a skeleton or framework of clay, lime and oxide of iron, the cells being filled with earthy oxide of manganese and clay, and containing at their lowest part a little carbonate of lead and copper. This material gradually passed into the brecciated limestone. The shales curved round these bodies, and were smooth and crushed in contact with them, as if the pockets had expanded by increase of their metallic contents during their formation, or the "country" had contracted or squeezed around them: this was more noticeable at the base of the pockets. Between 30 and 40 tons of ore from this mine yielded at the rate of 50 ounces of silver to the ton and 5 per cent. of lead.

Texas Copper-mine.—This mine is distant 2 1/2 miles west of the Silver Spur; it was worked by a company for some 3 years previous to 1894. The country-rock, consisting of claystones of a greenish colour, is harder and more siliceous than the shales on the east. The cap was represented by a mass of siliceous ironstone containing a little carbonate of copper, below which was a bedded lenticular mass of blue and green carbonates of copper, which had a lateral extension of 40 feet by a width of 3 feet and appeared to cut out at a depth of 60 feet below the surface, the footwall being smooth and well-defined. Work was stopped here and a large shaft started on a fault to the north, the flucan of which contained a little copper gossan, derived from the decomposition of chalcopyrite. This shaft was carried down to a depth of 150 feet and ground stoped out on each side of the shaft along the fault, small but isolated patches being met with. The results were not satisfactory. No prospecting was done on the site of the first discovery of ore.
At several localities in the neighbourhood bedded veins of quartz crop out; they are somewhat vesicular, from the decomposition of pyrites, and generally yield a trace of gold; veins of quartz containing copper-glance have been met with. Native copper has been found in the amygdules of a basic, much altered volcanic rock, resembling dolerite, 3 1/2 miles east of Schneider's selection. Ores of antimony and arsenic, haematite, and limonite occur in the surrounding region. These deposits, with the exception of the antimony, have not been worked; they appear to be small lenticular bodies associated with quartz.

The Silver Spur Mine.

General Characteristics.—The ore-bodies are developed in proximity to a diorite-dyke, and consist of lenticular masses approximately parallel to each other and intercalated with the shales (Figs. 1 and 2, Plate VI.). They are apparently confined to beds of soft dark bluish-grey shales which have been subjected to considerable local movement along the bedding-planes; these movements, however, do not appear to extend for any great distance along the strike of the rock. The shale-beds are confined between hard compact siliceous claystones. The length of the ore-bodies up to the present has not exceeded 150 feet by a width of 40 feet. The strike varies from north 7 degrees east to north 55 degrees east and the easterly dip from vertical to 72 degrees. They occur near and in contact with a fault striking north 50 degrees west. They have been opened up to a depth of 150 feet, and found to vary from 2 to 40 feet in width, by 150 feet in length. The zone of oxidation does not extend beyond a depth of 90 feet, water being met with at 92 feet from the surface in No. 1 shaft. The ridge on which the ore-bodies crop out is 1,400 feet above sea-level.

No. 1 Lode.—The No. 1 ore-body (Fig. 2, Plate VI.), distant about 600 feet southwest from the diorite-dyke, strikes about north 10 degrees east and underlies to the east about 72 degrees. It was marked by a strong outcrop of copper-stained ferruginous quartz and iron-ore, rising 2 1/2 feet above the surface, by 10 or 12 feet in length, the surface for some distance to the south being strewn with fragments of ore (floaters) embedded in a stiff clay which assayed from 3 to 14 ounces of silver per ton. This ore-body has been proved and opened up to a vertical depth of 142 feet by about 80 feet in length (Figs. 3 and 4, Plate VI.).

The oxidized portion, which extends to a depth of 95 feet on the foot-wall side, consists of a mass of vari-coloured oxide of iron intermixed with ferruginous and vesicular quartz, the whole being stained more or less with carbonates of copper (blue predominating); carbonate of lead occurred among the softer varieties of ore and in large and small pockets of a friable, granular, and semicrystalline character. A large patch of "tile-ore" was worked on the hanging-wall side between the 30 feet and the 90 feet levels; it was rich in copper, but averaged only 8 ounces of silver per ton. White vesicular quartz containing small crystals of cerusite, assaying up to 80 ounces of silver per ton, was met with at the northern end of the ore-body, between the 80 feet and 60 feet levels. Small vughs, filled with clay resembling lithomarge and having a finely laminated appearance, occurred in various parts and towards the centre of the ore; this clay averaged 11 ounces of silver per ton.

Native silver occurred sparingly in superficial coatings on the wall-rock and quartz near the tile-ore. In the same locality, a few small specimens of chalcotrichite in capillary crystals, associated with cuprite, were found.
The gossan-ore was devoid of show-specimens and contained no "mullock;" its average value per ton was:—Silver, 30 ounces; gold, 20 grains; copper, 2 1/2 per cent.; and lead, 5 to 6 per cent.

The ore-body as a whole presented a banded appearance, running parallel with the bedding-planes of the wall-rock; it was divided into parallel floors from 2 to 5 feet apart, horizontal near the fault, and they dipped southward 30 to 40 degrees near the shaft. These floors in several instances were found to correspond with joints in the wall-rock, being continuous with them. In the softer portions of the ore-body, they were filled with clay, but in the harder portions the floors were often 1 1/2 inches apart and generally filled with carbonates of lead and copper.

The walls, although somewhat irregular, were fairly well-defined, the ore but rarely adhering to the rock, and showed no general movement; the joints in places showed slickensides: as did also the bedding-planes at the southern end of the lode. Most of the movements and slickensides appeared to have been caused by pressure from the ore-body itself, as these crushings were local and occurred generally where the ore curved outwards.

At the 60 feet level north (Fig. 3, Plate VI.) the ore passes to the right and left of a mass of crushed shale. At this point, for a space of 3 feet, there is no marked difference between the rock and ore, the former gradually passing into the latter, the colour of the rock changing from grey to dark blue-brown or brick-red and so merging into the gossan. The joints and bedding-planes in the rock are lined with steatite, the rock containing numerous grains and small pockets of blende and pyrites at this point. The rock is greatly crushed, and appears as if it were squeezed and bent round by the growth of the ore-body.

A little soft and friable sulphate-ore occurs where the zone of oxidation commences; beautiful crystals of native sulphur were found lining the joints in the ore, also sulphate of lime. Below these products of decomposition, the sulphides occur massive; they consist of a dense compact, finely crystalline body of galena and blende, containing patches and parallel bands of an intimate mixture of copper- and iron-pyrites; a few isolated patches of a coarser-grained variety of galena and blende occur occasionally. The floors and joints are lined with pure white silicate of alumina, which is soft and gives an acid reaction.

The ore-body appears to be underlying rapidly towards No. 2 shaft and has made along the fault at the bottom-level (142 feet) thus connecting the two ore-bodies. The average value of the ore (sulphide) per ton is:—Silver, 16 ounces; gold, 1 dwt.; copper, 2 per cent.; and lead, 5 per cent.

Between the 90 feet and 142 feet levels, the hanging-wall rock is greatly crushed and collapses when the ore is removed, or frits away until the siliceous claystone is reached. At the lower level, on the foot-wall side, a band of rich auriferous mispickel occurs; and this is the first time that this mineral has been seen in the mine. The following is an analysis of the sulphide-ore from No. 1 shaft:—

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>26.35</td>
</tr>
<tr>
<td>Sulphur</td>
<td>27.83</td>
</tr>
<tr>
<td>Iron</td>
<td>24.57</td>
</tr>
<tr>
<td>Zinc</td>
<td>11.40</td>
</tr>
<tr>
<td>Lead</td>
<td>6.46</td>
</tr>
<tr>
<td>Copper</td>
<td>2.20</td>
</tr>
<tr>
<td>Oxide of manganese</td>
<td>1.19</td>
</tr>
</tbody>
</table>

No. 2 Ore-body.—The gossan-ore extended to a depth of 60 feet below the surface, and did not differ materially from that of No. 1 lode. It was smaller than the latter,
contained more lead carbonate, and was more irregular in shape, the foot-wall being well defined between the 60 feet level and the surface, and the ore underlying slightly to the west.

At 40 feet south from the shaft, at the 56 feet level, the ore appeared to cut out, but later developments proved the existence of a parallel vein of ore, overlapping No. 2 lode, projecting past it inside the foot-wall, and separated from it by about 4 inches of shale. It was from 8 to 12 inches wide by 20 feet long, and when stoped towards the surface opened out into a large body of good ore resembling No. 3 lode in character. As the surface was approached, the overlap gradually disappeared until the two ore-bodies almost touched each other.

At the 142 feet level, the sulphide-ore which had been rapidly thinning out has again increased in size against the fault, and appears to be widening as the shaft goes down. At the present depth of the shaft (190 feet), the ore assays 100 ounces of silver per ton, and contains more iron-pyrites than usual (Fig. 5, Plate VI.).

No. 3 Ore-body.—This lode is situated 200 feet south of No. 2 shaft. The outcrop consisted of a few large ironstone-boulders, differing in appearance from No. 1 lode and showing no copper stains. These

were embedded in stiff clay, which contained fragments of ore scattered through it, and assayed from 6 to 18 ounces of silver per ton.

In general character this lode was similar to No. 1, but the walls were better defined, showing a greater amount of movement between the 50 feet and 142 feet levels. As the ore was stoped towards the surface the hanging-wall was very irregular, and in several places the ore extended beyond the shale-beds into the more siliceous claystone, forming irregular pockets of sandy, friable lead carbonate with minute quantities of ruby silver, which crumbled away when touched.

During stoping operations at the 50 feet level, a record of the daily assays was kept showing the distribution of the silver in the lode (Fig. 6, Plate VII.). The limit of oxidation was 75 feet below the surface (Fig. 7, Plate VII.), which corresponds, taking into account the difference in level, with 90 feet in the No. 1 lode.

The sulphide-ore has been explored to the same depth as the No. 1 lode, which it much resembles in appearance, but it contains less zinc, more copper- and iron-pyrites, and assays higher in silver. At the 142 feet level, the ore has been opened up for a distance of 150 feet, averaging 5 feet wide, the ore reaching up to the fault, which has a greater extension eastward than in the upper part of the lode. This ore-body is divided by horizontal floors having a slight southerly dip; they are generally lined with silicate of zinc and in several instances form cavities, the floor of which was strewn with fragments of the ore cemented together by the silicate of zinc.

For some weeks, a steady flow of carbonic acid gas proceeded from these joints near the centre and eastern corner of the drive; and, as the work progressed, this discharge was traced to a fissure in the country-rock on the eastern side of the level. It has been flowing for about 4 months, and still continues.

The vein-walls—shales—at this level are somewhat chloritic, and appear to have been subjected to great lateral pressure. This crushed and broken country, according as the width of the ore varies, extends back a foot or more to the siliceous claystone, which presents a hard smooth surface, being a case of "walls within walls." As the ore is stoped, the shale falls away from this second wall in large and small, elongated, lozenge-shaped masses. Here, as elsewhere, are small bedded veins of milky quartz, seldom containing metalliferous minerals, which frequently show small horizontal planes of faulting. Another interesting feature in connexion with these beds is the occurrence of oviform pebbles, and boulders of quartz which show faulting.
No. 4 Ore-body.—This ore-body was met with in prospecting to the north-west along the fault at the 60 feet level from No. 1 shaft, at a distance of about 66 feet from the end of the level. It was very irregular in shape, possessing no defined walls, the wall-rock being saturated with metalliferous minerals in proximity to the ore, and containing pockets of carbonate of lead (Fig. 8, Plate VII.). Its length was 30 feet and its average width 3 1/2 feet; it extended to within 37 feet of the surface, and pinched to about 6 inches in width at 20 feet below the 60 feet level, where sulphide-ores made their appearance. The gossan was extremely dry and friable, and resembled that of No. 3 lode in character, but contained more lead and less copper, zinc and silica.

A small patch of lead carbonate was mined at the surface between the Nos. 1 and 4 shafts; it extended to a depth of 30 feet below the surface at the fault, gradually pinching out, and having little lateral extent.

Summary.
The ore-bodies at the Silver Spur mine are splendid examples of lodes formed by replacement of country-rock.

Here is a line of fault crossing shales of varying composition, by which mineral-bearing solutions have reached the shattered beds. The minerals have dissolved out, and taken the place of, the aluminous shales, and in so doing have assumed their very habit and appearance. The floors, joints and cracks of the shales reappear in the ore, and thus in many cases can be seen running continuously from the shale into the ore.

It would even appear that the formation of ore is still going on, both above and below the oxidized zone, as evidenced in No. 1 lode at the eastern end of the 60 feet level, and in No. 3 lode at the 142 feet level.

The plans and sections attached will speak for themselves, and render plainer what has been said above.

Plates VI. and VII.[between pages 134 and 135]

Figs. 1 and 2.—Showing outcrops of ore-bodies, and also below the surface at about the various levels. The plan (Fig. 2) includes the latest developments at the 200 feet level.

Fig. 3.—No. 1 ore-body at the 60 feet level, showing the bedding-planes of the shales following the outlines of the ore in places. The shales on the north between the gossan and the fault, blend with the gossan at the extremities of the beds, the change being so gradual as to be hardly distinguishable. The shales are jointed with veins of steatite.

References.—a, Silicious quartz ore, averaging 30 to 40 ounces of silver per ton. b, White quartz, seamed and lined with oxide of iron, poor, c, Pockets of lithomarge, assaying 11 ounces of silver per ton. d, Showing alteration of shales into gossan, near contact with ore; there is no clear line of demarcation, the replacement being very gradual, e, Unaltered shales.

Fig. 4.—Section of No. 1 shaft along line A-B, Fig. 3 (60 feet level, No. 1 ore-body). The quartz from the 60 feet to the 90 feet level was poor in metallic minerals; the sulphide-ore contained over 20 per cent. of zinc near the centre of the ore-body.
Fig. 5.—Longitudinal section between No. 2 and No. 3 shafts up to the fault. The sulphide-ore is in contact with the fault at the 142 feet level.

References.—A, Fault, north of No. 3 shaft. B, Fault, north of No. 2 shaft.

Fig. 6.—Plan of the 50 feet level, No. 3 shaft, showing assay values of the gossan-ore in silver.

References.—a, Average ore in this zone, 45 ounces of silver per ton. b, Average, 60 ounces of silver per ton. c, Average 90 ounces per ton. X, is placed where native-silver occurred.

Fig. 7.—Longitudinal section along the strike of No. 3 ore-body, between the surface and the 70 feet level. The horizontal shading shows the ore pinching somewhat like the keel of a ship; these portions of the ore were high in silver.

Fig. 8.—Plan of the 40 feet level, No. 4 ore-body, the appearance being as near the original as possible. There is no faulting apparent along the joints to the west in contact with the ore. The wall-rock appears everywhere to have been eaten into and replaced by the mineral solutions.

In drawing these plans, accurate measurements were taken every 2 feet (and less) and no trouble was spared to make them as complete as possible.

APPENDIX.

Since January, 1898, No. 2 shaft has been sunk to the 200 feet level, and drives have been opened out in an easterly and westerly direction along the fault, proving the existence of large payable bodies of ore. This ore is similar in character to the sulphides at the 150 feet level, containing, however, more carbonate of lime, iron-pyrites, and arsenical pyrites, with small irregular masses of proustite and pyrargyrite. Several of the smaller ore-bodies at this level occur along cross-joints, instead of following the bedding-planes of the shales. As heretofore, they appear to be confined exclusively to the blue shales.

The fault at the 200 feet level, although irregular in dip, may be considered as vertical; the throw has not yet been determined, but the writer believes that the displacement is slight, and that the ore-bodies have been formed subsequent to the faulting.

The meeting was then closed.

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THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
Held at Furness Abbey, July 12th, 1899.

Mr. J. L. HEDLEY, Vice-President, in the Chair.

The Town Clerk of Barrow (Mr. C. F. Preston) wrote that he was requested by the Mayor (Mr. Alderman Chapman) to say that an official engagement prevented him from attending the meeting of members that morning.

The Secretary read the minutes of the last General Meeting.
Mr. W. Leck read the following paper on "Fire-damp in the Iron-ore Mines of Cumberland and Furness":

FIRE-DAMP IN THE IRON-ORE MINES OF CUMBERLAND AND FURNESS.

By J. L. HEDLEY and WM. LECK, H.M. Inspectors of Mines.

The visit of The North of England Institute of Mining and Mechanical Engineers to the Furness district was suggested to the writers as a desirable and opportune occasion on which to present a short paper dealing with above subject from an essentially practical standpoint.

To many people, however, and probably to none more so than to the bulk of the persons employed in connexion with the iron-ore mines of Cumberland, the title of this paper will appear as somewhat of a misnomer, inasmuch as the majority of Cumberland iron-ore miners have, happily, never come into contact with the dangerous gas known as firedamp.

Until last year, indeed, the Cumberland iron-ore mines, with one exception, were entitled to claim entire immunity from the visitation of this insidious and unwelcome agent.

The exception referred to is the Montreal mine, situate at Cleator Moor, and, although gas has from time to time been noted there, it should be mentioned that no accidents have been recorded, probably owing to the fact that the officials, having a practical knowledge of the nature and properties of fire-damp, take the precaution to carefully inspect with locked safety-lamps any place where it is likely to generate or accumulate. Montreal enjoys the unique distinction of being both a coal and iron-ore mine, both minerals being drawn up the same shaft.

The only other iron-ore mine in Cumberland where fire-damp has been reported is at Hodbarrow, by far the largest and most important metalliferous mine in the district. It was not until August, 1898, that for the first time the presence of gas was there discovered, and then a small quantity, which had collected in a cavity in the roof, ignited at a miner's candle. The injuries inflicted were very slight, and the man went on with his work.

Most of the Furness iron-ore mines have had some experience of firedamp, but not in large quantities. Although the accumulations of fire-damp in these iron-ore mines have never reached such an extent as to create the dreadful havoc and destruction too often experienced in coalmines, yet the records show that fire-damp is a factor which must be reckoned with in winning iron-ore in this part of the district.

During the last 7 years 10 accidents from explosions of fire-damp in iron-ore mines have been reported, whereby 12 persons were more or less seriously injured. The only fatal accident from this cause which has occurred in the district took place at the Mouzell mine, near Dalton, in 1888, when a man was so severely burned that he succumbed to the injuries received.

There can, the writers think, be no question as to the source or origin of fire-damp in the iron-ore mines hitherto investigated.

At Montreal mine, Cumberland, the iron-ore is found in close proximity to coal, the coal-fault forming the boundary of the iron-ore. In this mine, the geological formation is an all-sufficient explanation of the presence of gas, and it is not surprising that under these conditions gas is met with in working the iron-ore.

The methods adopted in mining the softer ores of Furness are largely the same as those in use at the Hodbarrow mine, in Cumberland, and the presence of gas, at both
of these places, may be directly traced to the same cause, namely, the
decomposition of mining-timber, especially in places where water is percolating.
The accidents investigated have all occurred in places where old and decaying
timber was present in large quantities, and in no case has gas been discovered in the
Furness iron-ore mines in opening out new or virgin ground.

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The reason why gas has not been found at the Hodbarrow mine, until recently, is
probably owing to the fact that this mine is younger than those in Furness, where
explosions have occurred, and the process of decomposition of timber is not
therefore so far advanced.
Fire-damp being lighter than air, would naturally be expected near the roof, and
especially in rise-workings, hence the writers find that most, though not all, of the
accidents occurred through small quantities of gas collecting amongst the old timber
which forms the roof of ordinary working-places.
These mines are all worked with open lights, and the actual explosion has usually
been caused by the miner pushing his candle into the interstices or cavities among
the roof-timber—of course in complete ignorance of the fact that gas was lodging
therein.
Old workings, which had been abandoned for some considerable time and were only
partially closed, were, on being reopened, responsible for some of the accidents, and
although, as previously observed, the gas is not met with in large quantities, there
was sufficient to inflict on the persons concerned more or less serious burns.
In view of the peculiar nature of the accidents, and owing to the fact that they may
occur at any moment, inasmuch as the miners, generally speaking, have had little
experience of fire-damp, it behoves the officials responsible for the management of
each mine to take precautions similar to those adopted in coal-mines, and to have
each working-place examined with a safety-lamp prior to the commencement of
ordinary work—proceeding on the prudent assumption that as gas is generated in the
mine, its occurrence may be expected in any part thereof. The practice of examining
part of the mine with safety-lamps and part with open lights is unwise, and has been
the cause of many accidents in coal-mines in the past.
Good ventilation is, of course, essential in every mine, both for the health of the
workmen, and in order that pernicious gases may be safely diffused, nevertheless
the above-mentioned precaution should never be relaxed.
In conclusion, the writers may be permitted to express the hope that—inasmuch as
the Metalliferous Mines Regulation Act, 1872, has never been amended, so far as its
safety-provisions are concerned—an amending Act may become law at an early
date. The provisions of the existing Act are unsatisfactory and incomplete, and
although the writers have pleasure in stating that mine-owners, as a rule, have gone
far beyond its requirements, so far as the safety of the workers is concerned, it is

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at the same time exceedingly desirable, in the interests of all concerned, that an Act
of a moderate nature should be passed with the view of bringing the regulations
affecting metalliferous mines into line with modern requirements.

Mr. Henry Ayton (Newcastle-upon-Tyne), with regard to the last paragraph in the
paper, thought that there was already too much legislation relating to mines. H.M.
inspectors of mines admitted that owners and managers of mines exercised greater
precautions than they were required to do. by Act of Parliament, and he did not see
why they should ask the Government to make them do compulsorily what they were
at present doing voluntarily.
Mr. Cedric Vaughan (Millom) said that the accident described in the paper was the first which had occurred from the accumulation of gas in the Hodbarrow mine, but since the paper was written, a second accumulation had been found, in a drift in close proximity to old workings. Its presence was ascertained in time by means of a safety-lamp, and steps were immediately taken to clear the place of gas. The occurrence showed that where there was a quantity of old timber in process of decomposition, the presence of gas was to be suspected, and steps should be taken to guard against its accumulation. The Hodbarrow mine had been working for about 40 years, and gas had only been discovered on the two occasions mentioned.

Mr. W. I. Barratt (Millom) supposed that the suggestion as to the examination of the working-places only referred to portions of the mine where the presence of gas was known.

The Chairman (Mr. J. L. Hedley) said that the suggested examination would apply to all working-places.

Mr. J. Cartmell Ridley (Newcastle-upon-Tyne) said that it would be of interest to have an exact description of the gas and of the reactions occurring from the decaying timber.

Mr. Bennett H. Brough considered that the authors' paper was one of very great value in that it directed attention in a practical manner to the fact that gas was met with in metalliferous mines more frequently than was usually thought to be the case. In a paper* contributed to the Institute 10 years ago, he had given a history of the occurrence of gas in metalliferous mines, and brought forward evidence to show that all the occurrences observed were not due to the same cause, but might be explained by eight different hypotheses, the one most generally applicable being that the decomposition of timber in a mine, in a manner similar to the decomposition of vegetable matter in marshes, might produce fire-damp which would accumulate in cavities. Messrs. Hedley and Leek's observations tended to support that hypothesis. It was also supported by the recent observations of Mr. J. Libert,* who recorded five cases in which fire-damp had been encountered in iron-ore mines in the province of Namur, and also by those of Mr. Lodin,† who described gas-explosions in the mines of pisolitic iron-ore in Alsace. That hypothesis was, however, not applicable in all cases. For example, Prof. G. Nordenstrom‡ had recently found that inflammable gas issuing from borings in the Dannemora iron-mines contained 33.6 per cent. of marsh gas and 66.4 per cent. of nitrogen. In that case, the gas had certainly not been derived from the decomposition of timber under water. It was curious to note that gas-occurrences similar to those described by the writers had been observed in metalliferous mines more than 200 years ago. Thus, the celebrated Jesuit, Athanasius Kircher, devoted a chapter of his great Latin work Mundus Subterraneus (1678) to mine-gases, and described the occurrence of inflammable gas in the Herrengrund copper-mine, near Neusohl, in Hungary. Gottfried Moller in his treatise De aere fodinarum metallicarum noxio (1730) described an explosion of gas at an abandoned shaft in the Carl adit at Sandberg. According to Stelzner's Beobachtungen uber Grubenwetter (1786), 12 miners lost their lives by a fire-damp explosion in a silver-mine at St. Andreasberg in 1694. The occurrence of fire-damp at the Idria mercury-mines and at the Weitwiesen iron-mine in Salzburg, was also recorded. In all these ancient examples, the origin of the gas appeared to have been similar to that of the fire-damp in the iron-ore mines of Cumberland and Furness. Reference to them might, therefore, perhaps not be out of place in the Transactions.

Mr. George Scoular (Whitehaven) asked if gas had been found only in wet or damp mines. Many of the iron-mines in the Whitehaven and Furness districts were quite dry, and it would be well to know if it was safe to reckon upon immunity from gas in such mines.


Mr. Miles Kennedy (Ulverston) remarked that he had always found the gas in the driest parts of the iron-ore mines.

Mr. W. E. Walker (Whitehaven) remarked that in Cumberland his experience had been that gas was only produced where the timber was dry and he had never found it where the timber was wet.

Mr. W. Leck, replying to the discussion, said that there had been practically no legislation with reference to metalliferous mines since the passing of the existing act in 1872. More than a quarter of a century had elapsed since that time, and with the advent of a new generation, different conditions had arisen, which necessitated further legislation. It was certainly true that most mine-owners were in advance of legal requirements, but a new act would bring up some of those owners who were somewhat laggard, and it was only fair that all should be put under the same conditions.

He was unable to give the composition of this gas, as it had hitherto been impossible to obtain a sample for analysis. The gas had always been found in small quantities, and was therefore easily diffused. In every accident which he had investigated the gas had been dispersed before his arrival.

Actual experience of these accidents showed that the gas accumulated for the most part in places where water was exuding from the roof. In one case, which occurred recently, the working-place was absolutely dry when the men went away at night, but when they returned the next morning they found that during their absence a piece of stone had fallen from the roof, leaving a small hole through which water was percolating. A miner pushed his candle into the hole, and an explosion occurred, by which he was burned. The water evidently assisted in the decomposition of the timber which produced this gas, and so far as they could ascertain, the latter was of the same nature as ordinary fire-damp.

Mr. G. Scoular proposed a vote of thanks to the writers of the paper, and it was cordially approved.

Mr. William Kellett's "Description of the Machinery and Process of Iron-ore Washing at the Park Mines, in the Furness District of North Lancashire," was taken as read.

DESCRIPTION OF THE MACHINERY AND PROCESS OF IRON-ORE WASHING AT THE PARK MINES, IN THE FURNESS DISTRICT OF NORTH LANCASHIRE.

By W. KELLETT, Mining Engineer, Wigan.

In the Furness district, the iron-ore produced is, except as to a small percentage, sufficiently clean when sent out of the mines to permit of its being taken direct from the pits to the smelting-furnaces, with no other
dressing than the picking out of any lumps of clay or stone that may be seen when the ore is tipped from the small mine-waggons into the railway-waggons. In some of the deposits of the district, however, a small proportion of the ore is so mixed with sand and clay as to make it necessary to submit it to a process of washing before sending it to the furnaces, and certain portions of the Park deposit are of this description. The writer proposes to describe briefly the process adopted for washing such ore.

The separation of the impure portions of the ore, from the good, takes place in the underground workings, and the impure ore is sent out of the pit as “washer-ore,” and carried direct to a common depot near the washer. This depot consists of a series of hoppers into which the ore is tipped, and whence it is run into small waggons or bogeys which are taken up an incline-tramway to the uppermost floor of the washing-shed by means of an endless wire-rope.

At this point, the process of disintegrating and washing the ore begins. The ore is tipped slowly into a Blake stone-breaker, and a stream of water is passed with the ore between the jaws to assist it through. The action of the stone-breaker is to crush the clayey lumps and make their after-disintegration easier.

From the breaker, the ore, along with a stream of water, drops into a trough in which revolves a shaft furnished with cast-steel blades or cutters, which help to break up the clayey lumps and secure a regular feed to the revolving-drum, into which the ore next passes by means of a feeding-chute. The revolving-drum is the essential part of the washing machinery. It is a tube made of boiler-plate, 19 feet long and 4 1/2 feet in diameter, furnished on the inside with a double-threaded screw or worm made of 3 inches angle-iron, riveted to the drum at a pitch of 20 inches. The spaces between the threads of the screw are furnished with spikes, also riveted to the drum. The intake-end of the drum is narrowed by means of an end-plate to 2 feet 4 inches in diameter, and the last 4 feet of the discharge-end of the drum is perforated with 5/8 inch holes. The drum is carried on two sets of rollers travelling in steel rings riveted on to the body of the drum, which is made to revolve by cogwheel gearing at a speed of 9 revolutions per minute. The drum is placed slightly on an incline, the discharge-end being elevated 19 inches above the intake-end. A powerful stream of water is supplied near the discharge-end, and flows out underneath the feeding-chute at the intake-end. The action of the drum is to roll, disintegrate, and travel the material forward in the midst of the flowing water, which, passing out of the narrowed end of the drum, carries along with it the finer portions of the sand and clay which have now become reduced to a slime.

As the washed ore approaches the discharge-end of the drum, it traverses the perforated space, and is there subjected to a riddling process. What passes through
the holes goes off to the jiggers, and the rougher portion is discharged on to a reciprocating picking-table, where any stones and unreduced clayey lumps are picked out, and the cleaned ore drops from the picking-table into railway-waggons. The unreduced

clayey lumps are dropped into a disintegrator, which is placed underneath the picking-table, and the discharge of this disintegrator is elevated to the intake-end of the revolving-drum to go again through the washing process. The material to be jigged is a mixed mass consisting of good ore and numerous pieces of quartz containing a percentage of iron, but far too high in silica to be of any value for smelting, and the object of jigging is to throw off these particles of quartz and other impurities. For jigging purposes the material is classified into seven different sizes, and

each size is dealt with by a separate jigger. The separation into the first four sizes is effected by means of revolving trommels or perforated drums, 4 feet long and 23 inches in diameter with 3/8, 1/4, 3/16, and 1/8 inch holes respectively: the finer sizes are separated out by means of pointed boxes supplied with a jet of water, and attached to the bottom of a trough along which the fine material is made to flow. The jiggers are of the ordinary piston or pulsating type and have three compartments in each. The jigger-sieves are made of perforated plates, the holes in the plates supplied to each jigger corresponding with the different sizes of the material that has to be dealt with. The good

ore from the jiggers is made to discharge into tanks, and is then raised by elevators to a sufficient height to fall into the railway-waggons. The very fine material which passes beyond the jiggers is conveyed to a propeller-buddle, which consists of a revolving shaft furnished with iron arms, at the end of which are fixed thin iron blades which traverse the material sideways along a sloping surface, down which flows a stream of water carrying off the impurities. The whole of the machinery is operated by a semi-portable Roby engine with a cylinder 11 inches in diameter and 16 inches stroke. The several parts of the machinery are brought into connexion by means of belts and pulley-wheels and cog-wheel gearing. The quantity of material that can be dealt with in a day of 9 working hours is about 110 tons. The quantity of water supplied to the different parts of the machinery amounts to about 400 gallons per minute. The waste from the washer is all concentrated in a discharge-trough, the rougher portions are extracted by passing the water through watertight bogeys, which, when full, are tipped on to a waste-heap, and the finer portion of the waste is taken to the sea along a line of troughs. The photographs supplied will help to illustrate the principal parts of the machinery.

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The average working cost (excluding renewals to machinery) is 10.81d. per ton of clean ore delivered. The average percentage of clean ore is 64.42 per cent. of the "washer-ore" put in, showing that there is 35.58 per cent. of waste stone removed in the washing process.

The Chairman (Mr. J. L. Hedley) proposed a vote of thanks to Mr. Kellett for his description of the ore-washing plant, which the members were to inspect.

The vote of thanks was cordially adopted.

Mr. Jas. Davison read the following "Description of the Pumping-plant at the Stank and Yarlside Mines in the Furness District of North Lancashire":

DESCRIPTION OF THE PUMPING-PLANT AT THE STANK AND YARLSLDE MINES IN THE FURNESS DISTRICT OF NORTH LANCASHIRE.

By JAS. DAVISON.

The iron-ore mines of Furness are situated within the area of the Carboniferous Limestone of the district. This limestone is thickly-bedded and traversed by numerous vertical joints, in which there is frequently more or less open space. It is also subject to weathering, and lends itself to the formation of subterranean channels and caverns by percolating waters. These channels in many instances extend long distances and penetrate to great depths, forming underground watercourses which drain the surface of the country and convey large quantities of water into the mines that come in contact with them. There is also in the western part of the district a considerable fault running in a northerly and southerly direction, by which the limestone is thrown down westward to unascertained depths, and the Permian sandstone overlying it is brought into juxtaposition with the limestone on the eastern side of the fault. This sandstone is also proved to be a very heavy water-bearing rock.

The Stank and Yarlside mines are situated in the south-western corner of the Carboniferous Limestone area, close to the great fault, and extend eastward along the course of several veins. The workings of the mines have from time to time come into contact with several large caverns and underground watercourses, as described above, and considerable quantities of sand and water have been liberated on several occasions in the course of the development of the mines. Strong dams of concrete and brickwork, with heavy doors of pitchpine plated with steel to close on such emergencies, have been built. In one instance the volume of water that came away after blasting in one of the bottom-levels was so great that the men had barely time to climb the ladders to the upper working. The door, put in to protect the pumps, being open for the purpose of approach to the workings where the men were engaged, and there being no time to close it, the water rose so rapidly that in 15 minutes there was over 90 feet of water in the shaft. The pumps were worked for a month under water, without lowering it, and finally a diver was employed to go down and close the door.

The large quantity of water that has now to be dealt with being unforeseen in the earlier development of the mine, engines and pumping-plant of comparatively small size only were provided; but, as necessity has arisen, one pumping-engine and plant after another has been erected until, at the present time, there are 6 and sometimes 7 engines delivering water to the surface. About two thirds of the water is pumped from the 720 feet level and one-third from the 420 feet level. The quantity of water
pumped varies from a maximum of 6,860 gallons per minute in winter to a minimum of 4,940 gallons in summer. The average quantity per minute pumped during 1898 was 5,662 gallons, which is equal to over 8,000,000 gallons in 24 hours; and the maximum quantity in winter is 9,878,400 gallons in 24 hours. Adit-levels are brought to the pumping-pits from the lowest points of the adjoining valleys, to shorten as much as possible the vertical distance of pumping. The following table describes the types of engines and pumps with which the mines are now furnished and their dimensions:

[Table omitted]

No. 11 Pit.—In addition to the above pumping-plants, there is also an auxiliary horizontal engine (with a cylinder 25 inches in diameter) formerly used as a winding-engine. This has been compounded and geared 5 to 1 to work two 24 inches rams, each 5 1/2 feet stroke, pumping from the 720 feet level to the 558 feet level to supply the two 20 inches rams at the No. 10 Pit. The No. 5 Cornish and the No. 11 Hathorn-Davey are the two pumping-engines (each one of its type) which do the largest amount of work. No. 5 pumping-engine averages throughout the year 5 strokes per minute, and delivers 238 gallons each stroke, equal to 1,190 gallons per minute to an average vertical height of 382 feet. No. 11 engine averages 6.27 strokes per minute, and delivers 267 gallons each stroke, equal to 1,674 gallons per minute, to a vertical height of 550 feet. The average duty of these two engines is about equal. The following remarks on the different types of engines now at work at these mines are offered for the consideration of the members:

(1) Engines with geared wheels, pumping-shafts, cranks, etc., where heavy pumping is concerned have been found very unsatisfactory and expensive in working and repairs; the various and severe strains set up in the several working-parts are almost sure to lead to occasional if not frequent breakdowns, and the transmission of power from part to part must occasion loss. The experience gained at these mines is in condemnation of the use of the geared engine for heavy pumping.

(2) The Cornish engine is well adapted to its work, but being only single-acting it cannot do as much work as a similarly sized double-acting engine will do. Its action during the stroke is more irregular and violent than the Hathorn-Davey engine, causing greater shock in the pump, and making it necessary to divide the pump into shorter lifts. The ponderous beam and strong building necessary to carry it occasion greater outlay in erecting this class of plant, and in case of loss of the load in the pit the result is often a very serious breakdown. With these exceptions, and as regards repairs in an ordinary way and the matter of duty, the engine does not appear to be inferior to any other type of engine.

(3) The Hathorn-Davey engine is double-acting, and therefore a much smaller engine of this type will do the same amount of work as that done by the larger single-acting Cornish engine. In addition to this, it allows of two rams being used, which discharge into the same delivery-pipe; there is also less shock in the pumps, owing to the more uniform speed during the stroke: consequently longer lifts can be used, which means fewer clack-boxes, rams, stuffing-boxes and glands, and these lessen the first outlay and also the cost in working, and a much cheaper building can also be used to house the engine. There is further the fact
that loss of load in the pump does no damage to the engine, and this has been proved at the No. 10 pit Hathorn-Davey engine on several occasions. This engine has been at work nearly 19 years, and the piston has never been known to strike the cylinder-end. The valve-arrangements on the No. 11 pit Hathorn-Davey engine, which are of the double-beat Cornish type, do not govern the engine as perfectly as the ordinary slide-valves on the No. 10 pit Hathorn-Davey engine. In putting down this type of engine, it has been found that it is very important that the connecting-rods, bell-cranks, gudgeons and bearings be made of the very best materials and of ample size, otherwise a great deal of trouble and expense will be incurred in renewing and strengthening them.

Referring now to the class of pump—ordinary plunger or ram-pumps attached to heavy spear-rods connected to the bell-cranks of the horizontal engine or beam of the Cornish engine, as the case may be, are almost exclusively used. In the smaller pumps, the clack-boxes are placed immediately under the delivery-pipe, and they are furnished with side-doors and hinged flap-clacks, leather "geared" or "grathed." For the larger pumps, chambers are opened in the sides of the shaft for the clack-boxes, which are furnished with heavy top-covers and double-beat valves geared with strips of gutta-percha, set on edge in dovetailed grooves cut in the face of the beat of both seating and crown of valve. The drawings supplied show the arrangement of pumps as fixed in the pit (Figs. 1 and 2, Plate VIII.), and also the details of the valves used in connexion with the 20 inches ram-pumps (Fig. 3, Plate VIII.).

For the Cornish engines, the lengths of lift vary from 240 to 360 feet, but it is found that the shorter lifts are much better in working and are not so troublesome as regards keeping the joints tight and maintaining the glands in good order. With the Hathorn-Davey engine, there is no trouble with blown-out joints in the pumps, although the lifts are over 378 feet in vertical height: they work without shock, and the glands will last for 2 years without repacking.

It has been found that it is desirable that all foundations for heavy permanent pumps should be built on solid rock or cement concrete, and where girders are used that they should be made of wrought iron or steel and never of timber, as with timber it is almost impossible to avoid springing, and thereby causing broken joints and sometimes pipes.

The cost of pumping at these mines averages 1 1/4d. per 1,000 gallons pumped. This is not considered high, having regard to the price paid for fuel owing to the distance of the mines from the coal-fields. The

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duty of the engines is not set forth, as this depends so largely on the kind of fuel used, the temperature of the feed-water, the efficiency of the feed-water heaters, and other conditions which in this brief paper it is difficult to mention in detail. What is more especially aimed at is to set before the members of the Institute, on their visit to this district, the extraordinary quantity of water that has to be dealt with and the means employed to cope with it, and to invite discussion thereon.

The Chairman (Mr. J. L. Hedley) said that the members, on their visit to the mines described in the paper, would be interested in seeing what was being done. He (Mr. Hedley) had seen all the pumping-plant, and he knew how much trouble Mr. Davison had taken over the pumps in times past, and he probably looked upon them almost as his own children. He did not know whether pumps had elsewhere worked for a month under water, but it would be interesting to see what the pump was like, if it was still in existence.

Mr. G. Scoular (Whitehaven) said with respect to Mr. Davison's statement about one of the Hathorn-Davey engines stopping when the load in the pit had been lost, he had had a somewhat similar experience, but the engine, in his case, had not
behaved quite so well. The differential gear was, no doubt, a very excellent one, but it was altogether too much to expect that it would act in time to prevent disaster in the event, say, of the pump-rods breaking. He had found it necessary to place buffer-beams in the pit strong enough to arrest the weight of the falling-rods, and he would like to know how Mr. Davison had overcome the difficulty. He would also be glad to know if Mr. Davison had found it necessary to place safety or relief-valves upon his clack-boxes. His (Mr. Scoular's) experience had been that spring-loaded relief-valves were a great protection to the castings. When from any cause, such as the pumps drawing upon air, the ram came down with a shock upon the water, the intense pressure which would thus suddenly accumulate is relieved by the instantaneous action of the spring-loaded relief-valve and a probable splitting up of some of the castings averted. Mr. Davison's cost of pumping was very low, and no doubt much of this economy was due to the efficiency of the feedwater-heaters to which he had referred in his paper. He (Mr. Scoular) would like to know if the exhaust-steam passed through the feedwater-heater on its way from the cylinder to the condenser.

[Plate VIII.- Diagrams of Pumps at Stank and Yarlside mines]

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steam-engines encumbering the mouth of the shaft and ponderous pump-rods conveying the power to the pumps, he would like to hear what some of their electrical engineering members had to say on the subject. A dynamo placed in some convenient situation on the surface, driven by a comparatively small high-speed steam-engine or other available means, a cable conveying the power to the underground motor-driven pumps would seem, in many respects, to be an improvement. There was, however, the almost always threatening danger of drowning the underground pump, and he feared there would be some difficulty in working an electric pump for a month under water, a feat which Mr. Davison had accomplished with the existing type of pump at the Stank mine.

Mr. Cedric Vaughan (Millom) said, with reference to the gearing or grathing of valves, that it was found at Hodbarrow that when the gearing was set on the seat of the valve it did not last so well as when it was set on the crown. The reason for the change was that when the gearing was on the seat it was found when pumping sand-and-water that the gearing was beaten out of shape in from 24 to 36 hours; they noticed that in valves of the butterfly type, with the gearing on the top, the valves lasted a much longer time, and it occurred to him that the gearing in the double-beat valve might be transferred to the crown. Accordingly that was done, and since the change the same valve would pump sand-and-water for a week, whereas previously it would not pump for over 36 hours without being beaten out of shape. He would like to ask whether Mr. Davison found that occur in his case, and whether the gearing on the seat of the valve was punished in the same way. It was the first time he had heard of gearing on both seat and crown, and he would like to know Mr. Davison's experience as to how long the gearing lasted. Leather was used for the gearing.

Mr. H. Ayton (Newcastle-upon-Tyne) said that in pumping with a Cornish engine at Wallsend colliery there had been two breakdowns, caused by the losing of the load, and in both cases the piston was broken. Since then a controlling engine had been erected, but when the load was lost a second time the piston was again damaged. They did not pump so large a quantity of water at Wallsend collieries as that described by Mr. Davison, although the engines were capable of pumping 4,000 gallons per minute. Husband valves were used with four faces, the object being not to allow the valves to rise too far. The four faces were lifted simultaneously, and a sufficient quantity of water was released to run through all the faces. The bottom part of the valve was lined
with white metal, which could be run in and turned down at small cost. Even when pumping sand-and-water the valve acted efficiently, but the pumping-engine did not work so economically as he would like.

Mr. G. S. Corlett (Wigan) said that he had erected electric-driven machinery to deal with volumes of about 1,000 gallons per minute, and he was not aware of anything like 4,000 gallons per minute being dealt with electrically at any one installation in this country. He did not think that anyone had yet constructed electric motors of the size that would be required, and which could be satisfactorily operated under water. It was possible to build electric motors to produce from 10 to 50 horsepower, which would run satisfactorily under water; but he did not think anyone had attempted to build motors of sufficient size which it would be safe to run under water. He hoped to have the opportunity of looking at the pumping-plant in detail, because he did not think that the question of electricity, as applied to such installations, had been very carefully considered by mining engineers, and he was inclined to think that they would be largely guided by what might be termed their previous experience. They knew what a steam-plant could do, but they did not know what an electrical one could. He did not know of any motors which had been running for any length of time under water, but he was at present running an enclosed and hermetically sealed motor—that at full load—which had not been opened for a month. It would be quite feasible to run such a motor under water, as water afforded a ready means of dissipating the heat.

Mr. J. S. Jeans (London) said that Mr. Davison stated that it had been found desirable that all foundations should be made of wrought-iron or steel girders. He would like to know how far iron and steel girders had superseded timber in this district for various purposes, and whether there was any general movement for the superseding of timber in the future.

Mr. J. Davison, replying to the discussion, said that he could scarcely account for Mr. Scoular's Hathorn-Davey engine, which did not protect itself from striking the end of the cylinder. The load had been lost at the No. 10 pit by the valves sticking, and no accident had occurred. They used buffers at the end of the slide bars, made of india-rubber and oak-timber, and in addition they inserted strong catch-logs in the shaft (6 feet deep by 2 feet wide of solid oak) and wings on the pump-rods, which in the case of the engine over-going the stroke, took the weight of the pump-rods, but they had never had a blow from that engine. He could not say the same for the No. 11 pit engine, but the accident was attributable to the gear. When they lost the load suddenly the weight was so great that it was almost impossible to prevent the engine from striking the end of the cylinder.

Berryman feed-water heaters were used, and tended materially to reduce their costs. The discharge-water from the condensers was not used in the boiler, as pit-water was used for condensing, and was not fit for boiler use. Town water was used in the boilers.

With reference to the pump working in water, the plans (Figs. 1 and 2, Plate VIII.) showed the pump and also the pump-rods working below. The water was 90 feet above the bottom of the shaft, and the pumps worked for a month at the rate of 8 strokes per minute, under water, until they came to the conclusion that it was of no use to pump any longer: a diver was then sent down to close the door referred to in his paper.
In Fig. 3 (Plate VIII.) it would be noticed that gutta-percha was used in the seating and in the crown as well, as experience with the valve had proved that these were the right positions. The valves supplied by Mr. Davey were geared with strips of leather in the crown of the valve, but this arrangement proved that these were unsatisfactory, and having a large quantity of sand in the water it necessitated their constant renewal. Two strips of gutta-percha were then placed in the grooves, and between these split copper pegs were driven into the dove-tail cut in the bottom of the groove. The pins held the gutta-percha perfectly tight and it never came out. The bottom of the valve required frequent renewal. In refacing, the valve became too low for the seating and a new bottom part was required. To obviate that loss, he cut grooves, and inserted gutta-percha in the same manner as at the top, and valves so fitted had been in use for two years and six months, and were still quite good.

He was unfortunately able to say that they had had serious breakdowns of the Cornish engines, as described by Mr. Ayton, by losing the load at the lift. All the gearing of the No. 2 Cornish pumping-engine had been broken not long ago from the same cause. He had not had any experience of four-faced valves, but with two-faced valves the lift did not exceed 2 1/4 inches.

At the No. 10 pit, oak-timber foundations were used with a span of 6 feet. There was a brick pillar under the bottom valve, and when the engine was making a forcing lift, these timbers yielded, and the joint gave way at the point x (Fig. 1, Plate VIII.). Of course in condemning the use of timber-beams he only referred to their use in connexion with permanent heavy pumping. In erecting a new pumping-plant he was compelled to use iron girders or steel beams, so as to avoid risk of breakage of joints and pipes.

Mr. H. Ayton sympathized with Mr. Davison in regard to the fractures of the joint indicated. It had been remade on several occasions at the Wallsend collieries. On one occasion, the whole column of pumps had to be raised, so as to allow them to remake that joint. He recommended the use of iron girders made of ship iron of the coarsest obtainable quality, in order that acid mine-water could exert the least possible effect on the girder. The girders used at Wallsend colliery were 5 feet deep and 40 inches wide at the top, and upon them the ram-case was placed, but the greatest difficulty had occurred from the springing of the girders, as Mr. Davison had explained, and the resulting fracture of the H joint.

Mr. J. Davison said that he had considerable experience in pumping sand-and-water. Within three weeks of starting the No. 10 pump and the Hathorn-Davey engine, they came across running-sand, and for a week the engine was pumping sand-and-water.

Mr. Cedric Vaughan asked Mr. Davison whether he had pumped sand-and-water since he used gearing both at the seat and crown of the valve. Mr. J. Davison said that they had pumped sand-and-water, but not in so great a volume.

Mr. Cedric Vaughan said that the effect of pumping sand-and-water with the gearing on the bottom of the valve was very severe.

Mr. J. Davison said that he used gutta-percha and found that the sand became bedded in it, making it almost as hard as iron, and it lasted a very long time.

The Chairman proposed a vote of thanks to Mr. Davison for his valuable paper, and the resolution was cordially adopted.

The following paper by Mr. C. E. de Rance on "The Geology of Furness" was taken as read:
Lancashire-over-Sands, or the old Liberty of Furness, is physically part of South Westmoreland, just as the northern part of the latter is physically part of Cumberland, the drainage running respectively north and south from the central watershed of Westmoreland to the sea, through the two counties named.

The Furness boundary of the county of Lancashire follows valleys for the most part:—the Duddon to the west, Langdale valley to the north, the west side of Windermere to opposite Bowness, where it crosses the lake, and then the watershed, and follows a tributary stream of the river Kent to the south-east.

The district is drained by the Leven on its eastern side, which, out of an area of 202 square miles, contains 190 square miles of Silurian rocks, 10 square miles of Carboniferous Limestone, and 2 square miles of Hawcoat Sandstone.

The Ordnance Survey Catchment-basin map, prepared for the Duke of Richmond's Royal Commission on London Water-supply in 1867, and subsequently published separately by the Survey, includes in this basin of the Leven the small stream draining the Cartmel Valley, the Carboniferous Limestone district of Grange terminating to the north by a north-west fault, ranging to Newby Bridge. To the west, it thins out on the Bannisdale Slates, along a line ranging from Cark to Cartmel. The former place is on the Hawcoat Sandstone, extending to Flockburgh, where it rests on the Carboniferous Limestone. Between Holker and Ulverston, the river Leven occupies a broad flat valley, in which are mounds and patches of Carboniferous Limestone.

Following the left bank of the river Leven from its mouth, Windermere Lake is reached; it is 10 5/8 miles in length, and lies in a valley, excavated by the agency of running water; over the portion of the valley, concealed by the waters of the lake, is a rock-basin, excavated below the level of the outfall of the lake at Newby Bridge, and due to the erosive action of glaciers during the Glacial period. Whilst employed on the Government Geological Survey of a portion of the Lake District, the writer sounded the lake, and found its deepest part to be opposite Wray Castle, on the western shore, where a depth of 39 fathoms, or 234 feet, was obtained, a depth greater than that of the English Channel between Folkestone and Boulogne. The surface water of the lake is 134 feet above Ordnance datum (mean sea-level), and the bottom of the lake is consequently 100 feet beneath, being a true rock-basin, the foot of the lake being 0.2 of a foot below the head, and the overflow running away in a river-cut slot. The analysis of Windermere waters by the Rivers Pollution Commission gives only 4 degrees of hardness, and only 2.4 degrees of permanent hardness. The upper portion of the lake has a clear rock bottom, and glacial groovings maybe often noticed near Brathay, through its clear waters. At Bowness, the bottom of the lake is filled with fine white felspathic mud, or kaolin, resembling the material that might be expected if old china-plates were put through a pug-mill. The late Dr. Miller, F. L.S., found growing on this the quillwort (Isoetes lacustris, L.) The habitat of this plant is the bottom of alpine and subalpine lakes from North Wales to North Siberia, and marks a survival of the Arctic flora introduced by the Glacial episode in Furness.

It is worthy of note, that the representative of the subgenus of the salmon family living in Windermere, known as the charr or Salvelini, or Salmo Willughbi (Gunther), also occurs in Cumberland lakes, at Loch Bruiach in Scotland, and is closely allied to S. Colii (Gunther) from the Irish loughs and the Eske, all of which are glaciated
countries, and point to their survival, on the retreat of the ice, at the close of the Glacial episode.

Just at the county boundary, the river Brathay is seen cutting a gorge in the Lower Volcanic Series at Skelwith Force, and following that river up to its source the sections of that series are disclosed to perfection under the wild and barren Wetherlam. A minor watershed divides the water of the Leven from its tributary, the range passing through the latter hill, north-east to Low Fell, thence across the Tilberthwaite "col," over Oxen Fells across the "col," through which is carried the coach-road, between Ambleside and Coniston, at a height of 1,056 feet.

The Skiddaw Slates, the oldest rocks in the north-west of England, of Cambrian age, consisting of shales and mudstones, were named by Jonathan Otley, after their uprise at Skiddaw. They indicate a passage from submarine volcanic conditions to those of terrestrial and wholly subaerial volcanoes.* Though forming the mountain of Black Combe,


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in Cumberland, so salient an object to the north-west, from a long coast line in Lancashire, they do not cross the Duddon, and are consequently not present at all in Lancashire. They are supposed to represent the Tremadoc Slate Series and Lingula-flags of Wales.

Overlying these rocks in northern Lancashire are "the Volcanic Series of Borrowdale," so named by Messrs. Harkness and Nicholson in 1872, which were previously known as the "Green Slates and Porphyries" of Messrs. Otley and Sedgwick. They can be nowhere better studied than in the belt of country lying in North Lancashire, between Brathay on the shore of Windermere, where they are overlain by the Coniston Limestone series, to Yewdale, north of Coniston, the outcrop of the latter being well marked by the old lime-kilns, set up for the purpose of producing agricultural lime, before the introduction of railways, and the entrance of lime from other counties.

The uppermost stratum of the volcanic series is a massive breccia, and extends over a wide area; beneath it are the Tilberthwaite Slates, which furnished the covering of St. James's and Kensington Palaces and many of the earlier London mansions. They are thicker than the North Wales slates, and are remarkable for the beautiful stripes of the component beds and the minute faulting that they have undergone, which is generally "reversed." The writer called the attention of Mr. J. J. H. Teall, F.R.S., to them in 1884, and he described one in the Geological Magazine.* The writer has deposited several of them in the Museum of Practical Geology, Jermyn Street, London. In these measures the copper-bearing rocks of Coniston occur, which have been worked probably since the time of the Romans. At the entrance of the Tilberthwaite valley from Yewdale, the writer discovered some years ago visible gold in a blende vein, which was most favourably spoken of by the late Sir Andrew Ramsay, F.R.S., the late Sir Warington Smyth, F.R.S., the late Professor Morris, F.G.S., and the late Mr. John A. Phillips, F.R.S., but owing to the experience at that time happening on the Duke of Sutherland's estate in the north, the writer did not disclose the site. He thinks it advisable, however, to record the general fact, as processes now in existence may render what was useless a quarter of a century ago a commercial success at the present time.

In the Furness portion of the English Lake District the sequence of Silurian rocks is as follows, in descending order :—
The Kirkby Moor Flags, 1,000 feet thick.
The Bannisdale Slates, of no commercial value, 5,000 feet thick.


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The Coniston Grits, so named by Prof. Sedgwick from Coniston in Lancashire, where they are well exposed, 4,000 feet thick.
The Coniston Flags (Brathay Flags, of Prof. Sedgwick) are fairly cleaved, and form good flags at Brathay quarries, near the head of Windermere; they are over 2,000 feet thick.
Stockdale Shales, so termed by Mr. W. T. Aveline from their occurrence at that place near Windermere; they average 200 feet, but are very variable; in North Wales they are the Tarannon Shales.
Graptolitic Mudstones—they were so named by Prof. Harkness in 1868—are 40 feet thick and well seen at Skel Gill near Ambleside, and at Applethreeworth Beck, near Yewdale, Coniston; at the latter place they rest on the Coniston Limestone, with a calcareous gritty base.
Ashgill Shales, so named from Ashgill, 3 miles south-west of Coniston, are 200 feet thick, and pass into the grey crystalline Coniston Limestone, which, with its associated shales, reaches another 200 feet. These beds form the uppermost member of the Lower Silurian system in this district, there being an unconformity at the top, as pointed out by Prof. Hughes, in this immediate area. The late Mr. John Bolton of Ulverston pointed out that the Coniston Limestone* was formerly used for cement and agricultural purposes, and was the first to note the occurrence of hematite in it at Millom.

Mr. W. T. Aveline was the first to point out that there is an unconformity between the Coniston Series and the Borrowdale volcanic Series below it so far back as 1872. The late Prof. Phillips stated that the superior hardness of the rocks forming the Borrowdale Series was the cause of the picturesque mountains of the Lake District, and the variety of their outline. These, for the most part, are beyond the Furness boundary, but are the visible frame to that area looking northward.
The Carboniferous Limestone plays an important part in the scenery at Grange and Cartmel, and a still more important part commercially in the district lying between the Duddon and Ulverstone, in yielding the extensive deposits of haematite-ores.
Miss E. Hodgson, in 1864, in a memoir "On the Glacial Drift of Furness, Lancashire,"‡ pointed out the extreme solubility of the limestone, when remaining long in contact with moisture; and in 1867, published an interesting paper on "The Moulded Limestones of Furness,"* in which she describes the Carboniferous Limestone as flanking the Silurians, in a band 10 miles in length, in the Furness area, and from 1 to 5 miles in width, extending to the seacoast, and rising to 446 feet at Birk Rigg Common. She suggests that, as the beds dip seawards, at an angle of 9 degrees to the south-east, they may form a part of the floor of Morecambe Bay. A representation† is given of the moulded and indented limestone, 7 to 15 feet of pinnacles and clefts, the latter going
down into the "rotten-rock" of the quarry-men, overlying the compact limestone suitable for building-stone, at Tarn Close Quarry, 1 mile north-west of Ulverston, where the rock is over 60 feet thick, notwithstanding that it is only 300 feet from its junction with the slate. She points out that the percolation of waters charged with humus, as first suggested by Prof. Liebig, is a potent cause of disintegration, the ordinary action of frost and lichens at the surface, and of circulating absorbed rainfall in fissures, this latter cause must have an important influence on the distribution of iron in pot-holes and fissurse.[sic]

It is probable that the Windermere united glaciers did not follow the present outfall stream between Yewbarrow and Backbarrow and the Leven, but passed over the flat tract connected by a "col" with Ayside Pool valley, flowing through Cartmel to the sea at Cark.

The river Crake, falling into the tidal portion of the Leven, may be regarded as a separate stream; it drains the valley in which occurs the rock-basin, known as Coniston Lake, the surface of which is 147 feet above mean sea-level, with a depth of 160 feet, or 13 feet below sea-level, while its surface is 13 feet above that of the surface of Windermere. Above the lake rises Coniston Old Man, to a height of 2,633 feet, being the highest point in Lancashire, beneath which is Levens Water, 1,350 feet above the sea, and the copper-mines are drained by Church Beck, which discharges milky water into Coniston Lake.

Westward of the Crake basin is that of the Duddon, the left bank of which alone is in Lancashire, and forms the boundary of the Liberty of Furness, of which the manor of Ulverston forms a part. The name first appears in the foundation-charter of Furness Abbey, bearing date 1126, where it is Latinized into "Fudernesia," pointing to its derivation from the "further ness" or promontory as against "Amounder-ness," the tract lying south of Morecambe Bay, between the Lune and the Ribble. At one period, the Furness Fells formed the boundary between England and Scotland, and so late as 1138 the Scots turned the peninsula into a desert.

† Ibid., page 403.

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The Duddon is 10 miles in length, with an area of 46 square miles, all occupied by Silurian or granitic rocks. Its upper feeder, on the Lancashire or Furness side, rises near the Three Shires Stone at Wrynose, the high "col" between Pike of Blisco and High Carrs, which latter is noted for its large garnets, in the volcanic ash. The estuary on either side of the sand is fringed by peaty alluvial soil up to the ridge of Coniston Grits, on which Broughton-in-Furness is built.

Eastward, small streams occupy an area of 56 square miles, of which 26 square miles consist of Silurian, 22 square miles of Carboniferous rocks, and 8 square miles of Hawcoat Sandstones. The area so drained has an extensive coast-line for its size, commencing near Baycliff and trending south-west by Aldingham, part of which has been eroded by the sea, by Newbiggin, where a stream comes from Gle斯顿 Castle, thence north-west to Roose, west to Barrow-in-Furness, then north of Cocken and Ormsgill, to the estuary of the Duddon.

Between Haverigg Point and Walney Island, a distance of 3 1/2 miles, are the Duddon Sands, extending seawards in a convex curve, broken in the centre by the Duddon Channels, which unite near the middle buoy, and are joined by the Scarth Channel, flowing in from the north-end of Walney Island and draining at low-tide the sand-banks between that island and the mainland as far as Palace Nook, east of which these sands drain at low tide in the opposite direction, flowing into Walney Channel. This, after receiving the Barrow Channel, flowing between the Isle of Barrow and the mainland, becomes the Peel Channel, which from Roe Island
(attached to which is Peel Pier) turns south, and flows past the south-east corner of Walney Island, passing over Peel Bar to the open sea. Walney, west of this channel, is 8 miles in length, ranges south 30 degrees east, and is covered with sand-dunes, rising to 50 feet above the sea, resting on Boulder Clay, and underlain by Keuper or New Red Marl, containing thick deposits of rock-salt. The western coast is straight, the eastern deeply indented; the Salt-measures are cut off to the east by a fault, which crossing Morecambe Bay, also cuts off those of Preesal, near Fleetwood, being a downthrow west, bringing up the Red Sandstone to the east. These Red Sandstones of Hawcoat and St. Bees were considered by Messrs. Murchison, Sedgwick and Harkness to be Permian; and it is of interest to note that the current number of the Geological Magazine* contains a letter from the veteran geologist, Mr. W. Talbot Aveline, F.G.S., formerly in charge of the north-west of England,


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including the Furness area for the Geological Survey of England and Wales in which he entirely dissents from the view now taken by the Survey, that they are referable to the Trias and to the Bunter portion of it. The writer regrets that he is compelled to still more strongly dissent from the views of his former chief, and to refer these beds to the Keuper as stated recently in your Transactions. In this relation it is curious to note the see-saw of geological opinion as to the exact horizon of these Red Sandstones of St. Bees Head and Furness. In 1832, the Rev. Prof. Adam Sedgwick gave a plate in his paper "On the New Red Sandstone Series in the Basin of the Eden and the North-western Coasts of Cumberland and Lancashire,** in which Fig. 1 ranging from south-west to north-east, from St. Bees Head to Whitehaven gives, in descending order:—

No. 11. New Red Sandstone resting on gypseous marls.
No. 10. Magnesian Limestone.
No. 9. Lower New Red Sandstone.
No. 8. Coal-measures.

Consequently he regarded the St. Bees Sandstone as undoubtedly Triassic, and beds Nos. 10 and 9 as Permian, to employ the names now used for these formations. And at page 396, Prof. Sedgwick states that "the gypseous marls are surmounted by sandy marls . . . overlaid by a great thick bedded freestone . . . these upper rocks are identical with the finest specimens of the New Red Sandstone of Lancashire and Cheshire, of Low Furness, Appleby and Carlisle." In 1864, Sir Roderick I. Murchison, in his introduction to a joint paper with Mr. R. Harkness, "On the Permian Rocks of the Northwest of England and their extension into Scotland,"† in placing the Upper Red Sandstone in the Permian, admits that up to that time they had always been coloured as Bunter Trias, and that the change has been made without any evidence from a fauna or a flora, but simply to carry out his triplicate arrangement of the Permian. There being at Barrowmouth, a Rothliegende below the Magnesian Series, therefore a theory was made that the superior bed must be Zechstein, whether it was fossiliferous or not. Now, in the maps and memoirs of the Geological Survey, these beds are again relegated to the Bunter Trias, and still more recently the writer has ventured to place them a stage higher, namely, the Keuper,

while Mr. Aveline, whose opinion is of great value from his wide and varied experience, still supports the views of his former colleague, Sir Roderick Murchison, as already stated.

Whatever difference of opinion there may be as to the age of the rocks above the Magnesian zone, this does not apply to those below it.

Sir Roderick Murchison (loc. cit.) gave an early description of the Permian "crab-rock" at Park, from about 1 1/2 to 2 miles north of Furness Station, on the Furness Railway—angular fragments of Carboniferous Limestone, cemented above but interspaces below, resting on the solid limestone below, the breccia being locally known as the "crab rock." It is well seen at St. Helens, 1/2 mile to the north of the Park cutting, immediately east of the railway, and also at Dalton. Sir Roderick Murchison points out that joints, fissures, and caverns were formed before the era of the crab-rock, and became subsequently filled with haematite, an opinion formed by Prof. Phillips as far back as 1857.* The crab-rock, as pointed out by the late Prof. Henry Alleyne Nicholson,† is overlain at the village of Stank by Middle Permian yellow Magnesian Limestone, consequently the infilling of the iron is of Permian, or pre-Permian, age.

As regards the iron-ores, both of the Coniston and Carboniferous Limestones of the Furness district, Mr. J. D. Kendall, F.G.S., M.E., has adduced such a mass of material in his work on the Iron-ores of Great Britain and Ireland;‡ and in various papers published in the Transactions of various scientific societies, that the writer feels there is no need to refer to this portion of the subject, as all must realize that Mr. J. D. Kendall has collected a wonderful mass of facts, whether all the conclusions he draws from them are agreed to or not.

This communication has been suggested to the writer as being possibly useful to members attending the general meeting. He has had the advantage of knowing the district for over 30 years, and being officially connected with it on behalf of the Geological Survey, and of meeting many of the original observers, amongst others the late Sir Roderick Murchison, the late Prof. Harkness, the late Mr. Binney, F.R.S., the late Mr. Bolton of Ulverston, and Mr. Talbot Aveline, who is still present with us to write the last published communication on

‡ London, Crosby Lockwood & Son, 1893.

the geological aspect of Furness. The writer hopes that this paper will be taken as an introduction to that just issued on "The Occurrences of Anhydrite in the North of England."**

The Chairman moved a vote of thanks to C. E. de Rance for his valuable paper, and the motion was cordially adopted.

Mr. G. Scouler proposed a vote of thanks to the owners of mines and works to be visited, and also to the Furness Railway Company for the arrangements which had been made for the transport of the members during the meeting.

The Chairman seconded the motion, which was carried with acclamation.
Mr. C. Vaughan moved a vote of thanks to Mr. Hedley for presiding, and the motion was cordially adopted.

The following notes record some of the features of interest seen by the visitors to mines and works, etc., which were, by kind permission of the owners, open for inspection during the course of the Furness meeting on July 12th and 13th, 1899:

HODBARROW IRON-ORE MINES.

The mines were first discovered by the occurrence of veins of ore on the shore. The late Earl of Lonsdale worked one of the veins at Towsey Hole. He eventually gave up the venture, and granted a take note to the founders of the Hodbarrow Mining Company, Limited, in 1855.

A shaft was sunk on the same vein, and the shaft and engine-house were still visible. As the vein was followed it began to nip out, and boring became necessary. The late Mr. Wm. Barratt observed that the veins were converging towards the west, and put down a bore-hole into 100 feet of solid ore, and so discovered the present mine in 1856. This deposit produced excellent ore, and while the company were working this mine workmen's houses were built without knowing what was beneath them. While sinking a well to supply these houses with water, another large deposit was found by means of a bore-hole, put down at the bottom of the well with the view of increasing the water supply. Afterwards other bore-holes were put down, and it was found that there was a very large deposit of ore.


The first-discovered deposit was comparatively shallow, with not more than 60 feet of cover over it at any part, and in one place it came almost to the surface. The second deposit was also a good one, and it overlapped the third deposit, which was much larger and considerably deeper, the cover being about 200 feet thick. The longest section of uninterrupted ore-ground occurred in a north-and-south line. At the northern end the ore-deposit abutted against Carboniferous Limestone, and was covered with sand and clay, until it ran under the sea-wall and out to sea.

Before the sea-wall was erected, a barrier of ore, 360 feet wide, was left along high-water mark so as to protect the mines from the sea, the deposit being worked on the system of caving-in (by which the ground was allowed to fall in after the ore was removed). It was recognized that a large quantity of ore was left to protect the mines from the sea. At that time the sea was encroaching on the sandbanks, and timber revetments were erected to protect the ground from the sea. The first sea-wall was built for the purpose of working this belt of ore 360 feet wide, and it had answered its purpose admirably. Sir John Coode was the engineer, and it was his last work, for he finished it just before he died. It was a novel piece of engineering, being a combination of a wall and a water-tight dam.

The wall was made of concrete in mass, and it was carried down to a bed of clay varying from 18 to 22 feet below the surface of the shore. Inside the wall was a bank of puddled clay which was pinned down into the clay below the bottom of the wall. In addition, a row of pitch-pine sheeting (12 inches square) was driven down 6 or 7 feet below the bottom of the concrete wall, so that the sea was absolutely cut off, and if any water by chance got through the sheeting, it was cut off by the puddled clay and trench. The sea-wall was supported by the backing of clay and a timber revetment, the latter of which, however, had not proved of much use. The idea was that if any water came over in a high storm it would fall on the asphalt pavement and be stopped by this revetment, scuppers being provided for returning this water into the
sea. By means of the sea-wall they had been able to practically take out the whole of the ore within its area. While this working was proceeding, borings were made beyond the sea-wall, and they proved the seaward extension of the ore at depths varying from 13 to 109 feet. It was sufficiently proved that there was a large seaward deposit of ore, but the extent of the ore-ground had not yet been fully proved. The new scheme proposed the erection of another sea-wall, which would exclude the sea from a larger area. It might be thought rather foolish perhaps to decide finally upon such a scheme before one knew how far the ore extended, but there were reasons why it would not be wise to enclose a larger portion than that contemplated. The most important consideration was navigation, and nothing could be allowed which would imperil the navigation of the Duddon estuary. As the ore went seaward it passed under a limestone roof, which began about the line of the existing sea-wall like the thin edge of a wedge, and it increased in thickness seaward until it became over 100 feet thick. Consequently, if the ore did extend beyond the second seawall it would be possible to work it out beyond the barrier with so thick a roof of limestone. The second sea-wall, when it was made, would enclose an area of about 170 acres. The mode of construction would not be the same as the old wall, as a more flexible structure would be less liable to fracture under certain circumstances. It was proposed to form a main bank of limestone rubble, faced with blocks of concrete pitched pell mell so as to break the force of the sea; there would be an inner and smaller embankment of slag or limestone; and the spaces between the two walls would be filled with clay. In order to make the structure watertight a bank of clay-puddle would be placed in the middle and carried to a height of several feet above high-water mark of ordinary spring tides. The puddled-clay would also be protected by sheet-piling driven sufficiently deep so as to prevent water percolating below it. It was stated that such a dam would be completely watertight during the time that the tide was up. As the tide was intermittent, the pressure of water had only to be resisted for a certain number of hours during each day, and although it might not be watertight against a constant pressure it would be so against the intermittent pressure of the tides. About 12 months ago, while working the ore-ground on the western side of the mine, a run of sand came into the mine, and as runs of sand had previously occurred northward, no special precautions were deemed necessary. However, one morning the shore—outside the sea-wall—caved in, and there was a clean run of sea-water under the sea-wall into the mine. Fortunately it was found out almost as soon as it occurred, the hole was filled with gorse and clay, and the rush of water was checked. Although the ground continued to cave in all round the original depression until almost an acre of ground had subsided, the depression was filled up and made perfectly watertight. The most alarming feature was that the wall began to crack owing to undermining; but fortunately the process of filling up went on sufficiently fast, and the subsidence was arrested: all that had happened was the formation of a crack in the sea-wall. Messrs. Coode, Son & Matthews, the successors of Sir John Coode—the engineer
who built the wall—advised that it would stand sufficiently well if it were not exposed to shocks from the sea, and in order to prevent that occurrence blocks of concrete were thrown out so as to protect the wall from the sea. A large quantity of clay was also tipped inside the sea-wall, so as to make it quite safe, and the influx of water had been stopped.

Owing to this accident, the new structure would be placed as far seaward as possible, so that if ever similar runs of sand were encountered there would only be the enclosed area to contend with.

Under the pinnel, where there was no limestone, the caving-in system of mining was adopted; but under the limestone-roof the American system of mining and timbering would be adopted. The American system of timbering had been tried experimentally in other parts of the mine and found to answer admirably, except that it would not withstand side drag; but in the virgin ground beyond the first sea-wall it should prove very satisfactory. There was little doubt, however, that the limestone-roof originally extended all over the deposit, and that the limestone had been denuded over the northern portion by glacial action. At the Red Hills quarry, the upper surface of the limestone was deeply scored with glacial marks, and was ground perfectly smooth. At Hodbarrow point the surface of the limestone was polished perfectly smooth, and the glacial striae all pointed in one direction. There could be no doubt that the great ice-sheet had stripped the limestone off the ore, leaving it exposed over the northern area, and carrying away a certain portion of ore with it. This was clearly indicated by the fact that the overlying pinnel or Boulder Clay was deeply stained with ore. A solid pillar of ore would be left under the point of the limestone-roof, and the American system of mining and timbering would begin seaward of that line. This barrier would keep the timbering apart from the drag of the old mine.

The bore-holes south of the present sea-wall had passed through the iron-ore into limestone and thence into conglomerate, the lowest member of the Old Red Sandstone. This occurrence was interesting, as it pointed to the removal or absence of the strata intervening between the Carboniferous Limestone and the Old Red Sandstone. Possibly it may have been removed by a previous ice-age, as Sir Robert Ball suggested that ice-ages recurred at intervals of 25,000 years.

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The members also visited the Red Hills limestone quarry of the Millom and Askam Hematite Iron Company, Limited; the steel-works, Park, Stank and Yarlside iron-ore mines of the Barrow Haematite Steel Company, Limited;* and the Roanhead iron-ore mines and colour-works of Messrs Kennedy Brothers.


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APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PAPERS.

EDUCATION OF MINING ENGINEERS.

The present writer is an advocate for practical work, but he considers that theoretical instruction must accompany it. Students cannot be set to test governors, gas or steam-engines, without some previous knowledge, and this must be imparted either orally or by a course of lectures. Can mechanical teaching at mining schools, with its necessary theoretical accompaniment, be expanded in such a way as to render these experiments useful to the student? Or would it be better simply to instruct him how to carry out the trial, just as an ordinary workman is taught to make a chemical analysis? The latter course, if followed, would assuredly prove futile. On the other hand, if the mining engineer is to enjoy a scientific training outside his own special line, and trials of heat-engines are to be added to it, they will alter the curriculum, because they require much time and special knowledge. The question must be decided by the practical necessities of the case.

The engineer of a cotton-mill, for instance, will confine himself to a study of the looms under his charge. If he wishes to test a particular lubricant, it will not be worth his while to make the trial himself, but he will send a sample to a testing-station, where a quicker and better analysis will be carried out by trained experts. In the same way, a mining engineer should test his iron, but trials of the lubricant used, covering of steam-pipes, or action of the governor, should be left to others. Technical schools should be managed on the same practical lines. In the chemical laboratories attached to the mining-schools the pupils do not analyse indiarubber, petroleum, paper, etc., though all these are used in mining. In the same way, they should confine themselves in the mechanical laboratories to what is of importance in their profession, such as the testing of different kinds of iron, to which, in the writer’s opinion, they might add a study of steam-engine indicators, and of the tensile strength of materials.

In the Vienna schools, technical drawing forms part of the second year’s course, and follows geometry. A preliminary knowledge of the laws of projection is essential, otherwise a draughtsman cannot draw correctly. In Germany, technical drawing is taken in a student’s first year, but a knowledge of geometry is presupposed. Whether the course of study in technical high schools should extend over three or four years is a question often discussed. The writer is of opinion that three years are not sufficient. The hours of study of a third year’s student in a German school are:

From 8 to 10 a.m., lecture on electro-mechanics; 10 to 12 a.m., lecture on engines, pumps, fans, etc.; and from 1 to 6 p.m., work on the same subject with the same professor. These hours represent an average sample of the plan of work, but they are certainly too long. In the Austrian mining-schools, the term of study was formerly always four years, and it was not found that a student entered the profession too late. In a technical school, the student should never be overburdened with lectures and preparation, and his studies should be thoroughly and therefore quietly pursued. Time is required to assimilate his knowledge and make himself familiar with the literature of the subject, and this cannot be effected in a hurried three years’ course.

B. D.

EARTHQUAKE AT SINJ, DALMATIA, 1898.


This earthquake took place on the morning of July 2nd, 1898, and wrought considerable damage to buildings, etc., in the Sinj or Ravnica plain, and in the area immediately south of it on both banks of the Cetina river. The peripheral zone of feebler intensity was characterized by the limitation of the damage to roofs, some built of thatch, others of badly-laid stone flags. The next zone, going towards the epicentre, was indicated by cracks in the rough-hewn stone walls of the houses and
by partial collapse of small cottages. Within the zone of greatest seismic intensity there were wide gaping fissures in the house-walls, and many a cottage was reduced to a mere heap of ruins. This zone includes such villages west of the Cetina as lie along either slope of the divide between the Vojnic and the Ravnica basins. The damage, both in distribution and in kind, was exactly similar to that which is typical of most well-known earthquakes. Once again, and by abundant examples, the old-established rule was confirmed that buildings erected on loose soil or rubble suffer far more than those founded on solid rock.

Large numbers of pebbles from the alluvial deposits were hurled into the air and showered on the fields around; masses of rock were snapped off from the crags and tumbled into the roads. Cracks and fissures in the ground were observed in several localities along the south-western rim of the Ravnica plain, but the soil, softened by the rainy weather that followed upon the earthquake, soon closed up again. Small circular depressions, too, were formed; and many springs turned muddy, while others fluctuated up and down in their yield of water.

The author gives a detailed description of the geological features of this district, but this can hardly be studied to advantage without the aid of the Austrian Geological Survey map. The strata appear to be chiefly Cretaceous limestones, Nummulitic limestones, marlstones, and breccias, with a vast development of Neogene marls and conglomerates and other Tertiary freshwater beds. Within the area are comprised also the terminal portion of a ridge of Werfen beds (Alpine Trias), and two spurs of Muschelkalk. A review of the tectonic geology of the district shows that we are dealing here with a portion of the earth’s crust, which is cut up by a network of faults into a great number of fault-blocks (schollen of German-speaking geologists), thrust against each other both horizontally and vertically. The present period of earthquakes, ushered in by premonitory tremors during many previous years, is to be regarded as a new phase of the

"creeps" which have been going on in the fault-block area of Trilj ever since Neogene times; and the immediate cause of the earthquake of July 2nd last is probably a movement of the massif which lies between the radial faults of Kosute and Trilj. This is precisely one of those fault-blocks which, as far back as the Neogene, were depressed in relation to their surroundings, and have been subjected to much sagging since then. It appears possible that a slight downward sag of this fault-block, combined with lateral pressure, took place; the amount of thrust varying at the various boundaries. The motion was more or less transmitted to the neighbouring fault-blocks, and they, especially such as lay to the north-west, underwent slight thrust. Yet we are told that the transmitted shocks appeared to have been most violent in the area south of the sagging fault-block. The circumstance that regional depressions were not perceptible at the surface is explained when one bears in mind that the area is covered with a mantle of comparatively recent plastic formations, whereby the step-fault in the underlying rocks will have been masked and smoothed over.

The great majority of descriptions of the main earthquake point to undulatory motion, but in the area of highest seismic intensity one finds also records of an up-and-down movement preceding the wave-motion; and all agree in stating that a great rush of wind and a rumbling noise preceded the earthquake.

The innumerable after-shocks appeared to have been conditioned by the gradual return of the rocks to a state of equilibrium. Thence would ensue thrusts in the neighbouring fault-blocks, and this would explain how it is that some of the aftershocks were more distinctly perceptible away from the epicentral area. That the movement was easily transmitted along the strike of the beds, there being but few obstacles to check or deflect its course, is clearly shown by the isoseismal
curves which have been plotted out. Eastward, the shock appears to have almost
died away in the huge alluvial deposits of the Ravnica; and those reports which
represent the earthquake as having come from a direction diametrically opposite to
the epicentrum, really go to prove that there were reflex waves.

L. L. B.

EARTHQUAKE AT AND NEAR BRUX, BOHEMIA, 1896.
Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Clidsse der kaiserlichen
Akademie der Wissenschaften, Wien, 1897, vol. cvi., abtheilung i., pages 46-59, with
a map in the text.
This earthquake occurred shortly after 9 p.m. on November 3rd, 1896, along the
slope and crest of the Erzgebirge in the district north-west of Brux, and the author's
description is based on the reports sent in from 14 different localities. Negative
evidence, by help of which the limits of the disturbed region may be plotted out, is
forthcoming from a great number of Bohemian localities where no shock was
observed. The reports are exceptionally trustworthy, as they emanate from the
observers appointed by the Earthquake Committee of the Vienna Academy of
Sciences; and the scheme of organization adopted by that committee for the
accurate observation of seismic phenomena over the whole of the Austrian empire
was already in full working order.
The disturbed area is practically elliptical in form, its greater axis extending for about
25 miles from Reitzenhain to Hochpetsch, and its shorter axis for about 13 miles from
Gorkau to Ossegg. Most of the reports agree in stating that the main shock,
accompanied by a rumbling noise like the roll of thunder, was followed a few minutes
later by a similar though feeble shock. In the Alexander

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pit, at 240 feet below sea-level, the effect was that of a tremendous thump from
under the floor of the mine, with a simultaneous shivering motion.
The account from Niedergeorgenthal differs from all the others in recording the
occurrence, at 6.30 p.m., of a thrust-movement from south-west to north-east and
back again in the space of 2 seconds. Then at 8.55 p.m. took place, from north to
south, a second shock, beginning with a noise like thunder, and followed by a
subterranean rumbling. Close upon this came a violent shock in a southerly direction,
causing a great clatter of glasses, crockery, etc. This was equivalent to the main
shock of other localities. The final shock, at 9.10 p.m., was very slight, with a
tremulous motion. Looking at the map, Niedergeorgenthal appears to be one of the
localities which lie nearest the presumed epicentre.
The direction taken by the earthquake is mostly reported as north and south, but
there are many reports giving it as south-east and north-west, while a few from the
very edge of the Erzgebirge state the direction variously as east and west, north-east
and south-west, or south-east and north-west. No damage to buildings was done, but
small objects were displaced, clocks were stopped, stove-pipes, etc., were cracked.
In the Trupschitz collieries, timbering was thrust out of place, and there were falls of
coal from the roof. In fact, throughout the brown coal-mines of the disturbed area, the
earthquake was so distinctly felt that the pitmen fled for their lives, fearing that the
workings would fall in and bury them.
It appears evident, however, that the movement had its origin in the basement-rocks
of the Erzgebirge, and that the brown coal-basin was only concerned in it
secondarily. This view is confirmed by the reports of premonitory tremors, which were
felt chiefly in the mountains and in the villages nestling at the base thereof. At
Eisenberg, one observer noted no less than 23 such tremors, which he perceived the
more distinctly that his dwelling lies in the heart of the forest, far removed from the usual routes of traffic, and from the vibrations naturally associated with them. Some of the reports mention after-shocks, but the data are not very positive. Several draw attention to the fact that an unusually violent storm was raging at the time of the earthquake, followed by a heavy snowfall. In reference to this, the author supplies a table of barometric observations, taken every 2 hours at Prague, from the 1st to the 6th of November. These show that the preliminary shocks were coincident with a very low barometer, while the main shock occurred with a rising barometer, a few hours later than the registered minimum.

With regard to the geological aspect of the earthquake, Prof. Laube has pointed out that it took place at a point where an anticlinal of basement-gneiss, which farther west forms the southern boundary of the Erzgebirge, is cut off by a fault-fracture striking north and south. Eastward the gneiss-fan is either missing altogether, or present only in fragmentary patches.

L. L. B.

EARTHQUAKE IN THE SOUTHERN BOHMERWALD, BOHEMIA, 1897.

Bericht über das Erdbeben vom 5. Januar 1897, im südlichen Bohmerwald. By Prof. F. Becke. Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der kaiserlichen Akademie der Wissenschaften, Wien, 1897, vol. cvi., Abtheilung i., pages 103-116, with a map. The district over which the observations extended bordered on Bavaria and Upper Austria, and the reports represent the shock as most violent in four localities which lie about a line drawn approximately from northwest to southeast along the first-mentioned frontier. Reports from 30 other Bohemian localities represent the shock as feeble, from 8 localities as very feeble, while 9 localities, situated approximately on an elliptical curve bounding the area on the Bohemian side report no shock at all.

The earthquake took place at 7.45 a.m. on January 5th, 1897. It is described as a tremulous vibration, accompanied by a subterranean rumbling very like the muttering of distant thunder or the rolling of a heavy waggon upon a hard road. Some reports compare the sound to the roar heard in a chimney when it is ablaze. In all cases the rumbling was perceived to be simultaneous with the shock, but its duration was greater. Thus it is that in 6 localities observers claim to have heard the sound before, while others assert that it began only with the shock, and continued after it, dying away little by little.

The account given by observers at Innergefild (a "feeble-shock" locality) differs from all the others, which report uniform vibration, in stating that the vibration was an increasing one, terminating with two dull thuds. Two thumps, following close one upon the other, were also reported from Bischofsreuth; while at Winterberg a kind of lateral thrust was felt, coming from below.

The average duration of the tremor was 4 1/2 seconds. With regard to direction, the accounts vary considerably: thus 5 report it as north and south, 6 as northwest and south-east, 5 as north-east and south-west, 1 as east and west, and another as north-north-west and south-south-east. At all events, the majority of the observations go to prove that the Bohemian area was merely a peripheral portion of the actually-disturbed region, and that the epicentrum lay somewhere in Bavaria, to the south or south-west. This assumption is further confirmed by the marked increase in seismic intensity in a south-westerly direction.

A premonitory tremor was noted at Winterberg at 4.25 a.m. on January 5th, and an after-shock at Eleonorenhain at 6.30 p.m. on January 7th.
No damage was done by this earthquake, but it caused some excitement among the inhabitants of the district, as no such event had occurred there within the memory of man.
The map, which accompanies the paper, summarizes by various graphic signs all the main facts gleaned from the reports sent in.

EARTHQUAKE IN TRIPHYLIA, PELOPONNESUS, 1899.
At 9.48 a.m. on January 22nd, 1899, a somewhat violent earthquake occurred to the province of Triphylia, on the western coast of the Peloponnesus. This portion of Greece is frequently visited by earth-tremors, as, for example, the destructive earthquake of 1886.
The earthquake now described consisted of two violent shocks, the first of which was preceded and accompanied by a loud subterranean rumbling. The motion was undulatory and lasted for 7 seconds. The second shock, following close upon the first, was about the same duration and was accompanied by a similar rumbling, but the motion was more jerky and caused far greater damage.
At the epicentrum, the shock appeared to travel from south-west to north-east, almost at right angles to the major axis of the epicentral ellipse. Prof. Milne's observations at Shide (Isle of Wight) showed that the earthquake travelled to this country at the rate of 1.3 miles per second.

The reports received (on the special observatory forms) from all parts of Greece enabled the author to plot out the isoseismal curves. As usual, these assume an elliptical form, and divide the Peloponnesus into four zones of diminishing intensity. The epicentre was somewhere about Kyparissia, where 53 houses were completely wrecked, 70 rendered uninhabitable, and not a single building remained undamaged. Similar havoc was wrought in the neighbouring villages. At Philiaatra, the walls of all the houses were more or less fissured. Curiously enough, no crevices have appeared in the ground in the epicentral zone, but from Kalamata, in the next succeeding zone, small subsidences occurred, damaging the railway-line, and at Janitza a small fissure was observed in the ground. Springs, in various localities, were temporarily stopped or ran muddy. It was noted that before the earthquake, domestic animals, such as chickens and dogs, uttered cries of terror and ran about as if seeking to escape from some invisible danger.
After-shocks of minor importance continued for a whole week, until January 29th, 1899.

EARTHQUAKES IN CENTRAL ITALY.
On September 21st, 1897, took place an earthquake, having its epicentrum in the Adriatic, about 13 miles from the coast, between Fano and Sinigallia. The shocks were very violent, and much damage was done in the towns of Jesi, Pesaro, Sinigallia, Ancona, and the surrounding country. In the present paper, the author refrains, however, from giving the detailed account, which he reserves for the Bollettino della Societa Sismologica Italiana: his object is to set forth certain important results which may be deduced from the available data.
In the first place, he tabulates all the considerable earthquakes which have occurred during the past thousand years in the provinces of the Marches and Romagna. From
this it appears that at intervals of 100 ± 14 years earthquakes have taken place of a mean intensity of 9.1 in the Rossi-Forel scale. These are succeeded at intervals of 23 ± 10 years by earthquakes of intensity 8 in the same scale. The interval between the first series of earthquakes and the second varies between relatively wide limits, considering the length of the interval itself; but the similar intervals between the major earthquakes may be regarded as fairly equal.

In the second place, he draws attention to the velocity of travel of the seismic waves over distances varying from 18 3/4 to 652 miles from the epicentrum, in the case of the above-mentioned earthquake of September 21st, 1897 (classed as 7 in the Rossi-Forel scale). It is shown that the speed increased with the distance from 0.53 mile to 2 1/4 miles per second. The differences are due to the varying intensities of the initial impulses, and above all to the diverse constitution of the rock-formations traversed by the seismic waves.

L. L. B.

**RECENT EARTHQUAKES IN SWEDEN, 1897-8.**


In addition to the considerable earthquake which made itself felt in Scania and Blekinge on January 9th, 1897, two other earthquakes of minor importance were recorded in Sweden during the same year. One took place at 1.30 p.m. on June 16th in Rackeby parish, in the neighbourhood of Lidkoping, and the other on August 4th, at 3 a.m. in the neighbourhood of Uddevalla. Near the last-named town there was a landslip on a hill which stands over against Hagarne, and masses of rock weighing several tons crashed down upon and destroyed a wooden building. In 1898, earthquakes took place in the provinces of Scania, Northern Bothnia and Western Bothnia, and in the Sundsvall district.

On May 2nd, 1898, between 10.30 and 11 a.m., three distinct shocks were felt at Axelsdahl, parish of Morarp, Scania. The first was the most violent and was of quite unusual duration; between it and the second there was a lapse of 6 minutes; and between the second and the third an interval of 25 to 30 minutes. The movement seems to have travelled from south-east to north-west: during and after, but not before it, was heard a sound comparable to the noise produced by a heavy-laden waggon rattling over a hard road. A curious point about this earthquake is that persons who happened to be out in the open merely noticed the extraordinary rumbling, but did not feel the vibrations, which were perceived only by persons indoors. Moreover, the tremor was more acutely felt in upper than in lower rooms of dwellings.

On July 4th, 1898, about 10 p.m., two violent shocks, following close one upon the other, were felt at Sundsvall and in the surrounding country. The meagre reports sent in from five localities on a hill which stands over against Hagarne, and masses of rock weighing several tons crashed down upon and destroyed a wooden building. In 1898, earthquakes took place in the provinces of Scania, Northern Bothnia and Western Bothnia, and in the Sundsvall district.

On July 4th, 1898, about 10 p.m., two violent shocks, following close one upon the other, were felt at Sundsvall and in the surrounding country. The meagre reports sent in from five localities agree fairly well. After-shocks were recorded at Berghem on July 6th, and at Nianfors on July 8th, 9th and 17th. Mr. P. J. Holmqvist has pointed out that certain disturbances in the Rapakivi series of rocks of this district, which are evidently of quite recent origin, may well have been caused by this earthquake. As a matter of fact, the Sundsvall district is frequently shaken by earth-tremors, which at times attain a high degree of intensity.

The earthquake in Norrbotten and Vesterbotten took place about midnight of the 4th to the 5th of November, 1898, and most of the accounts received from eleven localities at the Central Meteorological Office agree in reporting two shocks. But they do not agree as to the interval between the shocks, which is variously stated as 2, 5 and even 30 minutes. At Pajala, the second shock was much feeble than the first, the motion was undulatory, and travelled from south-east to northwest. A dull rumbling sound both preceded and followed the first shock, which lasted about 1
minute. From Tarando, the direction of wave-travel was reported as north-west and south-east; from Malmberget, Haparanda, and other localities as west and east; while at Mataregiby it is said to have travelled from north to south. The author does not report any injury to persons or any serious damage to buildings (with one exception) from the foregoing earthquakes. L. L. B.

PROPAGATION OF EARTH-TREMORS FROM LABUAN, BORNEO.


At about 8.30 p.m. (Central European mean time) on September 20th, 1897, and at 6.30 the next morning, the most delicate instruments in the Batavia and Bombay observatories and in several European observatories were perturbed by seismic waves transmitted over a vast area and lasting over a considerable space of time. These were connected with the sudden emergence of a volcanic island near Labuan, on the north-western coast of Borneo. The director of the Batavian Observatory, in communicating to the author the particulars noted there, pointed out that the shocks were purely mechanical in character and not magnetic. Postulating that the epicentrum was not very far off the island of Labuan, in latitude 5° 30’ north and longitude 115° 12’ east of Greenwich, the author calculates a table of velocities and durations, from which it may be seen that the perturbations travelled at rates varying from 10 to 20 miles a second, and lasted from 1 to 4 hours. Comparatively low figures, however, are recorded for Bombay and Edinburgh. The enormous velocities tabulated in the present instance at Home, Nikolaiev, Potsdam, Shide, etc., differ so strikingly from those registered in the case of the Indian earthquake of June 12th, 1897, that the author seeks for an explanation.

Supposing, in the first place, that the quickest seismic waves (the longitudinal waves in the theory of indefinite elastic bodies) are really propagated along chords instead of along great circles, then the difference in the case under review will be, for European localities, sufficiently considerable. Thus, taking the observatory that is farthest from the epicentrum, namely, Shide, in the Isle of Wight, the arc of the great circle which unites it with Labuan is 7,098 miles long, while the chord is only 6,185 miles in length, shorter, that is, by 913 miles, or about 1/8 of the arc. Therefore, the apparent velocity of the seismic waves, on the assumption that they travelled along the chord, should be diminished by about 1/8.

In the second place, the Batavian magnetograph, being much the nearest to the epicentrum of any of the recording-instruments in question, probably began to vibrate during a phase of each perturbation anterior to the commencement of the phase recorded even as near as Bombay. Now, the calculated velocities were based on a comparison of the times registered at the more distant observatories with the times registered at Batavia, and at the moment when the European instruments began to vibrate they were reached by waves of a later phase and of different velocity. Taking the foregoing explanations into account, the true rate of travel would be 6 1/4 miles per second, which precisely agrees with that recorded for the Indian earthquake.

After discussing more in detail the records obtained in the Italian observatories of the periods of oscillation of the quick waves and the slow waves, the author points out that the velocity of the latter (1.55 to 1.85 miles per second) also agrees with that observed in the case of the Indian earthquake. The exceptionally low figures registered at Edinburgh show that the bifilar pendulum there was unaffected until the more pronounced undulations began—slow waves of great amplitude.
The author lays stress, in conclusion, on the advisability of having in all observatories similar recording-instruments similarly conditioned as regards sensibility. The data would then be much more easily comparable, and would enable one to follow the transformation which each phase of the motion undergoes as it travels onward. The uncertainty induced by confusing the various kinds of seismic waves (of different rates of motion) is much greater, in the case of earth-shocks propagated over a great distance, than the error resulting from inaccurate records of the exact time.

L. L. B.

EARTHQUAKE IN HAYTI, WEST INDIES, 1897.
At about 6:30 a.m. on December 29th, 1897, an extremely violent shock (9 to 10 in the De Rossi-Forel scale) was felt in the Yaque valley, which runs in the northern part of the island from east-south-east to west-north-west between the mountain-ranges of Cibas and Monte Cristo, the latter of which cuts the valley off from the Atlantic coast.
The effects of the earthquake were most perceptible along the lower course of the Yaque, but they were fortunately not so disastrous as might have been expected, mainly because the habitations are all built of wood. It is calculated that the position of the epicentre was about latitude 19° 30” north and longitude 71° west of Greenwich. At Santiago, some 20 miles east-south-east of this point, where the buildings are mostly of brick, great damage was done to walls, etc., and several houses had to be pulled down for safety’s sake.
The earthquake made itself felt at Port au Prince 105 miles away to the southwest, where a self-registering seismograph gave a remarkable diagram of 90 seconds’ duration ; and even at Great Turk's Island, more than 125 miles to the northward, the shock though slight was sufficient to stop the clocks. Moreover, seismographs were set vibrating at Toronto, 1,750 miles away, in Ischia and Catania on the Mediterranean, and even as far as Nikolaiev.
The quickest seismic waves travelled to the Italian shores at a speed of about 6 1/2 miles per second. These probably longitudinal undulations were succeeded by the characteristic slow-period waves, those of greatest amplitude travelling at an average speed of 2 miles per second. It is noticeable that the foregoing results agree with the figures obtained for the great Indian earthquake of June 12th, 1897.
There were about forty after-shocks of minor importance, during the space of a month, after which that portion of the earth's crust appears to have resumed its normal equilibrium.
The author proposes to publish a more detailed account of the earthquake in vol. iv. of the Bollettino detta Societa Sismologica Italiana. L. L. B.

FORMATION OF PEAT.
The author describes in some detail the result of his examination of the peat-moss of Fragny, situated east of Autun, at a height of 1,820 feet above sea-level. Among the plants which grow on its surface and swell it with their debris are sphagnum moss, sundew, bracken, reeds, grasses, a little gorse, juniper and heather, a few scattered willows, oaks and birches.
The upper peat-layer, of a yellowish-brown colour, is made up of the frequently recognizable debris of these plants. The lower layer, black when wet, dark brown when dry, is plastic, greasy to the touch, and stains the fingers: it is made up of
debris in an extremely fine state of division. After a description of these, the author tabulates the following conclusions:

1.---The microscopically small debris which make up the black peat are the most durable portions of the dead plants, such as cuticle, liber, spores, pollen, vascular framework, etc. The other tissues have been generally destroyed by various agencies; among others, by the action of microbes.

2.---Unlike many lignites, there is no fundamental cementing-matter binding together the constituents of this vegetable mud. Such matter, consisting of ulmic compounds, is swept away, as soon as formed, in the brown waters which so often ooze out of peat-mosses.

3.---The extremely fine state of division of the organic debris may be considered as the outcome of the work of microbes, and this observation also applies to those varieties of coal whose structure exhibits a similar fine state of division.

4.---The wood that occurs in peat-mosses shows from the surface downwards an ever-increasing alteration: the ligneous tissue being permeated with the mycelium of microscopic fungi. Moreover, such wood exhibits curious modifications of protoplasma, and swarms with micrococci, some of which continue in active motion even after being taken out of the peat. 

L. L. B.

CONSTITUTION OF CANNEL COALS.


The cannels are of more highly diversified microscopic structure than the bogheads, and may be divided into three principal classes. (1) Those containing a number of yellow bodies, chiefly microspores and macrospores, with but few algae. To this category belong the cannels of Lesmahagow, Bryant, Burghley, Cannelton, Ceberga, and Rive de Gier. (2) Those containing organized-matter—pollen-grains, spores and macrospores—mixed with fragments of plant-remains. Example: Commentry cannel. (3) Those consisting of completely dissociated organic elements; e.g., Buena Vista cannel.

The author examined Bryant cannel—under a power of 1,200 diameters—and discovered in the yellow matter of which about one-third of the total mass consists:—

(1) Spherical macrospores, 340u [microns?] in diameter, with enlargements bounding the lines of dehiscence, and with their surfaces furrowed by micrococci.

(2) Smaller macrospores: some measuring 41u, pitted with dark cavities (1.3u in diameter) and containing micrococci (diameter 0.5u); others 48u in diameter, and covered with tiny spikes.

(3) Reticulated macrospores 44u in diameter, resembling the calcified Sphenophyllum of Rive de Gier.

(4) Sub-triangular forms (rare), 33u broad, with enlargements edging the intra-radial space. When open, the aperture exhibits a crown of micrococci.

(5) Microspores, constituting about four-fifths of the total yellow matter, mostly isolated and triangular, measuring 46u by 33u, but sometimes forming tetrads 64u in diameter. These and the macrospores (No. 1) recall those of Lepidodendra and other arborescent Lycopods, and may possibly have been derived therefrom.

(6) A small number of algae, originally globular, but now flattened and hollow, measuring 45u by 25u. They are young Pilas (probably Pilax Scotica) and are filled with micrococci.
The foregoing organisms are infested in many places with the mycelia of thread fungi in the matrix, the filaments being straight or sinuous, single or branched. Short spurs bearing conidia are found on the branches; the individual cells of the latter measure 2.9u by 0.85u. In growing, the filament on entering the envelope of the invaded structure, throws out a branch which splits into two dichotome twigs 2u by 0.8u, bearing conidia 0.8u to 1u in diameter. The whole plant is about 6u long and resembles a minute Botrytis Carnea; the author names it Anthrocomyces cannellensis. It is frequent in Moscow cannel-bogheads, Armadale boghead, etc.

C. S.

CANNEL COAL IN BOHEMIA, AUSTRIA.

Cannel coal has been discovered in the Heinrichgluck pit at Peterswald, in the centre of the Ostrau-Karwin mining district of Bohemia, and is found in conjunction with hard bituminous coal. The strata consist of sandstone, sandy slate and shale, between which the seams of coal, varying in thickness from less than 1 inch to nearly 7 feet, are embedded. The Coal-measures are overlain by Tertiary rocks and diluvium. The seams form a deep depression running in a south-westerly direction, and cut in two by a wedge-shaped cleft. Here a fault occurs, and the northern part of the seam is thrown up nearly 200 feet above the corresponding southern portion, which alone retains its original position, and where the cannel coal occurs, none having been found in the northern division. The seam varies from 4 feet to nearly 7 feet in thickness, and is inclined at a slight angle. The roof and floor are shale, beyond which is sandstone, and Sigillaria, Calamites, and numerous other species of fossil flora and fauna have been found in both divisions of the seam. The cannel coal, which near the fault forms the whole thickness of the seam, thins off, and at last wholly disappears, giving place to ordinary bituminous coal. Near the fault, the seam is about 4 feet thick; the upper part is pure cannel, then a thin band of coarse-grained mineral streaked with cannel, and lastly a second bed of cannel coal. This lower stratum is the first to disappear, but the ordinary and cannel coal are mixed for a considerable distance.

The seam is intersected by two sets of fissures, mostly filled with white calcite and pyrites. One series of fissures runs parallel to the strata, and appears to have been produced during the formation of the coal; the other is vertical, at right angles to the seam, and probably owes its origin to shrinkage.

The cannel coal is of a greyish hue, with dull brown streaks, of low specific gravity, and very firm and tough. Fractured surfaces show a smooth glitter like ebony. It contains much bituminous matter, and chips of it can be easily kindled with a match. The writer is of opinion that cannel, like every other kind of coal, is of vegetable origin, and that the bitumen it contains is due, not to animal remains but to plants rich in resin. This he ascribes to the fact that, during the time the cannel coal was formed, no animals probably existed that could have imparted the large percentage of bitumen found in it.

B. D.

MOSAIC-PAVING, BOHEMIA.

"Red marble," so-called, from Sliwennetz, was used in Prague for water-pipes about 50 years ago. When discarded for cast-iron, the marble pipes were broken up for small paving-stones, and answered the purpose so well that this limestone has long
been regularly quarried at Sliwenetz and elsewhere in the Palaeozoic mountains, near Prague.
All the work is piecework. Formerly, a quarryman was paid from 1s. 3d. to 1s. 8d. for filling a truck 2 feet square and 1 foot high, now, not more than half that price is given. To make this mosaic paving, black, red and white limestones of the Lower Devonian formation are used, and the manufacture is now practically the monopoly of a large firm in Prague. The black limestone is easily worked, and a skilful quarryman can fill from 5 to 10 trucks per day, while not more than 2 trucks per day can be filled with the granular red and white limestone, and there is more waste with the latter.
As all stone used for mosaic paving must possess elasticity, durability and beauty of appearance, the writer tested Bohemian limestones for these qualities. To determine their compressive strength or elasticity, a vertical hydraulic press was used, and cubes of the three kinds of limestone were tested dry, and after soaking 2 days and boiling in water. The results are given in a table in the original paper. Their elasticity was found to vary greatly, partly owing to the organic remains which abound in these limestones. The elasticity of the red and white limestones was increased by soaking in water, and that of the coarser grained black limestone was diminished.
As the wear of footpaths is chiefly caused by the tread of feet, the stone was tested on a grindstone, and with a boring-tool. The grinding-machine had a treadle, and a horizontal rotating-stone upon which a surface of 5 1/2 square inches of the sample was exposed, and continuously moistened with water. Each sample was 13 cubic inches, and the loss by volume after 300 revolutions of the wheel was 8.6 per cent. with black limestone, 11.6 per cent. with red limestone, and 15 per cent. with white limestone. With Bohemian granite, the loss was 4.3 per cent. Therefore to use black and white, or black and red limestone together for mosaic paving, when exposed to much wear, is not desirable, as the flooring will soon become uneven. For the boring tests, a vertical machine was used, the borings were collected, weighed, and the loss in weight determined. The samples were of the same size as before. For the same number of revolutions of the drill, the black limestone lost 2.45 per cent., the red limestone 2.83 per cent., and the white limestone 2.97 per cent., while the loss with granite was 1.66 per cent.
The durability of the stone, that is, its resistance to the effects of the air, atmospheric deposits, as snow, rain, and hail, changes of temperature and rays of the sun, was next considered. As these subtle meteorological influences do not affect the "life" of paving-stones as much as the wear of traffic, the writer studied only the most important, namely, the disintegration produced by frost. This is much influenced by the capacity of the stone for absorbing moisture, since the destructive power of the water while freezing is the greater, the more porous the stone. Black limestone was found to absorb 3.1 per cent., red limestone 3.5 per cent., and white limestone 3.3 per cent. of its weight of water, after soaking for 2 days. The limestone was also frozen in a refrigerator. Samples of the same size as before were used, and were frozen and thawed 3 times. After being frozen twice the black limestone began to split, and crumbled and scaled at the edges. The red limestone showed signs of disintegration after being frozen once, while the white only began to break up after being 4 times frozen. The loss in weight was 8.8 per cent. of the black limestone, 11.1 per cent. of the red limestone, and 6.1 per cent. of the white limestone. The loss in consistency of a stone when exposed to frost has a most important effect on its durability, and this was estimated at 31 per cent. with black limestone, 28 per cent. with red limestone, and 26 per cent. with the white limestone. The third requisite in paving-stones intended for ornamental purposes is beauty of appearance, and in this respect the Bohemian mosaics compare favourably with
others. The black and red limestones lose their colour a little when exposed to the air, but the contrast is always pleasing, and is more striking when they are combined with the white limestone. Full details of the various tests and instruments used will be found in the original paper, but there are no drawings.

B. D.

PYRITES-DEPOSITS OF SCHMOLLNITZ, HUNGARY.


Overlying the crystalline schists, which between Kaschau and Neusohl strike east and west, parallel with the main axis of the Carpathians, is a series of varicoloured Devonian (?) metamorphic schists and schistose limestones, inter-bedded locally with a dark green to black "gabbro" (as, for instance, between Dobschau and Kotterbach). The ore-deposits of Upper Hungary are in such immediate topographical relationship with this gabbro, that some observers have sought to establish a causal relation between the outburst of that eruptive rock and the occurrence of the ores, an hypothesis which the author holds to be "not proven."

In the counties of Zips, Gomor, and Abaujvar, within the area of metamorphic rocks, bounded to the northward and southward by Carboniferous Limestones, four parallel belts of ore-deposits may be traced over a length of 40 miles, ranging east and west between Dobschau and Kaschau. In the northernmost belt, the ores appear to be interbedded with the Devonian (?) chloritoid-schists, but the author agrees with Mr. Faller in considering the ores of that particular belt as true vein-deposits. They have a steep southerly dip (70° to 85°); they do not invariably coincide with the bedding; the gangue sometimes includes masses of the country-rock, is generally coarsely crystalline, and is separated from the "country" by a narrow argillaceous salband. The average thickness of this deposit is 10 to 13 feet, but largely owing to the above-mentioned inclusion of masses of "country" it sometimes attains a thickness of 146 feet. It consists in part of spathose iron-ore, in part of copper pyrites and fahlore; repeatedly associated with these are various ores of mercury and nickel, and antimony-glance. Iron pyrites is a constant associate, but lead and zinc-ores are extremely scarce.

The next belt to the southward, ranging westward from beyond Rosenau to Aranyidka in Abaujvar county, consists mainly of antimony-ores associated with metamorphic clay-slates (which deep down pass into gneiss), striking north and south with a westerly dip. As these ore-deposits cut across the strata, and more-
of the Gollnitz valley. It is shut in by high hills, the Rothenberg and the Spitzenberg, and here the ore-deposits form a series of irregular lenticles, associated with a zone of greyish-green Archaean sericite-schists, metamorphosed by the irruption of diabase or gabbro. These schists sometimes pass, with gradual diminution of the sericite, into quartz-schists. At both walls, the ore-deposit is bounded by a 40 feet belt of dark grey to black phyllites, wherein carbonaceous or graphitic particles lie thickly scattered. Outside these come the light-coloured quartz-schists, which south of Schmollnitz include the spathose iron and chalcopyrite-deposits of the fourth belt. These quartz-schists, on the footwall side, are broken through by a complex of rocks consisting mainly of crystalline limestones. Dr. Steinhausz attaches considerable significance, from the point of view of the genesis of the ore-deposits, to the occurrence of a mass of diorite or diabase a few hundred feet vertically below them, and always in those areas where the deposits are richest. In the main, the Schmollnitz deposits form, three reefs, known respectively as the Top, Middle and Bottom reef, each varying in thickness from 3 1/4 to 58 feet, and traceable along the strike for 2 or 3 miles. They have been proved to a depth of 1,170 feet by means of 8 drifts and deep levels. On the whole, these reefs are singularly conformable with the sericite-schists, but sometimes they bifurcate, owing to the alternate nipping-out and wedging-in of the intermediate barren schists. In reality, no sharp dividing-line can be drawn between the reef with its rich lenticles (made up of coarsely granular iron pyrites and chalcopyrite so intimately commingled as to be undistinguishable by the naked eye) and the "country," impregnated with pyrites in an excessively fine state of division. The author quotes the following chemical analysis of the ore from Dr. Steinhausz's memoir:—Sulphur, 47.89 per cent.; iron, 45.31; copper, 0.46;* lead, 0.33; zinc, 0.37; arsenic, 0.55; antimony, 0.06; bismuth, 0.03; nickel and cobalt, traces; manganese, traces; lime, 0.03; magnesia, 0.05; residue insoluble in acids, 4.89; total, 99.97 per cent. He compares with it no less than 14 analyses of Spanish, Norwegian, and German pyrites, which tend to show that in chemical and mineralogical composition the Schmollnitz pyrites approaches most nearly the Spanish, except in the percentage of copper: therein the Norwegian comes midway between the poorer Hungarian and the richer Spanish ores. Regarding the origin of the Schmollnitz deposits, the author agrees with Messrs. Von Cotta and Hauch that it is purely sedimentary, and sets forth at length the reasons for dissenting in this case from Messrs. Vogt and Steinhausz's "vein-theory."

* Unusually low: the average variation is 0.5 to 2 per cent.

[15] The working of ores in this area, from the days in the far-off 13th century, when the Kings of Hungary, by charters and royal deeds of gift, made over fiefs and mining rights to the Saxon immigrants, has a long and chequered history down to our own times. There have been many changes of ownership, many transitions from prosperity to adversity and back again, in the course of six centuries. In 1890, the Hungarian State transferred its property in the then long decaying mines to a limited company, for a consideration of 1,000,000 florins (say £85,000). Up to the early seventies all efforts had been centred on the production of copper, but with the exhaustion of the rich copper-ores and the accumulation of enormous waste-heaps of pyrites, attention began to be directed to the utilization of the latter on a large scale, and a new era dawned on the mining industry of the region. Sulphuric acid is now the ultimate product sought for, 1 to 3 per cent. of copper is got by the wet way out of the pyrites, and the residue yields 60 to 65 per cent. of an iron-ore which is found especially suitable for the manufacture of Bessemer pig and for consumption in puddling-furnaces. The production increased from 38,388 metric tons in 1890 to
58,610 metric tons in 1894, while in the same period the number of workpeople employed about the mines rose from 300 to 450. At present, the fresh pyrites is being worked chiefly in the deeper portion of the deposits, and care is naturally taken to use for packing and stowing, as far as possible, waste which is free from pyrites, or even stone brought from neighbouring quarries. In the upper levels a productive "aftermath" is still reaped from the waste discarded by the old miners.

The temperature in the mines, owing to the continual oxidation of the pyrites, is very high, ranging from 35° to 50° centigrade (95° to 122° Fahr.), being highest in the neighbourhood of old workings or where the incursion of surface-waters favours rapid decomposition. A partial remedy is applied in the shape of constant spraying of both the working-faces and the packing with cold water. Nevertheless, the temperature sometimes rises sufficiently to ignite the timber left in the packing. Fires, therefore, are of frequent occurrence, and they can only be fought by the extension of the watering system.

Copper is separated by the cementation process on the mine itself, and the pyrites is sorted, according to size and quality, into nine different varieties (cubes, nuts, peas, dust, etc.). It is then loaded direct into trucks on the light railway to Gollnitz, whence it is carried to the company's sulphuric-acid works at Budapest and Sillin.

The paper is preceded by what appears to be an exhaustive bibliography of the subject.


The author's personal observations appear to be confined to the roofing-slates, which form a belt about 1/2 mile in width, beginning in the Bibarcz valley, and extending thence to the Fenes valley and beyond. Their coloration is bluish, greenish-grey, and red, and they can be split into slabs as thin as 1/8 inch (about 3 millimetres). Experts have pronounced them very nearly as good as the slates which come from Wales and from France; they admit of being bored and sawn through, and their behaviour in regard to change of temperature is perfectly satisfactory.

These roofing-slates are associated with sandstones and marl-slates, all of which are probably of early Tertiary age. The roofing-slate industry would be a new one in Hungary, and on the condition of applying competent technical knowledge and sufficient capital, the prospects before it are very good.

The remainder of the paper is a summary of the information culled from the Budapest and Hermannstadt archives, regarding the mining of gold, silver, and mercury in this district in former times.

RECENT BORINGS FOR COAL IN THE NORTH OF FRANCE.


The series of borings made in the North of France, with the view of proving the prolongation of the great Franco-Belgian coal-field, were brought to a close in July, 1898: the last syndicate, which had held out as a forlorn hope, then finally relinquishing the search.

As long ago as 1860, the author had proved that the Coal-measures of Hardingham and Ferques in Boulonnais were really the continuation of the Franco-Belgian basin, and he was of opinion that the Carboniferous Limestone and Devonian shales which
outcrop south of those two localities form an anticlinal fold dipping southward beneath yet another coal-basin.

The five borings of La Liane were put down, so as to strike this hypothetical coal-field. Of these, three—at Menneville, Bournonville, and Wirvigne, passing through Jurassic rocks, reached shales which strikingly resemble the Lower Coal-measures; but, although the above-mentioned three borings were carried on with great perseverance, they never got out of the barren shales. The fourth boring, at Samer, south of these localities, struck the Gedinnian—a horizon which, from Aix-la-Chapelle in the east to Bristol in the west, invariably occurs outside the boundaries of the true coal-field. The fifth boring, near Le Waast, struck the Upper Devonian, after passing through 314 feet of shales, which were at first regarded as Lower Coal-measures, but now prove to be Silurian.

While these borings were in progress, news came of the discovery of the Dover coal-field, and several French syndicates began to search for its continuation on the other side of the Channel. Eleven borings were put down in French Flanders, in the departments of the Nord and Pas de Calais. Four of these alone reached the Palaeozoic rocks, and then only struck Silurian—a result which brought about the speedy abandonment of the other seven borings.

The author, in correlating the Dover coal-field with the Franco-Belgian basin, had pointed out that the latter is probably thrown out northward, to the west of Ferques, and that its main axis probably passes somewhere between Wissant and Calais. This hypothesis was shown to be correct by a boring put down at Strouane, on the western flank of Cape Blanc Nez, which, after striking three well-marked coal-seams, passed into Devonian shales. Thereupon, borings were multiplied around Wissant, and they struck mostly Carboniferous Limestone, Devonian shales, and Silurian rocks. It is plain that the Wissant Coal-measures are a mere remnant, perhaps a transported remnant (by dislocation or thrust), of the great coal-basin, and that it would not pay to work them.

[17]

Now all the foregoing explorations had been made either north or south of the Jurassic anticlinal of Lower Boulonnais. It seems well nigh certain that this anticlinal corresponds to a Silurian plateau, and that there is no hope of finding coal underneath it. Thus, a boring, put down in the corresponding synclinal at Wimereux, struck Silurian rocks at 1,440 feet, and another at Framzelle struck the same rocks at almost exactly the same depth. In contrast with the results recorded in Lower Boulonnais is the discovery, by the engineers of the Lievin collieries, of black calcareous shales of Wenlock (Upper Silurian) age, beneath which lies workable coal-seams.* The author believes that these Wenlock shales are the beginning of the Silurian massif which spreads out in Lower Boulonnais.

L. L. B. and C. S.

IRON-ORES OF BRAY, FRANCE.


In the course of researches made in 1897, the author traced a number of old slag-heaps, and proved by means of shallow borings that iron-ore is present from one end to the other of the Pays de Bray, in widely scattered but very numerous deposits. Having thus ascertained that the occurrence of the limonite or brown haematite is not, as had previously been imagined, a mere local phenomenon, the author
conducted a series of deeper borings, whereby it was shown that in depth the oxides passed into sphaerosiderite or clay-ironstone, more or less compact, concretionary, or Oolitic. The harder and denser the ore, the richer it proves to be, the average tenour ranging between 30 and 40 per cent.

The carbonated ore really occurs in several continuous bands intercalated amid sands and clays of Middle Neocomian age, forming a regular succession rather more than 80 feet in thickness, and there is no such confusion or irregularity as had been postulated. Several artesian wells have been put down recently in the neighbourhood, and the records obtained from them entirely confirm the author's conclusions. These wells go right through the Lower Neocomian sands and refractory clays and reach the Upper Portlandian rocks.

It was only the superficial zone, where the original ore has been decomposed to limonite by the oxygenated waters percolating down to the general water-level of the country, that was worked in former times. As to the origin of the carbonated ore, the author does not regard it as an intermediate phase in the decomposition of iron sulphides; rather does he believe that it was chemically precipitated from waters charged with iron and full of rotting plant-remains.

The high dip of the Middle Neocomian strata in the Pays de Bray will necessitate extensive pumping operations before the actual working of the deep ore-deposits can be started.

In discussing this paper, Mr. de Lapparent pointed out that a similar passage of iron-oxides into carbonate, from the surface downwards, had been observed in the Oolitic rocks of Lorraine and in the lowermost Ordovician beds of Normandy.

L. L. B.


[18]

BLACK PHOSPHATE OF LIME IN THE PYRENEES, FRANCE.


The author's attention was first called to these deposits in May, 1898, 20 miles south of Oloron in the Lower Pyrenees. Since then he has traced them eastward and northward into Languedoc, in the departments of Ariege, Haute-Garonne, Aude, and Tarn.

Their stratigraphical position is in the Upper Devonian, at the junction between the Griotte marble and the overlying Carboniferous or Permian shales. They form a regular bed no less than 26 and often as much as 32 feet thick, and are of a lustrous black, reminding the observer of anthracite and smutting the fingers. Hence they have been miscalled "impure anthracite," "graphite-beds," etc. In its richer portions, the bed is characterized by the presence of flattened nodules, hard, black, and shiny: these consist of nearly pure phosphate of lime. ; the assays showing 62 to 77 per cent. of tribasic phosphate. The nodules are generally grouped either at the floor or at the roof of the bed, and the enveloping "gangue" is itself phosphatized. Moreover, the latter contains an enormous quantity of organic material, yielding no less than 0.3 to 0.5 per cent. of organic nitrogen. After sorting out the rich nodules, the residue still contains 14 to 16 per cent of phosphoric acid, which makes it very suitable for agricultural purposes.

The fact that the bed continues to be rich in phosphate down to great depths has been proved by the workings in the manganese-mine of Las Cabesses, where the nodule-layer is exposed in a level at 370 feet below the surface.

The Picardy phosphates, which are in pockets (in the Chalk) and the Quercy phosphorites, which form groups of veins, are occurrences essentially different from that above described.
The industrial value of these Pyrenean phosphates depends almost entirely on the question of means of transport, and on the greater or less proximity of railways.

L. L. B.

PROSPECTING IN SAVOY, FRANCE.

In Savoy, as in the Alps, the mineral deposits occur either in the crystalline or in anthraciferous rocks; but there are deposits of iron-ore in the Upper Jurassic and Lower Cretaceous series.

Iron enters into the composition of numerous rocks in the crystalline masses; and other metals are chromium, aluminium, titanium, and manganese. Numerous veins of quartz traversing these rocks are sterile; but sometimes they contain oligist iron, blende, galena, pyrites and grey copper, with occasionally asbestos, epidote, stilbite, wavellite, molybdenite and corundum. One of the smallest crystalline masses, at Rocherai-en-Maurienne, contains so many minerals that it has been called a mineral cabinet.

The anthraciferous rocks comprise argillaceous shales with mica and talc, quartzose sandstones and siliceous conglomerates with Coal-measure fossils and beds of anthracite. The anthraciferous schists have undergone a metamorphism which appears to be due to heat; but Mr. Michel Levy considers that the lamination of the schists must rather be attributed to a kind of metamorphism, while there is a gradual transition from schists and sandstones to porphyries and quartzites. The argillaceous shales are generally in non-concordant stratification with the crystalline shales, the aspect of which they sometime assume however; and these shales contain quartzose and pyritous veins with numerous anthracite-seams. The most important zone of anthraciferous measures in Savoy follows, on the south-east, the zone of the crystalline rocks, leaving an interval occupied by Lias. The schists are especially metamorphosed on the north-east, where they can with difficulty be distinguished from crystalline shales; but they contain quartz and gneiss-pebbles. The anthracite-seams in this zone are much faulted; and of the numerous metalliferous veins the most important are those of lead and zinc at Macot and Pesey, at which latter place, at an altitude of 5,000 feet, a school of mines was founded in 1802. Deposits of argentiferous lead occur in the Val Montjoie, of copper at Beaufort, of lead and copper at Bonvillard and Montchabert, and of iron and copper at Saint-Georges d'Hurtieres.

The anthraciferous rocks form, in Savoy, a belt, parallel with the crystalline rocks, extending from the south-west to the north-east; and another belt follows the north-eastern edge of the crystalline rocks. This last-named belt contains the Servoz argentiferous lead mines; and the main belt (wherein chiefly occur the richest mines of lead and silver in Savoy), those of Macot and Pesey, Du Sault and Des Sarrasins, near Modane. Iron is found in the Montagne des Sarrasins, and along the crystalline rocks from Montpascal to Montgirod and Bourg Saint-Maurice.

Near the Franco-Italian frontier, between Tignes and Bonneval, the crystalline rocks form a long belt parallel with the axial line of the Alps, passing by Aosta, Mont Cervin, Monte Rosa and the Saint-Gothard, and contain many quartz veins, some mineralized, most frequently by pyrites alone, and occasionally by auriferous pyrites. The best known of the auriferous pyrites veins occur in the Bernese Alps; and from south-west to north-east are met with in succession those of Ceres, Pratigione, Ceresole, Brissogna, Val Tournanche, Val Gressoney, Val Sesia, Val Anzaska and Val Vedro, while the St. Gothard tunnel intersected veins of auriferous quartz. The most important mines are those of the Val Anzaska, namely, Pestarena and Val
Toppa, which in 1883 produced 7,000 ounces (200 kilogrammes) of gold, with 300 men, and 6,000 ounces (170 kilogrammes) in 1890, a figure which has been maintained in more recent years.

The author cites, as an example of ancient gold-mining in the Alps, the Goldberg, near Rauris and Gastein, which is situated in the same geological series and under similar conditions as the above-named. At one time the production exceeded 35,000 ounces of gold per annum; and the plans that have been preserved show the existence of 19 miles (30 kilometres) of galleries, and 2 miles (3 kilometres) of winzes. About 800,000 tons of ore, containing at least 0.90 ounce (25 grammes) per ton, have been extracted from the Goldberg, while more than double that quantity, though of less than half that content remains unwrought, to say nothing of the rich pillars below the level of 7,700 feet (2,340 metres). As the deposit does not vary for a vertical height of 1,300 feet (400 metres), it probably continues for a greater depth; and the project has been formed of driving a drift 1 1/4 miles (2 kilometres) long, at the level of 5,300 feet 1,600 metres), so as to take advantage of an almost vertical escarpment,

J. W. P.

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THE IRON-PISOLITES OF THE KRESSENBERG, BAVARIA.

These early Eocene pisolites form a comparatively narrow belt, wedged in between the Flysch on the south and the later Tertiary Molasse on the north, ranging, not without interruptions, from Mattsee to Sonthofen. The ore has been largely worked, and more especially in the Kressenberg and Grunten districts. Part of the Kressenberg field has been abandoned since 1881, but the eastern portion is still worked. The deposits are classed as “black seams” and “red seams,” according to the degree of oxidation of the iron in the pisolite: apart from this, the origin of the seams is manifestly identical.

The assumption which formerly held good, that one is dealing here with a vast thickness of strata, is now disproved, and it is shown that in reality the same seams are repeated over and over again by folding and faulting. The author discusses the tectonic structure of the area in some detail, and considers that the original surface of deposition has been packed by the processes of mountain-building into a disproportionately small space. Therein the black seams mark the close of the epoch of iron-ore deposition, and the advent of the limestone-facies, characterized by such nummulites as N. complanatus.

Comparing and summarizing similar evidence from Switzerland, it appears that the relics of the Alpine Eocene sea bed are still found clinging here and there to the northern margin of the Alps, in sufficient mass to allow of the identification of littoral and shallow-water shell-beds, of pelagic sands and glauconites, while the iron-pisolites occupy exactly the middle position between the shallow and deep-water formations.

The sharp division between the sands, glauconites, and iron-ores is a striking example of the differentiation of clastic sediments according to the specific gravity of their constituents. Not, however, on the hypothesis that the lightest particles have been carried farthest, but that only the very strongest currents had sufficient impetus to sweep the heavy particles away from their original source, and then, as the current now and again slackened, these particles would fall to the bottom. The specific gravity of the iron-pisolites varies from 3.6 to 4, while that of the sands is 2.6, and of the glauconites 2.6 to 2.9. The coarsest siliceous particles are mostly found in the red seams: fossils occur both in these and the black seams, stained of the colour of the ferruginous cementing-material. Some of the fossils show no alteration beyond this
staining, while others are completely infilled with iron-ore, and form the nuclei of pisolites. The unaltered fossils belong to a fauna entirely distinct from the encrusted fossils, which, indeed, show unmistakable signs of fracture and corrosion anterior to the pisolitic encrustation. Rock-fragments and nodules occur with these, which have undergone the same process, and it is evident that all the corroded and subsequently encrusted material is derived from the underlying strata. This corrosion, in part perhaps the work of the ocean-surf beating on the old Vindelican shore, and in part that of atmospheric agencies, seems to point to a slow uprise of the sea-bottom, interrupted by periods of depression, during which powerful currents swept off the pisolitic and encrusted material to its present resting-place. Now, the frequency of these changes of level, if it does not actually justify the hypothesis of eruptive or volcanic phenomena, at least implies a state of disturbance, one resultant of which would be the outburst of thermal springs.

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Such springs may well have been the original factory of the pisolites and the associated processes of encrustation. The deep-lying granites and gneisses of the old Vindelican continent would furnish little lime, but, on the other hand, abundance of carbonated iron-oxides. Another circumstance which encourages the belief that the origin of the pisolite is inseparable from the near neighbourhood of an ancient land-surface, is the association, with the so-called “black seams” of the middle group, of miniature coal-seams, resin, and asphalt; while, in the black seams themselves, fragments of worm-eaten wood, and remains of turtles and crocodiles are not uncommon. It is plain, therefore, that the origin of these iron-pisolites is far from being exclusively marine. On the other hand, the highly-oxidized condition of the outermost crusts in the grains of the red pisolite, and of the iron in the cementing-material of the same, bears testimony to the influence of the excess of oxygen present in the waters of the open sea.

The author is entirely opposed to the hypothesis that the iron-pisolites are merely a result of the alteration of calcific or arragonitic Oolites, and points out that such an hypothesis was clearly shown to be untenable in the case of the Clinton pisolitic ores by Mr. H. Smith. He then discusses in detail the formation and nature of the beds which overlie the iron-pisolites, and the tectonic processes to which they have been subjected. From the industrial point of view, the importance of these considerations is that they furnish a solution of the problem as to whether there is an extension of the ore-deposits under the Molasse. Such an extension is highly improbable, and, even where beneath the Molasse sunken blocks of Eocene strata may occur, it is almost certain that the ore-beds would be found only at a great depth and much broken up. Another point is that the varying colour of the seams, due to their particular degree of oxidation, is to some extent a guide as to the probable existence or absence of ore-deposits north and south of those at present known and worked.

L. L. B.

THE IRON-ORE DEPOSITS OF STAHLBERG-KLINGE, THURINGIA, GERMANY.

Die Lagerstatten der Stahlberger und Klinger Störung im Thuringer Wald. By Hans Mentzel. Zeitschrift fur praktische Geologie, 1898, pages 273-278, with a map and three sections in the text.

The area with which this paper deals is a portion of the south-western slope of the Thuringian Forest, extending from Beierode in the north-west to the Schmalkalde valley in the south-east, and is disturbed by the system of faults and fissures which on all sides demarcate the physiographical boundary of the forest. The basement-rocks are crystalline, consisting of gneisses, mica-schists, and granite-porphries, seamed by dykes of melaphyre, syenite-porphyrty, etc.
Immediately overlying these is the Zechstein Series (Permian), and above this comes the Lower Bunter Sandstone (Triassic).

Taking the chief localities in the same order as the author, we come first to:—
1. Stahlberg.—Here the deposit of brown iron-ore extends with a west-south-western strike for about 4,800 feet along the slope of the hill, and is extremely irregular in form, rather of the nature of a "pipe." Seven headings have been driven in it, and several cross-cuts. The ore may be regarded as a metasomatic replacement of limestone and dolomite, by the agency of waters circulating among the many fissures in this disturbed massif. Some of the fissures are filled with heavyspar, and in many places the actual passage of the dolomite into the iron-ore may be traced. The character of the ore, moreover, varies according to the character of the dolomite which it replaces. Typical dolomite gives place to crystalline spathose iron-ore which, by loss of carbonic acid and oxidation in presence of water, is altered into pseudomorphous brown iron-ore. Dolomite with aluminous or clayey constituents is replaced by a clayey ochreous iron-ore, while the marlstone interbedded with the dolomites does not appear to have been susceptible of metasomatic replacement.

2. Mommel.—Here, as in the preceding occurrence, brown iron-ore is associated with heavyspar, while fluorspar also makes its appearance. This deposit comes to day along its whole length, from Herges, north-west of the Stahlberg, to Sandberg, near Beierode, and continues in depth lower down than exploration-work has yet reached. It is limited by two faults, which appear to enclose a sunken (and overturned) trough of rocks whose greatest breadth, 227 feet, is attained in the Kochenfeld district. As these faults run together, near Sandberg, they nip out the deposit by their convergence.

The author describes some other deposits of minor importance connected with the Stahlberg disturbance, and then goes on to speak of:—
3. Klinge.—This disturbance consists, like that of the Stahlberg, of a system of faults, while it possesses in common with the Mommel occurrence the peculiarity that the ore-deposits are an alteration-band in a troughed and faulted wedge of dolomite. The workings are in part opencast, in part drifts. The dolomite shows no sign of bedding, is wedged in among gneiss, and is altered in the space between two broad fissures. The ore is mostly brecciiform, and some of it is pulverulent or "pappy."

In conclusion, the author points out that the fissures which have split the rocks in this region are of Oligocene age, and therefore that the alteration of the dolomite into brown iron-ore must have taken place between Oligocene and recent times. Waters containing carbonated oxides of iron in solution are even now percolating through the rocks, as is evident from the existence of the Liebenstein spring. The resulting iron-ores are valuable for metallurgical purposes, because of their invariably high percentage of manganese and their freedom from phosphorus.

As to the origin of the iron-ore, this appears to have been furnished by the clays, shales, and sandstones which lay stratigraphically below the dolomite, and have been largely swept away by erosion. The barium for the heavyspar doubtless came from the felspars of the crystalline rocks, while the presence of sulphated solutions is indicated by the occurrence of gypsum in the Upper Zechstein near Beierode.

L. L. B.

GRAPHITE-DEPOSITS OF THE COTTIAN ALPS, PIEDMONT.
Although the detailed survey of the Cottian Alps, now approaching its completion, will, undoubtedly, necessitate some changes in the older classification of the rocks, one may, for practical purposes, adhere meanwhile to that of Dr. Gastaldi. He
recognized in the great series of crystalline schists two divisions: an upper, essentially calcareo-phylilitic, with enormous intercalations of roccie verdi (serpentines, etc. ?); and a lower, consisting essentially of gneisses and mica-schists. The graphite-bearing rocks are confined to this latter division, near the base of which they occur in their most characteristic facies, their occurrences higher up in the division being mainly of a sporadic and accidental nature. 

Beginning at Cumiana in the Northern Cottians, the graphite-belt continues unbroken to the heights which dominate the right bank of the Pellice; interrupted thereafter by the Quaternary strata of the Barge basin, it assumes more the aspect of a series of enormous stratified lenticles of graphitic schists enveloped in ordinary mica-schists and gneisses, but its horizon in the series is unchanged. The gneisses, sometimes white, but more often grey with graphite-pigment, are made up of very minute constituents and poor in mica; here and there are seen gneissose conglomerates, where, in the fine-grained, dark grey, gneissic matrix, parallel lines of fragments of various rocks, but chiefly quartz, appear laminated and squeezed out into fusiform shapes. It seems probable that these rocks are merely the metamorphic phase of a sandstone which had an argillaceous-siliceous cement.

Unlike the gneissose rocks, the mica-schists are very varied in aspect. Sometimes they are ordinary white mica-schists, sometimes they are visibly garnetiferous, or again they are characterized both by garnets and chloritoids. Then there are the spotted schists, with elongated white flecks consisting of a mixture of micaceous minerals and chloritoid; and the ampelitic schists, black, and more or less carbonaceous.

To most of these types there corresponds exactly a graphite-bearing rock, distinguishable, too, by its poverty in quartz, the most widespread of all being the lead-coloured garnetiferous graphite-schist, wherein the garnets range in size from microscopic dimensions to 1/5 inch in diameter. Quartzites play a very subordinate part in all this group: as a matter of fact, they may be regarded in this case as quartzitic schists extremely poor in mica, but they are sometimes associated with conglomerates of a quartzose character.

The breadth of the graphitic belt varies considerably. In the northernmost part, near Giaveno, it is 1,000 to 1,300 feet broad; in the valley of the Chisone, where various southern offshoots coalesce with the main belt, the width is much greater; and it reaches its maximum in the middle and lower valley of the Chisone and the Germanasca, where it is no less than 2 1/2 miles wide. At the lower end of Val Pellice the breadth is much less, and gradually diminishes as one proceeds southward.

The author considers that there can be no doubt as to the sedimentary origin of the graphite-deposits, the presence of such markedly clastic rocks as conglomerates being sufficient evidence—and the whole series forms, in his view, a normal succession of strata which have been metamorphosed into crystalline schists. They are in every respect comparable with those formations wherein shales and sandstones alternate with beds and lenticles of coal or lignite; and the change from coal into graphite is analogous to the change from sandstone into gneiss and from shale into mica-schist. The very fact that among the graphites themselves there are such differences observable as between graphites proper and graphitites or graphitoids, the result of differences in degree of metamorphism, appears to him an additional proof of the hypothesis.

With regard to the age of the graphites negative evidence only is forthcoming. In the Western Alps, the one formation which contains fossil fuel is the Carboniferous, and this (in the shape of anthracite) occurs in beds and lenticles, the lie and facies of which recall irresistibly those of the Pinerolo graphite. The analogy is still more
perfect when the Cottian graphite-deposits are compared with the fossiliferous graphite-basin of Styria.

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The graphites which are worked in the Pinerolo district under review have all the properties characteristic of the typical mineral: they have a fine black colour, semi-metallic lustre, they are soft and more or less unctuous according to their greater or less purity, the purest being the least lustrous. On combustion they leave a siliceous ash, with mere traces of iron. The schistose material is so intimately intermixed with the graphite that it is practically impossible to enrich the poorer grades by any mechanical process of sorting or separation. Few assays have been made by the mine-owners, and their methods of working are, in many cases, still incredibly primitive. However, the author groups such as have been published, in a table, together with assays made from his own and other specimens in the laboratory of the Italian Geological Survey. This table shows a percentage of carbon varying from 10 to 85, and a specific gravity of 2.25 to 2.38.

Mining operations were begun on a small scale in the Pinerolo district somewhere between 1835 and 1860, and the graphite was at first extracted (apparently for the purpose of evading the provisions of the Mining Code) under the name of "black earth," and classified as colouring-matter. It was not until 1886 that the graphite-workings were properly classified, and from that time up to the commencement of 1898 eleven new concessions were registered. The statistics of production are nevertheless unreliable: year after year the Custom House returns show that Italy exports graphite in greater quantity than the entire declared produce of her mines, and the author estimates the true average annual production at 4,000 tons.

The mines in active work are practically restricted to the region comprised between the rivers Chisone and Pellice: thus 9 out of the 11 above-mentioned properties are in the lower basin of the former river, and of these the 5 largest are in the Pramollo valley, a right-bank tributary of the Chisone. On the left bank, the graphitic schists crop out over and over again, but no mining-claims have been registered here, although it is precisely the area where the abuse of illegal excavations for "black earth" has been most rampant. The two remaining claims were declared in 1897, in the hills on the left bank of the Pellice, near the point where it debouches into the plain.

The beds of graphite dip generally southward, sometimes westward, at high angles: never less than 30 degrees, and often as much as 75 degrees; but the strike varies considerably. In some of the mines there are as many as three workable beds, one above the other, and the thickness varies from bed to bed (or sometimes within the same bed) from a few inches to 10 feet or more. Taking into account the fact that this is an Alpine region, the mines are situated at a very moderate altitude, all lying between 2,000 and 2,300 feet above the sea, the Siassera mine alone reaching the 3,100 feet contour. The long Alpine winter, with its heavy snows, does not therefore interfere with graphite-mining operations. When one adds to this the neighbourhood of the plains, assuring easy means of transit, the great extent of the outcrop, the solidity of the country-rock (in regard to roof and floor), and the facility with which waste water can be drained off in hilly ground, it will be understood how for 35 years or more an industry has prospered, which, up till quite recently, was carried on in the most primitive fashion. For a long period, the graphite was worked in each locality by the inhabitants when they happened to have nought else to do, at seasons of the year when labour in the fields was slack. As the shallow excavations went deeper, however, the need of practised hands became imperative, and thanks to an influx of such men from the mines of Sardinia and elsewhere, proper methods of exploration and winning, regular working, and improved transport from each mine to the nearest road, have gradually extended, despite the absence of qualified technical
management. This want makes itself felt, however, in the treatment and sale of the graphite. The raw material is sent direct from the mine to the mill without undergoing any selective process, and there, after having been crushed, it is packed straight into boxes or sacks, with the result that might be predicted: low prices, lower than those of any known graphite in the trade. An Italian metallurgist, who has experimented with it in the manufacture of crucibles, puts the percentage of pure mineral at 61, the value at the mine being 15s. to 19s. per ton, and at Pinerolo, packed, and loaded on to the railway truck, about 38s. per ton.

In addition to the table of analyses, a bibliographical list and the official statistics of graphite-production in, and graphite-exports from, Italy during the years 1860 to 1896 (both inclusive) accompany this exhaustive memoir.

L. L. B.

PETROLEUM IN CENTRAL ITALY.

At Salsomaggiore, a thermal resort in the Parmese Appennines, a deep well has been lately sunk to a depth of 2,010 feet, yielding water highly charged with chlorides, iodides, gases, and varying quantities of petroleum. Moreover, a large excavation (some 40 feet deep) has been made near the Baths, laying bare a considerable surface of the salt-marl, which is one of the characteristic strata of the neighbourhood. Through fissures in this marl come up brine-springs, charged with "petroleum," which, after exposure to the air, solidifies into a mineral wax. Those fissures are richest in petroleum which strike north-eastward and dip southward, both strike and dip being inverse to those of the strata themselves. The marl is overlain by breccia and underlain by Eocene limestones and "rough" clays.

The author's interpretation of the stratigraphical conditions is that we have here a group of petroliferous fissures confined to a belt which coincides with a fractured anticlinal—these conditions, according to Prof. Sterry Hunt, indicating that favourable results would attend a systematic search for petroleum.

East and west of Salsomaggiore, a number of wells have been sunk, all yielding brine and hydrocarbons. The Trionfo well, near Scipione, was started in 1884, reaching a depth of 475 feet, and the strata yielded oil more abundantly, according as the proportion of sand in the marl increased. In one month, 540 barrels of oil were got from that well, but by 1885 the output had dropped to 2 barrels per diem. Subsequently, other wells sunk to greater depths produced 8 and 10 barrels of oil per diem, as long as the supply lasted. Precise data concerning the wells which are now in yield are not available. The author points out that no attempt has been made as yet to tap what he regards as the most promising area for petroliferous fissures, where the dip of the Miocene marls is suddenly reversed.

He gives, in conclusion, some account of the oil-wells at Velleja, in the neighbouring province of Piacenza, a few miles to the westward. Here, a great "boom" in oil-production began in 1890, and, up to the end of 1894, fifty-two wells were sunk, thirteen of which were unproductive and five others were soon exhausted. Production was still increasing in 1895, the daily output for each well varying from 13 to 484 gallons. The syndicate who work the field were proposing to bore to the depth of 2,600 feet, when they hoped to strike what they regard as the primary source of the oil, the deposits hitherto tapped being in their view merely of secondary origin.

L. L. B.
PUMICE OF MONTE PELATO, LIPARI ISLANDS, ITALY.
Monte Pelato or Campo Bianco is an extinct crater, whereon the accumulations of pumice reach in places a thickness of 650 feet, and form the chief article of export of Lipari. In point of fact, only a relatively small portion of the pumice is of commercial value, and, all the good surface-deposits having been worked out, the material is now got from extremely primitive underground workings. The small landowners carry on simultaneously the cultivation of the vine above ground and the digging for pumice below. Timber being dear, nothing is done to prevent the workings from falling in, and therefore a certain number of fatal accidents occur every year. About 1,200 persons are engaged in this industry in 120 small mines, two-thirds of the last-named belonging to the commune and one-third to private owners. The annual production averages 6,000 metric tons, of an estimated value of £40,000. There is a local tax of 15s. on every ton produced. Prices vary according to quality, the average being £5 5s. per metric ton at Lipari. The fiore or "flower of pumice," the very finest quality, costs ten times that amount, but is of extremely rare occurrence.

Much damage was done to the trade by the action of a syndicate a few years ago. They worked the mines in a reckless fashion, indulging in over-production to the extent of five times the legitimate demand, bankruptcy following as a matter of course.

Most of the pumice is shipped from Canneto, on the eastern coast of the island.

The author devotes some attention to the history of the production of boracic acid, alum, and sulphur on Vulcano, an industry now defunct. But he points out the extreme interest, in connexion with the theories as to the origin of the stanniferous deposits of Saxony and Cornwall, which attaches to the study of the fumarole-products of Vulcano and the high silica-percentage of its lavas. The fumaroles yielded 21 out of the 24 chemical elements and compounds characteristic of stanniferous deposits.

MANGANESE-DEPOSITS OF CHIATUR, CAUCASUS.
The village of Chiatur communicates, by means of a narrow-gauge railway some 20 miles long, with the main line from Tiflis to Batum and Poti. It lies on the banks of the torrential Kviril, in the government of Kutais, and in its immediate neighbourhood are clustered the manganese-mines.
The ore-deposit forms a regular bed, showing as a black streak along the mountainsides, barely interrupted by small faults, and having a northerly dip of only 2 to 5 degrees, increasing at some points to 15 degrees. Below it are the Nummulitic (Eocene) rocks, while above it comes a great series of strata of Sarmatic (Miocene) age: fossil fishes belonging to passage-beds being found in the roof or hanging-wall.
The deposit ranges in thickness from 5 to 6 1/2, and even up to 8 feet: it thins out to nothing in every direction, extending about 6 miles down the Kviril valley and about 4 miles across the valley. Northward it is barred by andesitic rocks, the eruption of which is perhaps not unconnected with the origin of the metal. The estimated quantity of ore in the field is 100,000,000 metric tons.

The deposit is believed to have been formed in a shallow sea, and consists of a pisolithic peroxide of manganese, the pisolites increasing in size from top to bottom of the bed. There are marly intercalations, and, near the bottom, gritty bands gradually
passing into barren rock. Near the top, on the other hand, the ore becomes clayey and passes into hydrated oxides which are nevertheless still very rich in manganese. The miners persistently reject all the soft stuff, among it being thick masses of friable pyrolusite which yields as much as 52 per cent. of manganese: they regard as true ore only the hard portions of the deposit. Phosphorus is present only in very minute quantities, the average percentage ranging from 0.02 to 0.05, and but rarely reaching 0.15.

Although both British and French companies have started mining in this district, the methods of working are still very primitive. Nor is there any immediate hope of improvement, as local conditions, among which may be mentioned the extreme subdivision of property, make it almost impossible for any one person or syndicate to acquire enough land to set up a modern plant on a large scale. More than a third of the pure ore is left in the shape of pillars, the timbering is perfunctory, and falls of roof are frequent. The workpeople are mainly Imeretians, unreliable, inexperienced, and ill-fed. The ore is loaded into paniers, which are carried by ponies down the steep, badly-kept bridlepaths to the railway-line. Freights as far as Sharopan (the junction) are high, but thence to Poti more reasonable: f.o.b. at that port, the ore costs 20 kopecks per poud (say £1 10s. per ton). The paper concludes with a detail of the costs (at the mine and at Marseilles) and a table of chemical analyses made at the St. Petersbourg School of Mines.

L. L. B.

PLATINUM DEPOSITS IN THE URALS, RUSSIA.
Die Platinlagerstatten im Ural, By A. Saytzeff. Tomsk, 1898, and Zeitschrift fur praktische Geologie, 1898, pages 395-398.

This pamphlet contains the results of the author's investigations in the year 1897, the object of which was to discover primary deposits of platinum; his studies were chiefly confined to the Goroblodatsk and Bissersk district; these are respectively the first and third on the list of platinum-producing areas, that of Nishni-Tagilsk occupying the second place. The deposits of platinum-bearing gravels, typically developed in the valley of the River Iss, show the following section in descending order: Peat; brown generally sandy clay, beneath which a bluish-grey tough clay often occurs; below this come river-sand and gravels without platinum; sand without pebbles is known as sewun, gravel as vetschnik, this latter often carrying boulders of quartz, and, in the bottom layers, of the bedrock of the district. The platiniferous sand often contains numerous fragments of dark grey rocks and layers of variously coloured clays; the lower portion of the sands is often difficult to distinguish from the decomposed bedrock beneath.

The rocks that form the matrix of the platinum have been found to be olivine-rocks (peridotite and olivenite), porphyrite, gabbro-diorite and syenite-gneiss; all these rocks are in various stages of decomposition, schistose, shattered or containing secondary minerals. Rocks consisting of partially serpentinized olivenite containing bunches and disseminated grains of chromite were found to carry platinum in visible grainlets; an assay gave 0.0107 per cent. of platinum. Porphyrites and gabbro-diorites have also been proved to contain minutely disseminated platinum, but its existence does not seem to have been demonstrated in the syenitic gneiss.

H. L.

[28]

IRON-ORE DEPOSITS OF CENTRAL SWEDEN.
Ueber einige Mittelschwedische Eisenerzlagerstatten. By R. Beck. Zeitschrift fur praktische Geologie, 1899, pages 1-10, with 5 figures in the text. The author visited the most important mining districts of Central Sweden in the summer of 1898, and he describes them in the following order:—

1. Norberg. — In the parishes of Norberg and Westanfors in Westmanland, 200 iron-mines are dotted along a belt some 12 miles long and 2 miles wide, in the midst of
fine-grained gneisses (granulites and eurites of Swedish geologists). Three varieties of iron-ore are worked in this area, namely (1) crystalline iron-glance interlaminated with thin flakes of quartzite; (2) finely crystalline magnetite, intimately associated with garnet-pyroxene rock (skarn of Scandinavian geologists); and (3) manganiferous magnetite, occurring in lenticles amid dolomites and limestones. With the last-named ore, pyrites is frequently intermingled, and sometimes galena and chalcopyrite are associated with it in payable quantities, as, for example, at the Kallmora Silfvergrufva. The author's study of this deposit leads him to the conclusion that magnetite and garnet are the oldest constituents, while the ores of lead, copper, arsenic, and fluorspar, calcspars, and asphalt were of later introduction, consequent on tectonic disturbances. No fewer than 94 of the Norberg mines are managed by one company, employing about 450 persons, with headquarters at Karrgrufvan, on a line of railway.

2. Persberg.—These iron-mines are situated in undulating country, on a peninsula which juts out into Lake Yugen, in the province of Wermland. Magnetite alone is worked in this district: it contains on an average 0.002 per cent. of phosphorus, the maximum being 0.013 per cent. The percentage of manganese varies between 0.2 and 0.35, and that of metallic iron between 53 and 60. The ore occurs in extremely irregular lenticles embedded in a garnet-epidote skarn, sometimes in the immediate vicinity of masses of crystalline limestone and dolomite, and sometimes folded in with the fine-grained gneisses (granulites). In many places, the ore passes gradually into the garnet-pyroxene rock; and similarly, by following up pyroxene-bands in the granulite, a passage from this into the sham has been observed.

3. Dannemora.—Situated on the shores of Lake Gruben, near the railway from Upsala to Gene, these famous mines have been worked since 1532. The ore is an extremely compact magnetite, yielding on an average 50 per cent. of metallic iron. Across a great spread of granite runs a thick belt of halleflinta, granulite and manganiferous crystalline limestone. Interbedded with the limestone, or lying between it and the halleflinta are three series of ore-lenticles, striking north-northeast and south-south-west, and dipping 75 to 80 degrees north-westward. As at Kallmora in Norberg, there are in the Dannemora field instances of the association of pyrites, chalcopyrite, galena, blende, mispickel, etc. with the magnetite, in such wise as to make it abundantly evident that those sulphides are of much later introduction than the other constituents of the deposit.

4. Grangesberg in Dalecarlia is nowadays the most important of all the iron-mining districts of Central Sweden; its production of 630,000 metric tons in 1897 exceeded even that of the Gellivara district. For two centuries, the high percentage of phosphorus in the ore constituted an insurmountable obstacle to its working on a large scale, but after the introduction of the Thomas process there was an advance by leaps and bounds in the mining industry of Grangesberg. Four great companies, working in agreement, control the entire field, and most of the ore is shipped at Oxelosund for Rotterdam and Stettin, whence it finds its way to the Westphalian and Silesian blast-furnaces.

The mining-field covers a comparatively small area, 3 miles long and 2/3 mile broad, in which the predominant rock is a fine-grained biotite-gneiss. Inter-bedded with this is a pinkish gneissose granite, at the hanging-wall of which the chief ore-deposits occur. All the rocks strike north-north-east, and dip sharply east-south-eastward. In the western portion, the Lomberg, Ormberg, and Risberg mines work a great number of small deposits of iron-glance associated with magnetite, and containing from 0.02 to 0.8 per cent. of phosphorus. In the eastern portion, in the so-called “Export” field, two great lenticular masses are worked. The southernmost of these consists of fine-grained crystalline magnetite, containing 0.7 to 1.2 per cent. of
phosphorus, and yielding 60 to 62 per cent. of metallic iron. The northernmost, at the Sjustjernberg, consists (near its hanging-wall) of magnetite, with which so much apatite is associated that the percentage of phosphorus reaches a maximum of 2.8 ; near the footwall it consists of iron-glance with 0.5 to 2 per cent. of phosphorus. Pegmatite veins in some cases course through the deposits, the effect of their passage being to alter the iron-glance into magnetite. The Norra Hammar mines work a magnetic ore so intermingled with apatite as to contain 6 to 8 per cent. of phosphorus. The "country" in this case is a hornblende-gneiss streaked with highly micaceous bands.

As to the genetic relationship of the foregoing deposits, the author considers that the magnetite and iron-glance crystallized out simultaneously with the constituents of the country-rock; but, at Norra Hammar, the apatite and titanite separated out earlier than the hornblende, which was followed by quartz (in scant measure) and fluor spar. The deposits have been proved, in one case, to a depth of nearly 1,000 feet, and the amount of ore in sight will take many years to exhaust.

5. Langban.—These manganese and iron-ore deposits occur north of Filipstad in Vemmland, in association with a belt of dolomite which strikes north and south through a granulite-inlier isolated amid an enormous spread of granite. The manganese-ores (braunite and hausmannite) contain up to 45 and 47 per cent. of manganese: the iron-ore is mostly iron-glance, and, in a very subsidiary degree, magnetite.

Attention is directed to the remarkable occurrence of "native lead" in fissures of the hausmannite-dolomite.  L. L. B.

ARGENTIFEROUS DEPOSITS IN THE PROVINCE OF MADRID, SPAIN.

The area dealt with in this paper lies in the northernmost portion of the province of Madrid, in a country of hill and forest, 56 miles distant from that city, near the watershed between Douro and Tagus.  It lies west of the village of Robregordo, on the high road to Burgos, and extends eastward to La Acebeda, at a height of 3,580 feet above sea-level.  Halfway between these two villages are the four abandoned mines of Maria Josefa, San Antonio, Virgen del Carmen, and San Francisco, covering a superficies of 135 acres.  The author gives a careful description of the workings, into all of which he went, as far as the obstructing debris and the water would allow.

The predominant rocks of the district belong to the crystalline-schist series, being chiefly gneisses and mica-schists, with occasional beds of quartzite.  Going

southward, the crystalline schists are seen to rest upon granite, while eastward, they are overlain by the Cambrian, and this again by the Silurian.  The Silurian formation extends right through the province of Guadalajara; and there, in an inlier of crystalline schists, occur the wellknown argentiferous veins of Hiendelaencina.  Moreover, the nodular and macliferous gneisses with large felspar-crystals, characteristic of that area, are equally characteristic of the Acebeda district—the country-rock is in both cases the same.  In a general way, the crystalline schists dip eastward at varying angles, and are seamed in various directions by quartz-veins, mineralized with iron pyrites, spathose iron-ore, and argentiferous ores.  Native silver is so minutely commingled with the vein-quartz that often its presence cannot be discerned by the unaided eye: where richest, it imparts to the quartz a grey tinge, which darkens on wetting.  The chemical combination wherein the precious metal
occurs most commonly hereabouts is the sulpharsenate of silver. Marcasite, mispickel, and the oxides of iron (which redden the quartz in places) are frequent associates: they form bands parallel with the grey silver-quartz, sometimes in immediate contact with it, and sometimes parted from it by a band of white quartz. The thickness of the actually metalliferous portions of the veins ranges up to 10 inches, but the distribution of the ore throughout the complex of veins appears to be very irregular (and this is confirmed by the analogous occurrences of Hiendelaencina, so that no reliable inference can be drawn as to the richness of the deposits from their aspect at any particular point.

A table of assays, some of which date from 1853, and others are quite recent, shows that the percentage of silver varies from 0.125 to 1.25.

Unlike other metalliferous regions of the peninsula, no mining-exploration of any importance seems to have been attempted in this district until past the middle of the present century. Then, in the late fifties, there arose a "mining boom" in Spain, and a company was formed to work the deposits. Four shafts were put down, and a heading was driven 350 feet long at a locality known as El Carcabon. The shafts are now full of water and debris, but the sole reason assigned for the abandonment of these workings is the financial collapse which followed close upon the "boom," and hurried mining companies, good and bad alike, into bankruptcy.

In view of a possible resumption of mining-industry in this area, the author points out that the new railway from Madrid to Santona will pass through it, and that only 16 miles east, as the crow flies, from Robregordo, there are small outliers of Coal-measures (east of Tamajon, in the province of Guadalajara) which would doubtless furnish sufficient fuel for local consumption in the mines. Moreover, there are peat-deposits among the neighbouring hills, and the forests would furnish pit-props and charcoal, as well as firewood.

L. L. B.

GOLD-BEARING DISTRICTS OF EASTERN BOKHARA, CENTRAL ASIA.

In the summer of 1898 the author, as member of an expedition starting from Bremen, found the opportunity of visiting an auriferous region which is all but unknown in Europe. In the neighbourhood of the upper course of the Amu Daria or Pandj, which divides Bokhara from Afghanistan, in the provinces of Baljuwan and Darvas, run a series of ridges of early Tertiary gold-bearing conglomerates, whose elements are mainly derived from crystalline rocks. These conglomerates, which are distinctly bedded, form mountains running up to the level of 13,000 feet, closing in deep narrow valleys whose floor is 5,200 feet or more below the mountain-tops. In other districts, however, the conglomerates are made up of softer materials, bedding is obliterated, the hills are rounded, and the valleys broad. Nevertheless, these rocks reach an altitude of 11,300 feet or more. They are associated with evidently contemporaneous sandstones and marls, and at Kangurt (in the west of Baljuwan) the bright red sandstones are seen to rest upon Cretaceous limestones. Below and to the eastward of the Khob Rabat Pass, conglomerates showing no stratification overlie the crystalline rocks. Some 40 miles south-west of the pass, in the neighbourhood of Mount Khasret-i-Shan, bedded conglomerates with a low north-westerly dip are faulted down against vertical red sandstones, shales, and limestones of Lower Triassic age. The rocks whose debris go to make up the above-mentioned conglomerates are predominantly green diabase-tuffs and red felsite-porphyries with irregular druses infilled by calc-spar. Red and grey granites, diorites, porphyrites, gneisses, etc., also occur. In size the
pebbles average that of a man's fist, but here and there huge blocks with a cubical content of 35 to 70 feet are found. The cementing-material of the conglomerates, partly calcareous, partly sandy, is gold-bearing; so too are the sands of the rivers which flow through the conglomerate-region. The gold occurs solely in the form of thin flakes, it is never granular, nor have any nuggets been found. It assays to 92.7 per cent. The Russian engineer, Pokorski, informed the author that auriferous quartz-veins course through the crystalline rocks in the immediate vicinity of the conglomerate-region, and such veins are doubtless the primary source of all the gold that occurs in Eastern Bokhara.

Traces of ancient opencast workings and enormous waste-heaps are of frequent occurrence, and it is seen how the inhabitants of the country gradually abandoned gold-mining proper to betake themselves to gold-washing, which is alone practised nowadays. The sands washed by the natives (Sarts) are comparatively poor down to about 26 feet below the surface, at which level the rich deposits begin. In the middle portion of the rivers these latter sands lie below the general water-level of the country, but near the banks they rise higher, and are dry. The Sarts, therefore, prefer to dig their shafts near the river-bank; nevertheless, they work also the sands below the general water-level, leading off the water by subterranean rough-walled channels, a mile or more in length, which are carried approximately horizontally upstream, cutting gradually deeper and deeper into the sand-beds, which dip down stream, then passing through the water base-level, and finally striking bedrock. The auriferous sands are brought to day by means of sloping shafts communicating with the channels. The shafts, which reach a maximum depth of 47 feet, are not provided with timbering, and they often fall in, with fatal consequences. The 8,000 natives engaged in the work wash annually about 6,450 tons of sand, yielding 5,792 ounces avoirdupois of gold, nearly all of which is exported to Afghanistan. But this industry, though it is many centuries old, has made scarcely any appreciable inroad into the auriferous resources of the country. The researches of Mr. Pokorski during recent years have shown untouched deposits in many rivers (as, for example, in the Safet Darya), not to speak of beds believed to exist deeper still than the two horizons already determined.

The author points out that not only could the gold-washing industry in Eastern Bokhara, if organized on a large scale by Europeans, be made to pay handsomely for many generations to come, but that all the attendant conditions are, on the whole, favourable.

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Though there are no forests, trees grow thick in the valleys, and timber (if dear) is to be got in sufficient quantity: it is mainly poplar and walnut. With regard to climate, the rainless season lasts from the beginning of May to the end of November. Even in winter, work can be carried on in the open air, and it is safe to calculate on at least 250 working-days in the year. The water-supply is in some districts sufficient all the year round for all purposes but hydraulicing. South-west of the Khasret-i-Shan, however, and along the tributaries of the Mazur Su, the streams are entirely dried up in the late autumn.

As regards labour, it would be most feasible to employ the hardy though indolent Sarts, on account of their traditional knowledge and extensive experience of gold-washing. The average daily wage of a Sart labourer is 6 1/2d., while that of a Russian labourer is about 1s. 9d. Provisions, such as mutton and rice, are cheap, and scarcity of labour is only probable about harvest-time (August). The roads are mostly bad. Camel-transport is slow but cheap, and freight by pack-horses costs about half more. It is 10 days' journey to the nearest railway-station, Kokan, on the recently extended Turkestan line.
In the year 1896, Count Vresovski, Governor of Turkestan, promulgated a mining code for the Khanate of Bokhara, wherein it is expressly stipulated that Russian subjects alone shall prospect for gold-deposits or work them when found. Jews, Greeks and Armenians (even if Russian subjects) are excluded. The author intimates that further details regarding Eastern Bokhara are obtainable from Mr. W. Rickmers-Rickmers, of Bremen, and that Mr. P. A. Pokorski's papers may be consulted in a mining journal published at Kharkov.

L. L. B.

MINERAL RESOURCES OF JAPAN.
The author travelled through Japan in the autumn of 1897, and, in addition to the results of his own observations, this paper embodies information culled from the reports of the Japanese Department of Mines and other publications. Coal is practically the most important mineral product of the Island Empire, and the output reached in 1895 the total of 4,772,656 tons. Out of this total 1,376,068 tons were exported to foreign countries, the three largest customers being the British colony of Hong Kong, certain Chinese treaty-ports (Shanghai, Chi Fu, Fu Chau) and British India. It is all of post-Palaeozoic (Secondary or Tertiary) age, and 87 per cent. of it comes from two principal areas—one being the Island of Hokkaido, the other comprising north-western Kiushu and the province of Yamagushi. Turning first to the island of Kiushu, we note that the Nagasaki coal-field is the one that has been longest worked of all Japan: the Nagasaki coal is much esteemed for coke-manufacture, and its composition is as follows:

<table>
<thead>
<tr>
<th>Per Cent</th>
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<tbody>
<tr>
<td>Water</td>
</tr>
<tr>
<td>Fixed carbon</td>
</tr>
<tr>
<td>Volatile matter</td>
</tr>
<tr>
<td>Ash</td>
</tr>
<tr>
<td>Sulphur</td>
</tr>
</tbody>
</table>

The output from this particular coal-field shows a tendency to diminish.

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In the same island, the Fukuoka coal-field occupies from north to south a belt some 60 miles long, which is cut across into two distinct basins by an anticlinal axis. There is railway-communication from the various collieries to the harbour of Takamutsu, where the coal is shipped into junks, and thence transhipped on to larger steamers at Modshi, on the Straits of Shimonoseki. In the Miike basin, on the eastern shore of the Simbara Gulf, there are two well-recognized seams: the upper or eight feet seam, which in some places reaches a thickness of 19 feet, and the lower about 6 feet thick. The last-named has so far been worked simply at the outcrop, and then only for local consumption. The beds are extremely regular, and dip southward at 1 in 10. Five shafts and nine borings have been put down: the deepest of these, starting at a point hardly above sea-level, struck the eight-feet seam at a depth of about 780 feet, and it is computed that 50,000,000 tons of coal are in sight, exclusive of what may be got beneath the Simbara Gulf itself. The seams are not fiery, and naked lights are universally used. The mines are very wet, and need constant pumping to keep them dry. A certain proportion of convict labour is employed on the coal-field, in addition to the free labourers. The daily wage of the latter varies from 7 1/2d. to 10d., and the prime cost of a ton of Miike coal is reckoned at about 4s. 10d. Its composition is as follows:
In the island of Hokkaido or Yezo, the very numerous coal-seams are inter-bedded with Cretaceous rocks. Really active working in this field appears only to have begun within the last ten years, although it is true that the Imperial Government started the Poronai mine in 1879, but in 1889 the property was sold to the Hokkaido Coal-mining and Railway Company. The extremes of the seven analyses of coal tabulated by the author from Hokkaido are as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Per Cent.</th>
<th>Per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>0.63</td>
<td>5.59</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>51.10</td>
<td>57.60</td>
</tr>
<tr>
<td>Volatile matter</td>
<td>39.06</td>
<td>44.36</td>
</tr>
<tr>
<td>Ash</td>
<td>6.80</td>
<td>1.08</td>
</tr>
<tr>
<td>Sulphur</td>
<td>3.15</td>
<td>1.28</td>
</tr>
<tr>
<td></td>
<td>100.74</td>
<td>1.28</td>
</tr>
</tbody>
</table>

Comparing these Japanese coals with British coal, experiment has shown that to produce the same motive power as that got by burning 15 tons of Cardiff coal it would be necessary to use between 18 and 23 tons of Japanese. Nevertheless, the higher price of Cardiff coal makes the use of the Japanese more economical in the long run. For the supply of men-of-war, Welsh coal still retains its undisputed supremacy in the Far East.

Copper is, next to coal, the most important mineral product of Japan, but the output has somewhat diminished of late years. The most recent statistics available show, for 1893, an annual production of 18,000 tons. The Ashio mine sends its products about 3 miles by telferage down to the Nikko valley, whence they are taken by horse-tramway to the Nikko railway-station. The cupriferous veins occur at and near the junction of the schists and rhyolites, which are the chief geological formations of the district. Out of ten known veins only three are actively worked. The ore is a mixture of iron and copper pyrites with a little bornite, and is found in the form of impregnations in the silicified "country." Picking, washing and roasting are carried on at the mine, and the coarse metal undergoes complete refining by an electrolytic process at works in the vicinity of Tokio.

The Besshi mine lies high up in Shikoku, at a distance of about 10 miles from the western seaboard. The ore is partly treated at the nearest shipping-harbour, Niihama, whence a railway runs for 7 miles or so to Tatsukawa, some 2,000 feet below the Besshi escarpment. From the railway terminus, stores, etc., are carried up and copper-ore carried down the cliff by a telfer-cable. From the upper terminus of the cable, a small tram-line runs to the main haulage-road of the mine: this is in a tunnel which cuts right through the mountain. The workings are on a large scale, and, at the time of the author's visit, a shaft 1,770 feet deep had just been completed. The ore is rough-roasted on the spot, and then (as above mentioned) sent down to Niihama for
further treatment. The second matte, containing 55 per cent. of metallic copper, is roasted in a reverberatory furnace, yielding a metal containing 99 per cent. of copper, and further refining carries the tenour up to 99.7 per cent.

The author gives statistical tables of exports which show that the British colony of Hong Kong is far and away Japan's best customer for copper, taking four-fifths of the total; while China, Great Britain, British India, and Germany take nearly all the remaining fifth between them.

Antimony occurs in the form of stibine, chiefly in the provinces of Yeshin and Nara, and is largely exported in the raw state. Such metallic antimony as is exported goes mostly to the United States.

Iron.—Japan is poor in ores of this metal. There are some occurrences in the form of veins in the province of Iwate, and fairly abundant magnetite-sands in the provinces of Shimane, Tottori, and Hiroshima. Nearly all the iron and steel used in the Empire is imported from Great Britain, Belgium, and Germany.

Gold.—About 20,287 ozs. were produced in 1895, nearly all in the province of Kagoshima, island of Kiushu. Part of the gold was got from veins, and part was alluvial. At Aikawa, on the island of Sado, there is an important metalliferous mine, which, in addition to gold, yields silver, copper, and lead.

Silver.—The annual output averages 1,833,000 ounces. There are several mines, the most considerable being that of Innai, in the south of the province of Akita. The Hirayu mine, in Gifu, is situated about 6,500 feet above sea-level, on the flank of the Norikura volcano. At Ikuno, in Hiogo, the ore got from the mine near at hand is treated by the Russell process.

Petroleum.—One oil-bearing district is known, near Amase, in the province of Echigo. In 1893, this district produced 2,620,000 gallons of oil: the remainder of the petroleum consumed in Japan is imported from Pennsylvania and the Caucasus.

Sulphur.—An ever-diminishing quantity is got from solfataras, and is almost wholly exported to the United States.

L. L. B.

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GEOLOGY OF THE NORTH-WESTERN PORTION OF THE GOVERNMENT OF TOMSK, SIBERIA.


In the north and south of the region described in this paper, Middle and Upper Devonian rocks cover a vast area. The former is made up of coralline limestones, interbedded with clay-slates which are generally unfossiliferous; while the Upper Devonian consists of limestones rich in brachiopods, of marlstones, and clay-slates. Carboniferous strata occur in two areas widely separated one from the other by the Devonian rocks. One occupies the north-eastern angle of the region, the other lies in the extreme south-west. The fossiliferous Carboniferous Limestone forms the lower division of the group, while the upper consists of sandstones and shales interbanded with coal-seams. The Elbash coal-field extends along the river of the same name in a north-north-easterly direction, forming a belt at least 20 miles in length and not exceeding 1 mile in width. The coal-bearing strata are divisible into four distinct groups: the uppermost, down to 100 feet from the surface, contains three coal-seams. The next
includes a seam 5 feet thick; the third comprises one seam no less than 32 feet in thickness, and another about 40 inches thick. Another 5 feet seam is found in the fourth group. So far as these seams have been explored, they show no tendency to thin out.

The Izyla coal-field, 20 miles or so long and 2 miles broad, forms a belt running west-south-west and east-north-east. The seams which have been proved here range from 30 to 70 inches in thickness.

Ever since the Coal-measure period, the region under review appears to have been a land-area, over which atmospheric denudation has had free play. The oldest alluvial deposits occur in the neighbourhood of the streams which run down from the Salair range. They are mainly reddish loams containing numerous pebbles of very diverse origin.

Gold has been found only in the immediate vicinity of the hills, in a clay very slightly intermixed with sand, and full of rock-fragments ranging in size from small pebbles to large blocks of a hundredweight or more. These fragments are partly quartz (varying in colour from ochreous yellow to snowy white, the latter being the commonest) and partly limestone, dark and light-grey, granular, crystalline, and barren of fossils. This auriferous alluvium was evidently laid down quite near the original outcrops of limestone and quartz.

Eruptive rocks constitute an important feature of the region. They include post-Devonian granites and felsite-porphyries, and contemporaneous Devonian hornblende and plagioclase-porphyrites and tuffs.

Spathose iron-ore occurs, but nowhere in payable quantities. Some of the rocks would make good building-stones.

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LIGNITE-DEPOSIT OF MARCEAU, ALGERIA.


Marceau is a village 15 miles (24 kilometres) from the port of Cherchell on the Mediterranean. As early as 1860, traces of mineral fuel were noticed on the side of the hill forming the southern slope of the Marceau valley, and in the bed of the Oued Bouchouaou which descends this valley. The proofs of the existence of a lignite-seam were sufficient for the Government to offer, in 1880, the concession of about 30 acres (12 hectares) to whoever would, under certain conditions, put up glassworks for utilizing the siliceous sand from a neighbouring quarry.

The lignite-seams are comprised in the Sahelian Miocene, which terminates on the west the Algiers Neogene basin, while forming a veritable gulf in the upper and middle Cretaceous series. Two bands of eruptive rocks, stretching from east to west, bound on the north and on the south, the Marceau geological gulf; these eruptions being supposed anterior to the Marceau Sahelian formation deposited at their base.

The exploring works have revealed the existence of three lignite-seams having the following gross and net thicknesses respectively:—No. 1, 13 feet 2 inches (4.01 metres) and 9 feet 2 inches (2.8 metres); No. 2, 7 feet 11 inches (2.43 metres) and 4 feet 11 inches (1.5 metres); and No. 3, 3 feet 7 inches (1.1 metres) and 3 feet 3 inches (1 metre). In the second seam, tree-trunks about 18 feet (from 5 to 6 metres) long, in perfect preservation, and which appear to be conifers, have been found close to the floor.

The lignite is of compact texture and dull black colour, while it breaks up into parallelopipeds; and sometimes, in the middle of the seam, threads of bright black lignite, very compact and of conchoidal fracture are found. The analysis of a sample, carefully taken so as to be representative, showed water 30.8, volatile matter 31.2, fixed carbon 25.4, and ash 12.6 per cent., while the calorific power is 7,672 British
thermal units per lb. (4,264 calories per kilogramme). It is considered that 1.5 tons of Marceau lignite is equivalent to 1 ton of Newcastle coal; and the gas-producers at the glass-works are fired with 60 per cent. of lignite and 40 per cent. of British coal.

J. W. P.

GOLD-FIELDS OF THE MURCHISON RANGE, TRANSVAAL.

These gold-fields are situated in the Zoutpansberg region of the North-eastern Transvaal. From Pretoria, it is a three days' journey by the coach-road through Nylström, Marabastad, and Pietersburg to Leydsdorp, the principal town on the Murchison Range and the headquarters of the District Commissioner of Mines. The Murchison Range, itself, is an outlying spur of the Drakensberg, but of much inferior altitude to that great chain. It forms part of the unhealthy "low country," where bush-covered plains are infested with tsetse and swamps breed fever. The basement-rock of the country is hornblendic granite, which sometimes passes into syenite, and sometimes into gneiss. Indeed, the cupriferous gneisses of the Murchison Range are analogous to those of Namaqualand, which are regarded by some geologists as the richest in the world. Overlying the granite

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are crystalline schists of Laurentian (?) age, broken through by intrusive diorites, diabases and dolerites in the form of bosses, sills and dykes. It is in the fissures of the fractured granite and schists that most of the metalliferous occurrences are observed. Above these are great outliers of sandstones and shales, of quartzites and conglomerates much disturbed by greenstone-intrusions. The quartzites and conglomerates are seldom mineralized, and even then very poorly.

Turning first of all to the auriferous deposits, these occur in quartz-veins forming lenticular intercalations, sometimes oblique to, but more generally parallel with, the strike of the bedded rocks. The reefs are almost everywhere cut across by diorites and other eruptives. The Silati field, named after that river comprises three parallel gold-bearing belts. Of these, the northernmost, 12 miles in length, is characterized by the association of antimony-ore (stibine) with the gold. The precious metal occurs in thin flakes in the fissures of the quartz, or in coarse grains; and appears similarly on the surface of the stibine, or mingled with it in an invisibly fine state of division. The "country" consists of metamorphic schists and highly-altered quartzites thrust up on end, and forming a ridge 1,000 feet high. Two miles south of this, the next belt has shown some very rich occurrences at the outcrop, but they do not continue deep down. In the southernmost belt of the three, 12 to 15 miles long, the auriferous deposits have been followed down to a depth of 400 feet. The gold occurs among the flakes of talcose tremolite-schist or in small lenticles and venules of quartz. Thirty miles north of the Silati is the Klein Letaba gold-field, on the very banks of the Letaba, among the wooded foot-hills (Sutherland Hills) which mark the termination of the "low country." Here granite crops out everywhere, and in it lie long outliers of auriferous metamorphic schists striking west-south-west and east-north-east. The gold-bearing belt stretches over a length of 20 miles, but its extremities alone have been thoroughly prospected. At Letaba, a reef has been proved for a depth of about 150 feet and for an equivalent length; but it appears to thin out on all sides, and in depth ramifies into venules. Sulphides of iron, lead, and copper are associated in this with silver and gold. At Birthday, about 1/3 mile to the southward, the reef varies in thickness from nothing to 13 feet over a length of 150 feet. It is in the form of a doleritic lenticle, cut across by quartz-veins and diorite-dykes. Here the gold is found more especially along the salbands, in association with iron, copper, lead, and silver sulphides; the gold-tenour diminishes by more than 50 per cent. in depth. Two reefs
have been proved at Ellerton, with an outcrop 650 feet long, and going down to 330 feet in depth. The quartz occurs here in parallel bands, and is equally auriferous with the salbands.

The other gold-fields mentioned by the author in the Zoutpansberg region are as follows: (1) The Molototsi, on the river of that name, equidistant from the Letaba on the north and the Selati on the south. Here, in the universally outcropping granite occur auriferous quartz-veins to which, so far, small importance is attached. (2) The Houtboschberg and Hoenertzburg, 10 to 12 miles apart on the Pietersburg road, 32 miles west of Leydsdorp. Here the gold-quartz occurs veining granites, quartzitic sandstones and schists, while immediately to the south crop out the Drakensberg conglomerates. (3) The Marabastad-Smithsdorp, in the neighbourhood of Pietersburg. Here are the same schists, striking south-west and north-east, as on the Silati. Gold-reefs have been proved chiefly on the farms of Roodepoort and Eersteling. Alluvial gold occurs very seldom in the Murchison Range or elsewhere in the Zoutpansberg; the effect of denudation and erosion has been too great, and the precious metal has been carried far down the Olifants river, away from its tributaries the Silati and the Letaba. South of Marabastad, however, a few poor alluvial deposits have been found, as also at Tours and Mamotsuri, 20 miles west of Leydsdorp. The annual production of all the foregoing gold-fields ranges between 5,000 and 16,000 ounces, the total produced from 1889 to the end of 1896 being 63,771 ounces, of a value of £242,100. All the indications are against any great development of gold-mining in the Murchison Range.

East of the range are the Palabora hills, 32 miles from Leydsdorp. From the granitic plain rises a ridge of white marble, 2 miles or more in length. Along this runs a magnetite-reef which appears to be the gossan of a cupriferous deposit, speckled as it is with malachite and azurite. From this backbone ramify innumerable thin veins and venules of copper sulphides, bornite, tetrahedrite, etc., excessively rich in copper. The entire ridge is honeycombed with ancient workings, and there is every reason to believe that a great deposit of chalcopyrite occurs at no great distance from the surface. Cinnabar occurs at the junction of the schists and granite north of Witkopjes, and in grits and quartzites at their contact with porphyrite at Longweberg. A little tin has been found in alluvia on the Great Letaba, and there are some accumulations of rock-salt in natural saltpans in the same neighbourhood.

The author gives a very brief description of some of the Zoutpansberg goldmines.

L. L. B.

LIBOLLITE, A NEW BITUMEN, FROM PORTUGUESE WEST AFRICA.


About the end of 1896, a Catholic missionary rediscovered in the Province of Angola a so-called "coal-deposit" covering an extent of 6 leagues along the banks of the Lower Cuanza, whose waters are navigable by steamers between Dondo and Loanda. The outcrop is only a few feet above river-level, and is from 20 to 40 inches thick. A mining concession had been granted many years ago, but had been allowed to lapse.

Hand-specimens having been deposited at the Ministry of Marine in Lisbon, the author made a careful examination of them, the result showing that the mineral is certainly not coal, but has close affinities to albertite. It is of a pitch black, with resinous lustre, shows uneven fracture, sometimes conchoidal, and yields a dark brown streak. Its hardness is 2.5 in the Mohs scale,
and its specific gravity is 1.1. It burns brightly with a good deal of smoke on the application of a candle or gas-flame, giving forth a very disagreeable bituminous odour. It intumesces in a most extraordinary way, swelling up to a volume four or five times that of the original, and yielding a dull, fragile, "blistery" coke, of low specific gravity, difficult to reduce to ashes. The results yielded by chemical analysis are as follows:—

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<thead>
<tr>
<th></th>
<th>Including Ash.</th>
<th>Excluding Ash.</th>
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<tbody>
<tr>
<td>Hydrogen</td>
<td>7.83</td>
<td>8.412</td>
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<tr>
<td>Oxygen</td>
<td>8.80</td>
<td>9.415*</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>1.71</td>
<td>1.837</td>
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<tr>
<td>Carbon</td>
<td>74.74</td>
<td>80.300</td>
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<tr>
<td>Residue</td>
<td>6.92</td>
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* 1.97 in albertite.

For comparison, the author tabulates analyses of albertite, Virginia grahamite, Dead Sea asphalt, and Hanoverian petroleum.

[39]

Albertite yields a black streak, and, when ground to powder, remains black. These properties differentiate it from the mineral now described, as well as the carbon and nitrogen percentages (86.04 and 2.93 respectively in albertite); and the author proposes for the new mineral the name "libollite," Libollo being the locality where it occurs. Its calorific power is equivalent to 4,833 calories. Libollite shows no traces of plant-structure; and the author is inclined to believe that the occurrence will be found, like that of albertite, to consist of fissure-deposits starting from a great depth.

L. L. B.

LIGNITES OF TIERRA DEL FUEGO, ARGENTINE REPUBLIC.


The author examined samples of two varieties of lignite brought from Slogget Bay. No. 1 is a lignite of first-rate quality, of a jet-black hue, with conchoidal fracture and black streak. It burns with a short, rather dull flame; its specific gravity is 1.273. No. 2 has but little lustre, and is of a reddish hue, with a coffee-brown streak. It burns more readily and with a longer flame than No. 1, but is of a far inferior quality. The results of chemical analysis are as follows:—

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<th>Samples.</th>
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<tr>
<td></td>
<td>Per Cent.</td>
<td>Per Cent.</td>
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<tr>
<td>Hygroscopic water at 110° Cent.</td>
<td>26.85</td>
<td>17.00</td>
</tr>
<tr>
<td>Volatile constituents</td>
<td>31.63</td>
<td>31.88</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>39.47</td>
<td>18.40</td>
</tr>
<tr>
<td>Ash</td>
<td>2.05</td>
<td>32.72</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.466</td>
<td>Not ascertained</td>
</tr>
<tr>
<td>Absolute calorific power, measured in calories</td>
<td>3,482</td>
<td>2,324</td>
</tr>
<tr>
<td>Coke</td>
<td>Hardly caked together</td>
<td>Pulverulent</td>
</tr>
<tr>
<td>Colour of ash</td>
<td>Red</td>
<td>Grey</td>
</tr>
</tbody>
</table>

It has not yet been shown whether these lignite-deposits are favourably situated for working on a large scale. L. L. B.

GOLD-BEARING BEDDED-VEINS OF PASSAGEM, BRAZIL.
The Passagem gold-mine is situated about 4 1/2 miles east of Ouro Preto, the capital of the state of Minas Geraes. In mineral wealth it is reckoned among the richest in Brazil, ranking next to Morro Velho; and, although it has been worked more or less ever since the beginning of this century, its true development only began after it had passed into the hands of a reconstituted British company. From 1884 to 1893, out of 287,626 metric tons of vein-stuff, 76,360 ounces (2,375 kilogrammes), or not very far short of 0.1 per cent., of gold was got. Besides this, a quantity of metallic bismuth averaging 80 pounds per annum is separated from the gold. In 1892, the workings reached the depth of 1,462 feet.

The metalliferous vein is chiefly made up of milk-white quartz, tourmaline, and mispickel, with iron pyrites and magnetic pyrites as subordinate associates. It belongs to the category of bedded veins, being interstratified with flaggy quartzites, etc. It strikes north-east and south-west, and dips 18 to 20 degrees south-eastward. The rock-succession is as follows:—Quartz-mica-schists at the base, then greenish-white flaggy quartzites, above which comes the vein. There is a salband, about 39 inches thick, at the foot wall, consisting of black graphitic schist, while the salband at the hanging-wall is rarely graphitic, but is made up of garnet, pyrites, and black mica. Above the upper salband is a thin stratum of cryptocrystalline schists, consisting of quartz and black mica. Overlying this are the itabirites, a distinctly bedded mass no less than 160 feet thick, of granular quartz and shining flakes of iron-glance. The itabirites are overlain by a crust of canga, a brown porous conglomerate: this is made up of fragments of the underlying rock, bound together by a ferruginous, argillaceous cement.

The auriferous vein itself really forms a series of lenticles, here swelling out to 50 feet, and there contracting to 6 1/2 feet. Where thickest, it is generally poorest, and also the more quartz that goes to its composition, the poorer it is. In the richer portions, native gold is discernible with the unaided eye, in grains or crystals, encrusting mispickel and tourmaline. No gold is found in the flaggy quartzites, but in the itabirites nearest the vein, gold has been proved in the proportion of 1.8 per million.

The following is a complete list of the minerals found in this mine—(1) Vein-minerals: Quartz, mispickel (the most abundant of the sulphides present), iron pyrites, copper pyrites, magnetic pyrites, galena, stibnite, gold, calcite, dolomite, siderite, and limonite—the last five being evidently secondary infiltration-products. (2) Granite-minerals: Quartz again, muscovite, also a green chromic muscovite (fuchsite), biotite, oligoclase-albite, zircon, monazite, xenotime, amphibole (?), magnetite, and rutile. (3) Contact-minerals: Tourmaline, andalusite, staurolite, diasthenites, garnet, hercynite, cummingtonite, and biotite again. Of all these occurrences the author gives a detailed description, but it will be sufficient here to summarize his remarks on the gold. As before hinted, this is most frequently present in the crystalline masses of mispickel and tourmaline. It is also finely disseminated in aggregates of tourmaline microcrystals, and occurs in well-formed octahedra on the walls of druses of mispickel; but, as a rule, the precious metal is scattered very irregularly in minute particles, or in thin flakes and jagged fragments. There is also a secondary formation of native gold on the basal cleavage-surfaces of tiny tourmaline-prisms.

The bismuth, of which mention has already been made, probably occurs as a natural alloy with the gold, for it has been impossible so far to trace a single bismuth-mineral at Passagem. It should be noted, however, that in other localities not far off, bismuth-
minerals have been found in association with gold. The silver-content of the Passagem gold is infinitesimal. A petrographical description is given of the mineral-associations in the quartz-vein, in the schists in immediate contact with it on either wall, and in the itabirites, mica-schists, flaggy quartzites, etc., and the author tabulates the following conclusions as the outcome of his careful mineralogical and petrographical examination of the rocks:—
1. The Passagem quartz-vein is of intrusive origin, and is, in fact, a hyper-acidic granite apophysis.
2. It broke through the quartz-schists (itacolumite-slaty quartzites according to Dr. Ferrand), crushing them up and in part absorbing them, and formed a distinct contact-zone both at the hanging-wall and at the footwall.
3. It is, therefore, of later age than any of the country-rocks, all of which are metamorphosed sedimentaries.

L. L. B.

GOLD-PLACERS OF THE DEBATABLE LAND, NORTHERN BRAZIL.
The territory in question is claimed by France to belong to French Guiana, in virtue of the treaty of Utrecht; whereas Brazil claims that, in the aforesaid delectable treaty, the river Yapoc was confounded with the river Oyapok, and that the boundary should be shifted by 125 miles. The rival claims have now been submitted to the arbitration of the President of the Swiss Confederation; but our author proposes that his countrymen should meanwhile manufacture vested rights ("secure effective occupation" the wise it call) in the most valuable portion of the Debatable Land, by multiplying expeditions into the interior, by establishing direct steamboat communication with Cayenne, and by setting up favourable Customs tariffs.
The river Araguari cuts the territory in dispute into two physiographically distinct portions:—South of it stretch boundless savannahs, where the Indian half-breed pastures great herds of cattle; north of it lies a region of mountain and valley, through which flow the Caraseveno, the Cunani, the Oyapok, etc., their banks dotted with gold-placers. In 1893, two prospectors went up country from Cayenne, and, after a sojourn of 2 months on the banks of the Caraseveno, returned with a load of 795 lbs. of gold. The usual rush followed, and many blacks from the British West Indies (Barbados, Santa Lucia, etc.) took part in it, with the result that the floating population of the Debatable Land reached at one moment 10,000 souls, despite the difficulties and dangers inseparable from the journey thither. Numbers perished by the way, and many died of privation when they had reached the goal.
The area upon which the rush converged is a remarkably small one; it extends hardly more than 3 miles up the Lorenz or Factory creek and the same distance up the Great creek. In the former, at the point where a small stream known as the Onemark debouches into the valley, the richest accumulation of native gold was struck, and here the miners' sluices lay literally cheek by jowl. At this favoured spot, the deposit seemed to grow richer the deeper down it was worked; indeed, throughout the Caraseveno basin the top barren layer is so thin that spangles of gold were brushed in appreciable quantity off the roots of the plants. But the workings have been mostly stopped in consequence of the insufficient outflow from the sluices. In a district without mining legislation, it has been found impracticable to undertake such works as would secure a proper outfall, or to prevent robbery of water from the down-stream miners by surreptitious up-river intakes. All that is being done now is to wash the old tailings for gold, but even this is extremely profitable, and the author believes that if a great waste-flume were made it would still pay very well to re-wash these washed tailings.
Another circumstance which has contributed to the decay of mining-industry hereabouts is the behaviour of the workpeople. No reliance could be placed on them. Not only did they steal nuggets, but they worked their employers' ground (after working-hours and on Sundays) for their own profit; and, as if by accident, it always happened that the richest portion of the placer would be left for this "overtime." On the other hand, no case of robbery with violence has been authenticated, either on the placers or on the trails down to the coast. Meanwhile, those enterprising persons who are clamorous for concessions, to make assurance doubly sure, have registered both with the French and Brazilian governments claims covering 125 to 250,000 acres apiece, and this will complicate considerably the task of arbitration.

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The author admits that the rapids which obstruct so many of the rivers will constitute an insurmountable obstacle to any great development of steam-navigation, and he therefore sketches out a plan of railway-construction by convict-labour. The distance from Cayenne to the gold-fields of French Guiana proper is barely 100 miles, and the proposed line would have a total length of 220 miles.

No separate statistics of gold-production as regards the Debatable Land are given by the author, but he estimates the actual (not the declared) value of the total annual export of gold from Cayenne at £500,000. This includes the gold from the disputed territory.

L. L. B.

GOLD-PLACERS IN FRENCH GUIANA.
French Guiana possesses the richest gold-placers known in South America, yet it contrasts unfavourably, in respect of general prosperity and economic development, with the British and Dutch Guianas. The colony, rich at one time by its trade in spices and dyes, had been brought to the verge of ruin by the sudden abolition of slavery, when in 1853 certain Brazilians (who were fleeing from military service in their own country) discovered some gold-bearing alluvia on the banks of tributary creeks of the Appruaga river. A year or two later, these were worked with extraordinary success by a company which had obtained mining rights over an area of 500,000 acres. Then gold was sought and found in other districts, in the river-basins of the Sinnamary, the Mana, and the Maroni. The discovery of the St. Elias placer in 1878 was followed in 1889 by the rich finds on the Awa.

All the placers known and worked are in the immediate neighbourhood of streams which are navigable either by steam-launches or by native pinnaces. Remoter deposits are unknown or untouched, precisely because there is no means of access to them under present conditions. The prospectors start on their journeys of exploration, as a rule, at that period of the dry season when the water-level in the rivers is such as to make the passage of the countless rapids which obstruct their course somewhat less arduous: for this purpose the waters must be neither very low nor very high. The rivers forming the only routes into the interior of the colony, a reduction in the number of portages becomes a primary consideration. Freights are heavy: thus, from St. Laurent or Albina up the Maroni 50 miles to the Beiman Creek placer, with two rapids to pass, the charge is £6 per ton. Goods going up from the above-mentioned ports to the Awa placers, a distance of 150 miles with 15 rapids to pass, pay £16 per ton. Negroes on their way to work at the placers pay 18s. to 50s. for their passage up river, and about a third of the price to come down river. The gold sent down to the coast from the placers is packed in boxes hooped with iron, to which (in view of possible capsizings) a long line with a small but strong float painted red is attached.
The difficulties of prospecting in the country are intensified by the dense cloak of vegetation with which it is covered. The author never saw one bare hill-top, and however high may be the ridges that one climbs no vast expanse of country ever meets the eye.

A table of the curious local standards of gold-tenour is given: these range from the infinitesimal proportion of 5 1/2 to 2,000 grains (5/100 gramme to 166.5 grammes) of gold per cubic metre of alluvium. In French Guiana, prospectors estimate the value

of a placer by sampling a few inches in thickness of the uppermost portion of the bed-rock, and of the lowermost alluvium in immediate contact with it: their assays represent, therefore, the "cream" of the placer.

The placers are generally in marshy ground, overgrown with cabbage-palm (Euterpe edulis) which is easily cut. The negroes are very expert at clearing off this vegetation, aided by the circumstance that the roots of trees in Guiana have a tendency to spread parallel to the surface instead of striking vertically downwards. Some placers can be reached by steam-launches; beyond this, the means of transport are what they were in 1853; loads are carried upon men's backs along the roughest imaginable native paths, toiling up steep hills and splashing through swamps. The bridges are just tree-trunks thrown across the streams, and the wayside habitations are mere straw huts. Beasts of burden or draught-animals are not to be found, and, as a preliminary condition of their existence in the country, much forest must needs be cleared and turned into pasture. Such are the drawbacks which prevent the shallow placers of French Guiana from being worked on the same economical system as the very similar shallow placers of Siberia. Moreover, there is not sufficient slope in the placers nor sufficient room for tailings; wherefore the American fixed sluice is inapplicable, and hydraulicing is equally out of the question.

They are worked by means of a portable sluice, supplied with water from an intake farther up stream. The sluice is put down on the site of the workings, and is shifted up stream concurrently with the working-face. It is made up of a series of wooden troughs which are slightly narrowed at one end so as to dovetail into each other: the usual length of these is 13 feet, their mean breadth 1 foot, and their vertical sides are about 1 foot in height. They are carried by piles fixed in the bedrock. From 12 to 15 persons are employed at each working-place; about 5 lbs. of mercury is thrown into the sluice at the start, and cast-iron riffles placed at the ends of the troughs retain the mercury and amalgam.

A large number of placers are lying idle, in consequence of the heavy cost of working them by the methods at present pursued in the colony: below a tenour of about 3 grains per cubic foot of alluvium, it does not pay to work the deposits. The author suggests the introduction of dredges, after the pattern of those used in New Zealand, and, more recently, in the United States. This would be the easier that in French Guiana the bedrock is almost invariably mere clay. The Mana, Sinnamary, and Appruaga rivers are all unmistakably auriferous: a little digging with a long-handled spade brings up payable alluvium from their beds, and a vast amount of material that does not pay to work now would pay very well on the dredging system.

As regards labour, the author points out that in the British and Dutch Guianas the negroes contract to work on the placers at a fixed daily wage, and receive in addition their board, medical attendance, and a free passage. The contracts hold good for 6 months, and the colonial authorities see to it that both parties to the contract carry out fairly its stipulations. But in French Guiana it is far otherwise: the great majority of the colonists are negroes in full possession of the same civil and political rights as the white man. This majority elects the Colonial Council, and to negro influence may be traced the culpable slackness of the authorities with regard to the administration of the labour laws. Many a miner gets an advance on his wages, which he spends,
and then decamps to another mine, where he enters into a fresh contract, which he evades in the same manner. The employer's only remedy is the cumbrous mockery of a suit in the civil courts against a penniless defaulter.

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The immigration of Indian coolies has been prohibited for the past 10 years in French Guiana, while they pour into the neighbouring British and Dutch Guianas, where they work on the plantations and mines. To convict-labour, or to that of discharged, time-expired convicts, the author expresses himself opposed. For further information the reader may consult the same writer's voluminous manual: Rapport a M. le Ministre de l'Instruction Publique sur l'Exploitation de l'Or en Guyane—Guide pratique pour la Recherche et l'Exploitation de l'Or en Guyane française.*

ORE-DEPOSITS IN THE ATACAMA DESERT, CHILE.


This paper constitutes the first instalment of an account which the author proposes to give of his journeys in August and September, 1896, to about a dozen mines in the provinces of Coquimbo and Atacama.

Our attention is first of all directed to the copper-mine of Amolanas, in Atacama, latitude 28° south. North-east of this mine is a great series of red, poorly fossiliferous sandstones of Liassic age; south-west of it are huge masses of augite-porphyrite, while between the two is an intrusion of quartz-porphyry some 325 feet thick. At the contact between this porphyry and the sandstones copper-glance is disseminated over a breadth of 100 feet in little rounded nodules of the size of a walnut. The ore is nowhere seen to occur in the form of veins or infillings of cracks and fissures.

The author points out that in the case of most of the occurrences of copper-glance this ore gives place in depth to copper-pyrites, but the workings at Amolanas have not been carried much beyond 300 feet down, and thus far no such passage has been traced there. The only other copper-ore observed was malachite, which impregnates the rock in the uppermost portions.

Very sharply are the inclusions of copper-glance marked off from the enveloping porphyry, and, as a rule, no ore occurs in the groundmass of the rock. The porphyry is seamed by veins of diabase, and the sandstones near the junction are cut by a small dyke of melaphyre. The author considers that the ore must have been brought in in the molten condition by the porphyry itself.

The annual production is 20,000 tons, containing 5 per cent. of metallic copper—a percentage which may be increased by a simple process of washing to 25. Want of water-power and the great distance from any railway-station are the sole obstacles to a vast development of the mining-industry here.

The next locality to come under notice is Los Bordos, also in Atacama, latitude 27° 40' south. Here the Elisa mine, one of the most considerable in Chile, produces annually 12,000 or 13,000 tons of ore, with a yield of 0.1 per cent. of refined silver. The argentiferous deposit averages in thickness from 3 1/2 to 7 feet, strikes north 30 degrees east, and dips 15 to 30 degrees south eastward; the ore is mainly native silver and horn-silver. These are accompanied by mercury in various combinations, but sulphur, arsenic, and antimony compounds are conspicuous by their absence. The longest working follows the dip to a depth of about 1,620 feet, and here the hanging-wall is seen everywhere to consist of a light sandy tuff, called by the

* Annales des Mines, 1898, series 9, vol. xiii., pages 386-439, 443-564, 569-616, and plates V. to X. (maps, sections, etc.).
miners cantera (100 to 150 feet thick), while the footwall is frequently amygdaloidal augite-porphyrite (manto negro), at most 7 feet thick. The vein-stuff itself, or manto bordos, is a perfectly soft, greasy rock, extremely like talc-schist, never more than 10 feet thick. As the strike changes, the hanging-wall is found to pass into a decomposition-product, and there is pari passu an impoverishment of the vein-stuff. In the easternmost part of the mine, an augite-porphyrite breccia or agglomerate, very poor in silver, was being worked at the time of the author’s visit. The ore undoubtedly originated in the massive augite-porphyrites which follow upon the manto negro, and though it is not found in paying quantities in the former rock, its presence has been proved therein over and over again, and there it is much associated with mercury compounds. The workable silver-ore is evidently concentrated along a line of crush, at the junction between the above-mentioned cantera (tuff) and the augite-porphyrite. The author concludes with a brief petrographical description of the rocks, and the illustrative sections in the text enable the reader to picture exactly their relative positions.

CARACOLES MINING DISTRICT, CHILE.

An American-Indian legend had, during many generations, pointed to the existence of rich silver-mountains in the unexplored wilderness of Atacama; but it was not until the spring of 1870 that the accuracy of oral tradition was proved by the discovery of the legendary Silver Range in the argentiferous deposits of Caracoles. The discoverers were four prospectors who had started from Mejillones, on the Pacific coast, and the masses of horn-silver which they brought back with them were impressive tokens of the mineral wealth of these mountains.

Caracoles (latitude 23° 3’ south, and longitude 69° 13’ west of Greenwich) is situated in the midst of the Atacama desert, at a point equidistant from the shores of the Pacific and from the chain of the Andes, south-east of the Limon Verde range, and 126 miles north-east of Antofagasta harbour. A railway connects this port with Sierra Gorda, whence a fairly good cart-road runs for 26 miles to the Casa de Tabla mines, which lie at the foot of the Caracoles range. Thence, although the ascent is steep, vehicular traffic is easily carried on up to the highest mines in the field, and the extension of the railway would not be a very difficult matter. All this district is now Chilian territory, ceded by Bolivia after the war of 1879.

An interesting meteorological observation is noted by the author, after a residence of more than 20 years in the district:— Although rain is as infrequent as ever, the
dryness is now less extreme, the water brought to the surface in over fifty mines having induced a certain amount of saturation of the atmosphere over that portion of the great desert of Atacama.

The rush of immigrants took place from 1871 to 1877, when the mining population of the Caracoles district reached 18,000 souls. In those years, no fewer than 4,000 claims were registered. Towns rapidly sprang up, with all the usual appurtenances of civilized life, as it is understood in Spanish America. Then the customary reaction set in. The crowd of unlucky speculators, sharpers, wastrels, and ne'er-do-weels abandoned the district, to its great advantage, and the quiet development of the genuine mines pursued the even tenour of its way, despite injudicious legislation or meddlesome officialism. The present situation, however, is depicted in gloomy colours by the author: political crises, the rise in exchange, the fall in the value of silver, the extravagant freights, and the high prices of articles of prime necessity are freezing the marrow of enterprise and driving out the ever-diminishing population, which at the end of 1895 numbered barely 1,000.

Of the 4,000 claims registered in the years of the boom, 260 alone survive: the area of each of these varies between 2 1/2 and 12 1/2 acres, and all of them are under embargo for the payment of the "mining patent." The author supplies a complete alphabetical list of the surviving mines, with their areas and the names of the owners. From 1870 to the end of 1894, Caracoles produced 47,983,020 ounces of fine silver, or an average of 2,000,000 ounces per annum, with an average population of 10,000. During the last 3 years, with an average population of 1,000 only, the annual production of metallic silver has ranged from 400,000 to 530,000 ounces. It is not want of ore but want of labour which is keeping the production down, and at least 100 more miners could be fully employed.

The author enters into no details regarding the mineralogy or geology of the deposits.  
L. L. B.

LIGNITE FROM MAGALLANES, SOUTHERN CHILE.


In view of the importance of the discovery of beds of workable lignite in the provinces which border on the Straits of Magellan, in Tierra del Fuego on one side, and in Magallanes on the other, the author has made a very elaborate study of a specimen of the mineral from the last-named district.

It was taken from near the surface of the outcrop, and is a compact mass with flaky cleavage, conchoidal fracture, of an opaque black, giving a dark-grey streak, and alternately lustrous and dull in bands. It does not soil the fingers, and its number in the scale of hardness is 3. In dry air it cracks, much in the fashion of damp clay when exposed to the sun. It burns with a very bituminous flame, without giving off even a trace of sulphurous gases, and leaves an extremely light residue, without making any clinkers. Its specific gravity is 1.351, exactly that of the Hesse Cassel lignite.

By fractionated distillation, the author obtained 48 per cent. of coke of a lustrous aspect, pulverulent. This, when burnt in atmospheric air, leaves 24 per cent. of ash (or 11.5 per cent. of the total lignite). The ash is of a red colour, and infusible at 1,652° Fahr. (900° Cent.). Its composition is as follows: —

| Silicate of alumina  | 58 |
| Calcium carbonate   | 12 |
| Magnesium carbonate | 3  |
| Iron oxide          | 15 |
| Silica              | 12 |
The results of the analysis of the lignite, as a whole, are expressed as follows:

<table>
<thead>
<tr>
<th></th>
<th>Per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hygroscopic water</td>
<td>10.0</td>
</tr>
<tr>
<td>Combined water</td>
<td>20.0</td>
</tr>
<tr>
<td>Benzenes</td>
<td>2.5</td>
</tr>
<tr>
<td>Hydrocarbons and oxygen</td>
<td>25.5</td>
</tr>
<tr>
<td>Carbon</td>
<td>36.5</td>
</tr>
<tr>
<td>Silicate of alumina</td>
<td>6.77</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>1.48</td>
</tr>
<tr>
<td>Magnesium carbonate</td>
<td>0.43</td>
</tr>
<tr>
<td>Iron oxide</td>
<td>1.81</td>
</tr>
<tr>
<td>Silica</td>
<td>1.10</td>
</tr>
</tbody>
</table>

The calorific power is 3,500.

It is evident that this lignite has been much deteriorated by atmospheric agencies. Nevertheless, its properties place it beside lignites already much used in industry, and experiments made with it in furnaces show that, in regard to quality, if best Lota coal be taken as 100, the Magallanes lignite is 67.

The author states that his studies of coal-deposits in Great Britain, Italy, Austria, and Peru have led him to an opinion entirely at variance with that of many mining experts, who hold that coal got at the outcrop is identical with coal got at some depth from the surface. He considers that atmospheric agencies may profoundly modify the properties of coal at depths as great as 150 or 160 feet below bank. Therefore the fact that, in 1872, Mr. Lorenzo S. Rodriguez published an analysis of Magallanes lignite, yielding far more favourable results than those recorded by the present author, is easily explicable when one bears in mind that the samples analyzed by Mr. Rodriguez were got at a vertical depth of 70 or 80 feet below the surface, at a distance of 572 feet from the opening of the adit.

It is thus shown that, in depth, the proportion of volatile constituents in the lignite increases, while that of ash diminishes, the correlative result being enhanced calorific power.

The author thinks that the Magallanes deposits could be utilized for coaling steamers, provided their boilers were so modified as to admit of the use of high-class lignites, and thus the Chilians would become independent of British coal.

L. L. B.

**IRON-ORE AND LIGNITE IN HAYTI, WEST INDIES.**


In south-western Hayti, the author found hydrated oxides of iron in the post-Pliocene basalts of Grande Savane and Morne Carre, outcropping with surprising regularity along a west-north-west and east-south-easterly strike. It had before been observed by local field-surveyors that the compass-needle was constantly deflected in the basaltic areas of Anse a Veau, Aquin, and St. Louis, and this

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deflection was considered to be due to the presence of iron-ores, even where outcrops of such have not yet been traced. But the minute crystals of magnetite described by the author as present in these particular basaltic areas are of themselves quite sufficient to deflect the needle. The magnetite, it is true, forms in some places so considerable a percentage of the spheroidal basalt that it gave rise to the most extravagant delusions regarding a possible development of an iron-
mining industry on a large scale. Such as it is, however, the magnetiferous basalt of southwestern Hayti would not repay working.

In the Morne a Bekly and Terre Neuve districts in the north of the island occur, however, iron-ores in compact veins containing 62 per cent. of metallic iron. Returning to the subject of the hydrated oxides of the south-west, the author points out that these, in contradistinction to the magnetites, are of industrial importance. The most considerable mine so far worked is situated in the Tomau ravine near the road from Chapelle Morenceau to the Serpent river-valley. Here a vein 16 feet thick yields an ore of the following composition:

<table>
<thead>
<tr>
<th>Component</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>14.95</td>
</tr>
<tr>
<td>Iron sesquioxide (metallic iron, 15.37)</td>
<td>21.95</td>
</tr>
<tr>
<td>Silica</td>
<td>35.50</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.13</td>
</tr>
<tr>
<td>Phosphorus pentoxide</td>
<td>0.31</td>
</tr>
<tr>
<td>Alumina</td>
<td>21.30</td>
</tr>
<tr>
<td>Titanic oxide</td>
<td>3.73</td>
</tr>
<tr>
<td>Magnesia</td>
<td>0.51</td>
</tr>
<tr>
<td>Lime</td>
<td>0.43</td>
</tr>
<tr>
<td>Copper</td>
<td>trace</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>98.81</strong></td>
</tr>
</tbody>
</table>

From the metallurgical point of view, this is hardly satisfactory, but the ore makes a splendid colouring-material (deep brown to brilliant red), and is favourably reported on by the management of a German colour-factory.

In the period contemporaneous with the basaltic outpourings, the Asil Valley was a vast freshwater lake. Bands of lignite are interspersed with the marls which were quietly laid down at the bottom of this lake, and their most notable outcrop is on the Bedene plantation, 11 1/2 miles from Aquin. Here, at about 600 feet above sea-level, the lignites and intercalated marls show a combined thickness of 172 feet—out of this one may reckon a thickness of 17 feet of pure lignite in three bands. An analysis made in Paris showed:

<table>
<thead>
<tr>
<th>Component</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>26.86</td>
</tr>
<tr>
<td>Volatile matter (other than water)</td>
<td>32.56</td>
</tr>
<tr>
<td>Carbon</td>
<td>23.23</td>
</tr>
<tr>
<td>Ash</td>
<td>15.35</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>98.00</strong></td>
</tr>
</tbody>
</table>

Calorific power: undried, 3,177 calories; dried, 4,645 calories. This lignite does not form coke, and it is questionable whether the deposit would repay working.

Mention is made of old traditions regarding the occurrence of mercury among the basaltic rocks, but after careful investigation the author has failed to find any evidence that can be held to substantiate these traditions.

L. L. B.

CUPRIFEROUS DEPOSITS OF INGUARAN, MICHOACAN, MEXICO.

By E. Cumenge.

Sur le Gite cuprifere d'Inguaran, Mat de Michoacan, Mexique.


The mountain of Inguaran forms one of the spurs of the Sierra Madre, in that portion of it which runs through the state of Michoacan in north-western Mexico. From the federal capital 18 hours’ journey by rail bring the traveller to Pazcuaro junction, whence a branch line runs to Morelia, the chief city of Michoacan. From Pazcuaro to
Inguaran, however, the only means of transport at present is by pack-mules, a three days’ ride along very rough bridlepaths.

The recent volcanic cone of Jurullo (1,950 feet), dating only from the last century, rises from the plain within a mile or two of Inguaran. At the last-named locality, the evidence of incomparably more ancient volcanic eruptions exists in the shape of an enormous flow of andesite, and the great deposit of copper pyrites lies between this and the granite which forms the backbone of the neighbouring mountain-ranges. The cupriferous masses, locally termed guedales, occur in a belt of microgranulite, some 2,250 or 2,550 feet wide and 5 or 6 miles long which intervenes between the andesite and granite from base to summit of the mountain (3,250 feet difference of level). So rich are these brecciiform masses of altered microgranulite, wherein the chalcopyrite or copper pyrites forms the cementing-material, that one single mass at the base of Inguaran contains, according to the most moderate estimates, 30,000,000 tons of ore.

Relics of ancient workings show that the Aztecs, and after them their Spanish conquerors, extracted the ore for the manufacture of domestic utensils. Indeed there are still some primitive smelting-works in the little town of Santa Clara del Cobre, where the pyrites, crushed by hand between two stones, is washed, roasted, and finally smelted in a hole dug in the ground, by means of charcoal fuel and hand-bellows. The black copper thus obtained is refined on a small hearth, and the metal (which is of first-rate quality) is hammered into shape by very skilful workmen.

The chalcopyrite is associated at Inguaran with bornite and black sulphide or chalcocine, both minerals much richer in copper than pyrites. These two minerals are sometimes found here in rather thick layers, encrusting the less altered blocks of microgranulite in the breccia. Some of these harder blocks are several feet thick, and form barren caballos (horses) in the midst of the ore-deposit. The percentage of metallic copper in the ore ranges from 3 to 4, and the concentrates obtained by the primitive treatment described above usually contain 32 to 33 per cent. of the metal. The author believes that this high percentage is due to the almost entire absence of iron pyrites, an absence very unusual in cupriferous deposits.

The mineral resources of Inguaran would allow of an annual production of 25,000 to 30,000 tons of metallic copper, and it is expected that working will be started on a large scale with modern methods, so soon as reader means of access to the locality have been provided.

L. L. B.

SILVER-ORES OF PACHUCA, MEXICO.

The district of Pachuca is situated on the south-western slope of the sierra of the same name, which forms the north-eastern wall of the great basin of Mexico city. The sierra runs north-west and south-east for about 26 miles, and its highest summit, the Navajas, reaches the altitude of 10,440 feet above sea-level. The town of Pachuca lies about midway along the range, occupying both sides of a ravine walled in by lofty mountains. Through these latter course the metalliferous veins, over an area of about 5,000 acres.

The entire sierra is built up of Tertiary eruptive rocks, the oldest being andesites, the next in time rhyolites, and the youngest basalts. The andesites, which form the country-rock of the veins, are extremely variable in colour and structure, and in many localities are covered by sheets of spherulitic or petro-siliceous rhyolites. The author considers that all these rocks are the products of successive fissure-eruptions. The later andesites are more siliceous than the earlier, giving a premonition, as it were, of the next following outburst of petro-siliceous rocks. The last-named crashed suddenly
through the andesitic crust, and, as the bigger fissures reopened to yield them passage, narrower parallel cracks were formed through which the accessory eruptive phenomena found a vent in the shape of fumaroles and thermal siliceous waters. These waters brought with them sulphides, chlorides, and other metallic salts from great depths, and deposited them as encrustations on the walls of the fissures. Then followed a long period of repose, interrupted by the outpouring of basic lavas along the lines of least resistance. It is supposed that the andesites of the Sierra de Pachuca made their appearance in Miocene times, and that their eruption was the result of the movements which folded the great series of Cretaceous rocks in the immediate vicinity of the range. The slopes facing the great basin of Mexico are thickly mantled by the lacustrine Pliocene and post-Pliocene deposits, which form the bottom of that vast expanse.

The metalliferous deposits are all comprised within four or five groups of parallel fissures striking nearly due east and west. A few secondary fissures branch off from the main system, but never at an angle exceeding 30 degrees. Quartz is the predominating constituent of the vein-stuff. In thickness, the deposits rarely exceed 23 feet: the Vizcaina vein, winch, here and there, reaches the maximum, runs for 10 miles from the Leones ravine on the east into the district of Real del Monte, cutting through the Sierra de Pachuca on its way. The outcrop of the Cristo vein (3 to 16 feet thick), may be traced for about 2 1/2 miles, and its further extension is masked by the labradorite-rocks of the summit of mount San Cristobal. Similarly the outcrop of the Analco vein (4 to 20 feet thick), may be followed for close upon 4 miles, while its prolongation beyond the valley of San Bartolo is hidden by beds of volcanic tuff. The Valenciana vein ranges in thickness from 27 to 66 inches.

Sometimes the outcrops of the veins, crestones as they are called by the Mexican miners, form prominences jutting 1 or 2 feet above the surface of the ground, the whiteness of the quartz gleaming from afar against the dusky yellow-brown of the soil. Thus, from the city of Pachuca itself, may be discerned the creston that runs down from the summit of Santa Apolonia. But the veins which are richest in depth, such as the Vizcaina already mentioned, do not give rise to protuberant crestones: the quartz occurs in thin bands, much interseamed with clay and venules of calcite. Some portions of the quartzose crestones are associated with altered pyrites, pyrolusite and argentiferous minerals, containing a percentage of gold sufficient to make it worth while to work them—in fact, these were the superficial bonanzas of the early explorers, as may be inferred from the relics of old opencast workings.

Two distinct zones may be noted in going from the surface downwards, although not observable in all the Pachuca veins: (1) the zone of oxides or colorados, and (2) the zone of sulphides or negros. In the uppermost are the oxides of iron (often gold-bearing) and oxides of manganese in abundance. In the

lower are the various metallic sulphides, such as those of iron, lead, silver, etc. Of the upper zone little is now left, and the mining of the present day in this district is all in deep workings.

The author proceeds to describe more in detail the mineralogy of the deposits, and points out that the manner in which manganese occurs in the veins shows that it made its appearance after the first deposition of quartz, carrying with it black argentiferous sulphides. Calcite was similarly a late arrival, as shown by its occurrence in small crystals within the geodes of quartz. Pyrites, galena, argentite, etc., seem, in most cases, to have been deposited simultaneously with the quartz, with which indeed they are so intimately commingled that they cannot be separated from it. On the other hand, the quartz without sulphides is completely isolated from the quartz with sulphides: the rich quartz and the barren form alternating bands, symmetrically disposed with regard to the metalliferous vein.
In the Santa Ana mine, where the Vizcaina vein is worked, at a depth of 505 feet, black sulphides form the infilling of irregular venules which traverse the quartz, thus showing that they were of later deposition. Subangular fragments of rock detached from the walls of the vein occur in it, at all depths. They are not packed close together, but appear to swim, as it were, in a sea of gangue — and around and upon each fragment the incrustation of quartz and metalliferous ores has proceeded with the same regularity as throughout the vein.

In the Santa Gertrudis vein, Barron mine, at a depth of 490 feet, there is an exceptional occurrence of splendidly crystallized barytes. Native silver is found at all depths.

As one goes deeper down in the mines, the oxides of iron are seen gradually to diminish, and the manganese oxides little by little give place to silicates. Pyrites is of such constant occurrence, in the country-rock in the neighbourhood of the veins, that it has come to be regarded as a good indicator.

It is admitted as a general rule, holding good throughout the district, that the ores become poorer in depth. In many cases, the infilling is found to pass into practically barren blende: the ore is heavy, and has a good appearance, but the silver-percentage is so small that it does not cover the cost of working.

The deep workings are at the present time invaded by water, and there is urgent need of more powerful pumping-engines. When the mines are properly drained, it will be possible to pursue researches beyond the zone of barren blende, and the author thinks that rich ores will be found coming in again below it.*

L. L. B.

CARNOTITE, A NEW ORE OF URANIUM, COLORADA, U.S.A.


The mineral in question, which may prove to be of some industrial importance, was found in Montrose county (Colorado) by a French resident of Denver. It occurs in cavities at the surface of a grit, in association with the cupriferous ores, chessylite and malachite, and about 10 tons of the mineral have been got from this locality.

It is in the form of a yellow pulverulent substance, with no distinguishable crystalline structure, intimately commingled with quartz-sand. It stains the fingers, and is easily separable from the silica by means of solution in dilute nitric and hydrochloric acids. The authors describe the method of analysis, whereby they eliminated silica, iron, alumina, etc., obtaining a residue of which the chemical composition is as follows:

<table>
<thead>
<tr>
<th></th>
<th>Per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uranium sesquioxide, U2O3</td>
<td>63.54</td>
</tr>
<tr>
<td>Vanadium pentoxide, V2O5</td>
<td>20.12</td>
</tr>
<tr>
<td>Potash, K2O</td>
<td>10.37</td>
</tr>
<tr>
<td>Water, H2O</td>
<td>5.95</td>
</tr>
</tbody>
</table>

The percentage of silica varies from 2.6 (in very pure samples) to 60, and that of iron is also extremely variable, the yellow substance being in some places much richer in ferruginous venules than in others.

The mineral is named carnotite, in honour of Mr. Adolphe Carnot, French Inspector-General of Mines.

L. L. B.

* The author published a monograph on this district, "El Mineral de Pachuca, 1897," in the Boletin del Instituto geologico de Mexico, Nos. 7, 8 and 9.

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TESTING OF COALS BY RONTGEN RAYS.


Starting with the assumption that owing to the impermeability of silica and silicates to the Rontgen rays, the presence of ash-constituents of mineral fuels should be detectable by this means, the author examined anthracite, coal, lignite, peat, coke, and briquettes, and found that in all cases the minute structure of the mineral matter was revealed in clear detail as shadows on the screen. The transition between pure coal and slaty coal to true slate could be detected by this method; and in coke, the grains of iron sulphide from the pyrites were seen as black specks.

It is not necessary to shape the test-samples into regular blocks, the large fragments (1 1/4 to 2 inches thick) resulting from natural cleavage being sufficient to show the mineral skeleton of the fuel. The apparatus used consisted of a coil giving a 10 inches (25 centimetres) spark, with an independent interrupter and a Villard tube.

J. W. P. and C. S.


In order to obtain practical results from this method of investigation, the author submitted specimens of coal, coke, compressed fuel, etc, to the action of the Rontgen rays. The experiments were made by means of a coil with a 8 inches spark, furnished with an independent interrupter and a Villard coil; time of exposure, 1 minute. The specimens examined did not as a rule exceed 13/16 inch in thickness. The effect of exposing the same specimen of coal in different planes was very noticeable. If the rays penetrated at right angles to the plane of stratification, an extremely thin layer of shale arrested their passage, and consequently a dark tint under such conditions did not necessarily indicate a high percentage of shale, but on the other hand the transparency of a specimen so treated clearly showed its purity. If the rays fell on the specimen parallel to the plane of stratification, parts composed of pure coal were clearly differentiated from earthy or pyritic deposits. Exactly equal periods of exposure are essential for the comparison of radiographs. It is also necessary to take account of the exposure to sunlight. The thickness of the specimens examined is of capital importance, permeability to the Rontgen rays being greater in proportion to the thinness of the body traversed.

The process will be useful when it is desired to preserve the image of a sample of coal which has to be destroyed for analysis, as in the case of coal obtained from bore holes. The following method was adopted for determining the average ash-contents of ground coal. Finely powdered coal and shale were intimately mixed in proportions increasing by 10 per cent., and placed in an envelope of chemically pure paper having 11 cubical compartments, with pure coal at one end and pure shale at the other. This was submitted to the Rontgen rays and produced a scale of tints which are reproduced.

The writer also found that the Rontgen rays were applicable for the detection of flaws in iron plates up to 0.79 inch in thickness. Certain explosives have also been
examined: the rays are interrupted by potassium nitrate and sulphur while wood charcoal is transparent. The author found that two samples of nitrocellulose were absolutely transparent to the rays. W. N. A.

SOUNDING OF A DEEP SHAFT.


To survey and sink a shaft of great depth by means of two plumb-lines is one of the most difficult of mining-operations. The writer relates the results of such a survey at the Pribram colliery in Bohemia, in which little use could be made of modern instruments.

The Rudolph shaft in this mine formerly extended to the fifth level, at a depth of 450 feet, where it communicated with the Archduke Stephen shaft, about 1/2 mile off. It became necessary to sink it in its full dimensions, 6 1/2 feet by 11 1/2 feet, through the fifth, ninth, and eleventh levels, and a vertical depth of 650 feet. The Stephen shaft, from which the axis was determined, was wet, and the distance between the plumb-lines was only from 6 1/2 to 7 feet. The line was surveyed at the three levels with 210 theodolite-stations, and an error of only 3 minutes in the survey would shift the position of the new shaft by nearly 3 feet; the length of the levels being from 3,200 to 3,503 feet. Local conditions prevented the triangles from being of the exact shape required, and it was also difficult to allow for the swing of the plumb-lines. The connexions having been determined, the shaft was sunk from level to level. At the ninth level, an error of 8.2 inches to the east was found, and at the eleventh level of 10.2 inches. The writer is of opinion that plumb-line soundings, even under unfavourable circumstances, are very useful, and apart from the costliness of the instruments, are preferable to optical surveys. B. D.

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A ROMAN MINE IN SOUTHERN HUNGARY.


Near a group of mountains called the Baronfels, in New Moldavia, there is an old mine, consisting of an adit-level and a shaft driven vertically from it, which is supposed to have been worked by the Romans. The writer had the opportunity of visiting it in 1896. Northwards from the Baronfels, about 1,500 feet above sea-level, are a series of depressions, overgrown with trees and brushwood. From the bridle-path, a short ascent leads to an artificial cutting in the limestone-rock, at the end of which the mouth of an adit-level 36 feet long and 6 1/2 feet wide is visible. The level inside is larger than the adit, and is 62 feet long, 6 1/2 feet wide, and about 5 1/2 feet high. At 23 feet, a side gallery 20 feet long opens into it, which, like the level itself, has been carefully excavated with hammer and wedge. About 3 1/2 feet from the floor, small niches have been cut in the walls, which were probably intended to hold little earthenware lamps for lighting the mine. This gallery terminates in a large open space where the roof is 12 to 13 feet high, and the irregularly-shaped walls denote the presence of a lode. A shaft has been sunk here, running south-west at an angle of 40 to 55 degrees. The writer had a strong wooden beam driven into a fissure and a rope attached to it, and he and his party were lowered one by one about 16 feet down, when a platform was reached. Magnetic iron-ore and manganite were observed in the walls at this part of the shaft, and no bearings with a compass could be taken, because the magnetic iron affected the needle. At the lower level, brown
iron-ore, magnetic iron, copper pyrites and quartz were found in a granite-lode about 3 feet wide.
Proceeding down the shaft, at 60 feet below the upper gallery was a lower gallery, 70 feet long, which followed the lie of a lode running north-west, in a contrary direction, therefore, to the original lode. The two lodes seem to meet here. The floor and roof of the gallery consist of a tough stone, rich in quartz, and so smooth that it was difficult to walk over the slippery surface. At one part, where the floor sounded hollow, the writer laid bare with his hammer a layer about 4 inches thick of iron-ore, branching from the lode into the level. The road was blocked with tailings of quartz, granite, brown iron-ore, copper and iron pyrites and calcite crystals; but in a side gallery were found traces of blasting, showing that this part of the mine must have been worked in modern times. It was observed that no water had accumulated in the workings; probably therefore the lowest gallery and the main shaft must originally have communicated with other deeper levels.
The writer also examined a vertical open shaft, 6 1/2 feet by 5 1/2 feet, lying about 60 feet higher than the adit. Like the rest of the workings, this shaft had been wholly cut out with hammer and wedge, was absolutely perpendicular, with clean cut right-angled corners, and was truly a marvel of handiwork.
Many years ago, Roman pottery lamps were found in the upper gallery, one of which has been preserved in the Budapesth museum.
As mines in which silver-ore was found were known to exist farther south a few centuries ago, the conclusion may be drawn that all the hand-work which has been lavished even on the sterile rock in the open shaft, the adit, and the lower levels, is of Roman origin, and that the mine was worked to reach a lode of silver-bearing quartz-ore. Operations were carried on till within modern times, but apparently the lode has long been exhausted.

B. D.

GOLD INDUSTRY OF DUTCH GUIANA.
The gold-production of this colony scarcely received all the attention that it deserved until 1896, when a committee was formed for the purpose of undertaking a thoroughly exhaustive geological and economic survey of the country lying between the two great rivers. This survey will be completed in 4 years from its commencement, and the committee have obtained from the Dutch Government, in addition to pecuniary support and expert assistance, the right to exploit all the country surveyed by them and to build a railway.
The value of the gold exported from Dutch Guiana from the inception of the industry until the end of 1896 was £1,724,532 (20,694,380 gulden). The amount of gold produced in the colony in 1896 was 27,087 ounces (846,467 grammes), and in 1897 the amount was 22,164 ounces (692,621 grammes), two-thirds of which came from the Surinam district. The precious metal ranks highest in the list of exports, next to cocoa and sugar. Indeed, it is to the gold-industry that the colony owes such progress as it has achieved during recent decades, and should the survey now approaching completion yield favourable results in this respect a great influx of European capital and immigrants may be anticipated. Even now, the demand for labour exceeds the supply. The author controverts the widespread notion that the climate is unhealthy.

L. L. B.

EXTRACTION OF A BROKEN ROD FROM A BORE-HOLE.
The end of a boring-rod broke off in a hole about 1,000 feet (300 metres) deep, put down in the Gleiwitz district; and boring was interrupted through the diamond crowns being ground against the pieces of steel. After three weeks of fruitless endeavours to remove the obstruction, Mr. Degenhardt extracted the pieces by means of a powerful magnet. A bar of soft iron 59 inches (1.5 metres) long, and 2 3/4 inches (7 centimetres) in diameter, was wound with insulated wire; and, after the bar had reached the bottom, a current of about 30 amperes was sent through the winding from a small dynamo driven by the portable engine used for boring. On the same day that the bar was let down, it was drawn up with the pieces of rod fast adhereing to it.

J. W. P.

ROCK-DRILLING MACHINERY.
The Wolfdietrich adit, the deepest level in the Durnnberg salt-mine at Hallein, was first worked in the year 1596, at a distance of over 1 1/2 miles from the mouth of the adit. As this level was too small for modern requirements it was enlarged and improved in 1894, and the rock-drills were driven by electric motors. The plant consists of a 10 horsepower turbine coupled direct to a dynamo, from which the electric current is led through the length of the level, and applied to drive two Siemens rock-drills.

The water to provide power for the dynamos is obtained from a spring in the mine, yielding from 26,000 to 440,000 gallons per 24 hours, and from surface-water drawn from a spring at some distance, with a fall of 572 feet.
The electric motor is contained in a strong wooden box, which can be moved about as required. With a tension of 220 volts and 6 amperes, 1 brake-horsepower is obtained. The power is transmitted to the drilling-machines by cogwheels connected to the end of a flexible shaft, and undue strain on the machine is prevented by a friction-coupling. The flexible shaft is about 7 1/4 feet long, and consists of a number of small concentric steel spirals, coiled round a strong steel wire, and of a single spiral covered with leather, and with guides at either end. The two ends of the shaft are coupled to the rock-drill and to the motor respectively, by socket, clutches, and ball-bearings.
From the flexible shaft, the motion is transmitted through a fly-wheel to a crank driving a crosshead and piston working through a stuffing-box. The piston is hollow, and the boring-chisel fits into it, so that it cannot turn round except with the piston. As the crank rotates, a to-and-fro motion is imparted to the piston, and there are two springs which give such elasticity to its stroke that it goes much further into the rock than the actual stroke. The machinery is adjusted and started by a hand-crank, and the position of the drills is varied by screws. The piston makes about 450 strokes per minute. It is hollow, so that the drill can be drawn out through it, and changed, if required, without moving the frame, but this is seldom necessary.
With a tension of 240 volts, one drilling-machine usually requires a force of 5 amperes. Four men are employed, working 10 hours a day. In May and June, 1897, 572 holes were drilled, and a total depth of rock pierced per day of 27 1/2 feet, or about 11 feet per man per day. With a hand-drill, the depth bored was about 3 feet per day, or 3.4 times less than with the electric drill. All the work was piecework, and the total cost of drilling was about 3d. per cubic foot. B. D.

SCHAUB ELECTRIC COAL-CUTTING MACHINE.

The writer describes the Schaub electrically-driven coal-cutting machine which has been used to undercut in a mine in Poland, and has also been successfully applied in a lignite-mine in Austria.

A small carriage mounted on wheels carries a toothed wheel driven by the motor-crank, and gearing into two others, one on either side. These actuate two endless-chains, each connected to a vertical frame carrying three drills one above the other. The two frames are united to the central carriage, and their distance from it can be varied at will. They may also be raised or lowered vertically, the one descending as the other ascends. The chains act directly upon the spindles of the drills. Both sets of drills can be worked at the same time, or one or the other thrown out of gear. The two frames are moved out from the central carriage by means of a series of wheels gearing into a right and left-handed horizontal screw, which runs the length of the machine, and carries the frames at either end. The turn of a crank-handle varies the distance between them. Each of the frames is in duplicate, that is, there are on either side two frames, one beyond the other; the inner one alters the vertical, and the outer one the horizontal position of the drills.

The two toothed wheels which transmit the motion to the drill-spindles from the motor-shaft are connected to rollers on which the endless-chain revolves; the other end of the chain passes over another roller on the outer frame carrying the drills. The action is so regulated by means of chain-wheels attached to the rollers that all three drills of one set are driven forward at once. The vertical movement is obtained by a rack-and-clutch gear worked by two small shafts moving in a hollow groove and actuated by worm-gearing and right and left-handed screws. The movement is facilitated by an elaborate arrangement of levers, friction-coupling, and ratchet-wheels.

By these and other means, the drills are kept constantly rotating, and are worked alternately up and down in sets. As soon as they have reached their highest or lowest position, they are pushed forward into the rock, and the action is repeated in the contrary direction. It is also possible to move the drills back, or to work them rapidly backwards or forwards, as is sometimes required when shifting their position in narrow levels. Special levers and nuts are supplied for this object. The stroke of the drills is carefully adjusted according to the excavations required. To remove the rock as it is worked, the lowest drill in each frame has a revolving screw which pushes back the rubbish. The drill itself consists of four knives set round the spindle at different angles. When used in the Piberstein lignite-mine in Bohemia, the machine was driven by a Siemens and Halske dynamo, and worked well. The original paper is illustrated by drawings.

THE THEORY OF SAFETY-EXPLOSIVES.

The author has calculated the temperature produced by the detonation of a number of explosives, the quantity of heat evolved, and the amount of mechanical work corresponding to that heat. He calculates the heat evolved as follows: — The quantity of heat evolved in any explosion is equal to the difference between the heat of formation of the ultimate and of the original compounds. The heats of formation of the ingredients of the ordinary explosives and of the compounds produced by their explosion have been fairly well determined, though in some cases the precise reactions involved may be somewhat doubtful. The heat thus calculated refers,
however, to constant pressure; but as detonation is practically instantaneous, no
time is allowed for expansion, hence an amount representing the additional quantity
of heat at constant volume must be added to the above in order to obtain the total
amount of heat set free; the latter consideration adds about 1 1/8 to 1 1/2 per cent.
to the amount of heat first calculated.
The temperature is obtained from the well-known formula:
\[ t = \frac{Q}{c} \]
where \( t \) is the temperature, \( Q \) the quantity of heat and \( c \) the mean specific heat of the
products of the explosion. In the case of gases this expression becomes, according
to Messrs. Mallard and Le Chatelier:
\[ t = \frac{Q}{(a + bt)} \]
where \( a \) and \( b \) are constants varying for the different gases.

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The theoretical work that an explosive is capable of performing is by the Carnot law:
\[ A = 425 Q \left(1 - \frac{15^\circ}{t}\right) \]
where \( A \) represents the amount of work done in kilogrammetres, and \( t \) is the
temperature in degrees Cent., the mean temperature of the atmosphere being
taken at 15\(^\circ\) Cent.
The author thus calculates Table I.

[Table I. Compositions, calculated temperature s of detonation, and calculated
powers of 9 explosives, omitted]

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It will be shown that the degree of temperature of the explosions does not directly
determine the safety of the explosive, and that the theoretical force of the explosive
cannot be applied to the determination of its practical efficiency. In addition to its
force, its shattering power or the rapidity with which its force can be exerted, has to
be considered. Subsequently it will be shown how the shattering power can be
determined and what the relations are that probably subsist between it, the force, the
safety and the temperature of explosion of any explosive.
A large number of experiments were tried to determine the degree of safety of
various explosives, or the maximum quantity that could be fired without causing
ignition of (a) coal-dust alone in air or with 2 1/2 per cent. of fire-damp, (b) 6 1/2 per
cent. of fire-damp and air, and (c) 8 per cent. of fire-damp and air, with coal-dust in
both cases. The shots were fired from an unstemmed cannon into the mixtures. The
experiments are recorded in detail in the original communication, and their results are
shown in Table II.

[Table II.—Results of Experiments, omitted]

Gelatine-dynamite fired in the same way ignites coal-dust with a minimum charge of
50 grammes, but if an iron plate is set up firmly between 3 and 21 inches away from
the mouth of the cannon, so that the air with its suspended coal-dust was greatly
compressed at the moment of explosion, ignition could be produced with as little as
10 grammes of gelatine-dynamite; the direction of the bore-hole underground, i.e.,
whether it points along a drift or across it, will make a difference in the behaviour of a
blown-out shot.
Black-powder fired unstemmed by means of a detonator ignited coal-dust, with a
charge of 70 to 80 grammes; if fired by means of a fuse without a detonator, 250
grammes were required to ignite the dust; again, if the charge be tamped with 4
inches of dry clay, the degree of danger of the powder again increased, as a charge of 200 grammes then sufficed to ignite the coal-dust. Somewhat analogous results were shown by firing explosives freely supported in an atmosphere of gas and coal-dust; the author condemns this method of experimenting, because he finds that the explosion is apt to be incomplete and that explosives which possess the good property of being readily and completely exploded therefore show relatively unfavourable results.

The author gives a series of tests of the shattering-power of the various explosives by the Trauzl method, using first of all 10 grammes of each explosive, and secondly, such an amount as he calculates will develop 2,500 kilogrammetres of force; he shows that the force actually developed in the Trauzl block and that calculated do not stand in any relation to each other, and he calls the latter the shattering-power (brisanz).

He discusses the cause of the safety of explosives, and points out that a high measure of safety is closely related to low shattering-power; he considers that the increased danger due to increased weight of charge is due to the greater amount of compression thus produced, because the heat developed by compression may in itself be a source of danger, whilst a mixture of explosive gas is also fired more readily under high than under low pressures. He concludes that improvements in safety-explosives should be directed to producing the maximum of power at a temperature of detonation that does not exceed the danger-limit of 2,200° Cent, and to regulating the shattering-power so as to attain a definite measure of safety. A perfectly safe explosive is an impossibility.

EXPLOSIVES IN BELGIAN COLLIeries.*

Between 1895 and 1897, the intensity of blasting fell from 27 to 25 for slightly fiery mines, from 14 to 12 for decidedly fiery mines, and from 3 to 1 for those subject to sudden outburst of fire-damp. Comparative tables show that, although there is the apparent increase from 31 pounds (14 kilogrammes) in 1895 to 35 pounds (16 kilogrammes) in 1897 for decidedly fiery mines in the Couchant de Mons district (which increase is explained by the fact that mines formerly classed as but little fiery are now included in the decidedly fiery class) in all the other districts the diminution is shown to be general and considerable, the consumption of explosives for ripping roof and floor in the country collectively having fallen to 2.2 pounds (1 kilogramme) per 1,000 tons of coal raised. Again, while in 1895, the proportion of slow explosives used for driving roads in decidedly fiery mines was 62 per cent. of the whole quantity of explosives used, this proportion fell to 20 per cent. in 1897. At several collieries in the Couchant de Mons, Charleroi and Liege districts the use of explosives has been either entirely abolished or very considerably reduced.

Although the new Mines Regulations of December 13th, 1895, do not explicitly mention safety-explosives, they implicitly refer to them in the following terms:—"It is such, and not ordinary high explosives, that wise managers will use in fiery working-places, when they can not entirely suppress the use of explosives. From a theoretical standpoint, the cause of the greater or less degree of safety possessed by explosives in the presence of fire-damp and coal-dust must be sought in the different intervals between delay in ignition and that of the complete cooling of the explosion-products. The chief influences on which the extent of this difference depends are the rapidity of the explosion and the detonation-temperature;
but they are too imperfectly defined, and their interdependence is too complex for any limits compatible with safety to be assigned with certainty. For a given explosive, the degree of safety, always relative, depends upon the weight of it that is detonated together with external circumstances; and there exists for every explosive a limit of charge beyond which the ignition of fire-damp or coal-dust must inevitably occur.

From a practical standpoint, a limit of charge constitutes the most rational standard by which to measure the degree of security afforded by the various explosives; and it should be determined empirically, under danger conditions as similar as possible to those prevailing in fiery and dusty mines. A safety-explosive is characterized by a sufficiently high limit of charge and one comparable with those required by the use for which the explosive is destined. The most economical explosive is that which, in addition to the greatest degree of safety, possesses the highest explosive power and also that best suited to its object; and these conditions, which are not absolutely contradictory, may be realized by a suitable combination of the detonation-temperature and the ballistic power.

J. W. P.

ACCIDENT THROUGH OPENING A BOX OF DETONATORS.

At the Witkowitz colliery, near Mährisch-Ostrau, a carpenter was called in to the explosive magazine to open a box containing 2,000 No. 8 and 3,000 No. 6 detonators; but, only 110 seconds after his entrance, an explosion occurred. On the magazine being entered by men wearing pneumatophores, the body of the store-keeper was found, and also that of the carpenter, torn into shreds; and a hole in the middle of the cemented floor appeared, 19 inches (0.5 metre) deep and about 10 square feet (1 square metre) in area. The time of 110 seconds was afterwards found by trial to be just that required for taking out the screws of the outer case; and it is supposed that, for removing the screws from the inner box, one of them was first turned a little from left to right in order to ease its extraction, and that the point of the screw, carelessly directed so as to come out inside the box, had on being turned exerted a pressure on a detonator, this supposition being confirmed by several boxes having since been found thus imperfectly closed.

J. W. P.

SINKING A SHAFT UNDER DIFFICULTIES.

The sinking, between 1894 and 1898, of the No. 2 shaft at the Victor colliery, Westphalia, in the immediate neighbourhood of the No. 1 shaft, possesses special interest from three points of view, namely, the efforts made to sink the shaft with insufficient pumping power; the boring and tubbing thereof to the largest diameter yet adopted with the Kind-Chaudron method; and the works carried out for closing off the water, which was not completely excluded by the moss stuffing-box.

Sinking by excavation from the surface was begun in February, 1894; and at the same time, in order to hasten the work, upward drivings were started from the
return-airway and also from the first and second deep levels of No. 1 shaft. A sinking-cylinder with cutting-shoes, 20 feet (6 metres) in diameter, was got down without difficulty to a depth of 60 feet (18 metres), when it canted out of the vertical owing to the resistance being greater on one side than on the other, while cracks showed themselves in the tower, and the cutting-shoe broke at two places. In order to restore the verticality, a further depth of 23 feet (7 metres) was excavated, the cutting-shoes underwalled, and a masonry-lining of the finished diameter, 17 feet (5.2 metres), carried up to the surface.

Further sinking, partly with the aid of gelatine-dynamite, was continued to a depth of 751 feet (229 metres), without great difficulty, 95 feet (29 metres) being sunk and lined per month on an average. In the middle of November, 1894, however, a shot-hole put into the bottom of the shaft struck a water-bearing fissure yielding about 220 gallons (1 cubic metre) per minute, when sinking was stopped in order to permit of a connexion being made with the upward drivings from the lower levels, in order to afford means for drawing off the water, communications between the first and second deep levels being made in January, 1895. The hole, about 229 feet (70 metres) deep, to be put down from the bottom of the shaft to the upward driving from the return-airway, was bored of a diameter of 4 1/8 inches (105 millimetres), with a combined rope-and-rod method and the Fabian free-fall device, when sinking was resumed for a further depth of 39 feet (12 metres), thus laying the fissure bare to such an extent that the water increased to more than 1,320 gallons (6 cubic metres) per minute, a larger quantity than could be dealt with by the pumping-engine of No. 1 shaft.

Ultimately, at a depth of about 804 feet (245 metres), the quantity of water amounted to 4,620 gallons (21 cubic metres) per minute, and might be expected to increase as the shaft got deeper, when it was decided to sink the remaining depth by the Kind-Chaudron system.

The above-named bore-hole served to guide the small trepan, which was cast in one piece from Krupp steel, to a width at the chisel-edge of 8 1/2 feet (2.6 metres), and fitted with 19 crucible cast-steel chisels that could be renewed separately, while a cone was substituted for the middle tooth. The small trepan, the total weight of which was 7 1/2 tons, was also connected with a Kind free-fall device, and so articulated so as to prevent breakage of the rods. The large trepan, 16 1/2 feet (5.04 metres) wide, was built up of several cast-steel parts, the 12 boring-teeth being distributed at the two ends of the chisel-edge and the space in the middle occupied by a curved timber guide corresponding to the diameter of the shaft that had been bored by the smaller trepan. The chisel-edge was strengthened by two arms proceeding upwards from the ends in an inclined direction; and on account of the great weight of the large trepan, namely, 26 tons, a sliding-joint was used instead of the free-fall device.

The small trepan encountered great difficulty, first, from the many parts of tools and pieces of wood that had fallen into the pit-bottom, which could not be fished up, and afterwards by the numerous hard nodules in the marl, which necessitated frequent renewal of the teeth. The mud from boring was allowed to run into the central bore-hole until it became filled; and then the mud was taken out by the spoon. A connexion between this small central shaft and the upward driving from the return-airway was effected on February 4th, 1896, 17 inches (44 centimetres) having been bored daily on an average; and, inasmuch as the upward driving had naturally become filled up, a further depth of about 42 1/2 feet (13 metres) was bored.

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Work with the large trepan, which began on March 1st, 1896, was greatly interfered with by the fissure turning aside the trepan, so that a second boring out had to be
effected with scraping teeth, whereupon the rods frequently broke, which it was first attempted to counteract by guiding them, and afterwards with greater success by increasing their strength. As it was thought too dangerous, on account of the large influx of water, to allow the mud from the boring to run into the workings below, it was raised to the surface by the spoon; and during the latter portion of the time it became necessary to employ rods instead of a rope because the mud was very stiff. At length, on December 10th, 1896, the shaft, bored to its full diameter, reached the Coal-measures at a depth of 989 feet (301.5 metres), nearly 8 inches (20 centimetres) having been bored daily on an average. Inasmuch as it was not possible to form a smooth surface for receiving the moss stuffing-box on the Coal-measures owing to their hardness, a layer of concrete, 2 feet 3 inches (70 centimetres) thick, was laid on the bottom of the shaft and made level by a timber beam attached below the small trepan. Inasmuch as, for facilitating the insertion of the tubbing, two attempts had failed to pump the shaft full of water, a platform was put up just above the water-level, as otherwise the weight on the sinking-rods would have been far too great; and, round the platform, the sides of the shaft were widened out with the pick in order to afford the men room to work, while a cross-cut 10 feet (3 metres) long was driven for them to retreat into when the cast-iron tubbing rings were being let down. The cast-iron tubbing rings, 4 feet (1.2 metres) high and 15 feet 7 inches (4.75 metres) in diameter, were made in seven series, their thicknesses varying between 3 9/16 inches (90 millimetres) and 2 27/32 inches (72 millimetres), so as to weigh from 13.3 to 11.3 tons, and to stand pressures varying from 42 to 36 atmospheres, respectively. The moss stuffing-box consisted of an inner ring in one piece, like the tubbing rings, but a little higher, with six slight projections outside the upper edge, engaging with corresponding grooves in the outer ring, which was cast in six segments and put together with bolts and leaden packing, being also of slightly greater height. The inner ring was turned with a shallow groove on the outside, for receiving the ten segments of the wedging-crib, all these three members being 3 9/16 inches (90 millimetres) thick. Between the wedging-crib and the outer ring moss packing was rammed, having been kept in place by wire netting while being let down. Inasmuch as the shaft was lined water-tight for a depth of about 754 feet (230 metres), only that portion between the bottom of the walling and the bottom of the shaft was tubbed, being fitted with an equilibrium-pipe and a cover at both top and bottom, so that a saving was effected of about 330 feet (100 metres) of tubbing. The actual length of tubbing put in was 243 feet (74.2 metres), composed of ten rings each from the strongest and the weakest series, with eight rings each of the remaining series; and the total weight, including the moss stuffing-box with packing, screws, leaden jointing and covers, was 870.889 tons. The work of putting in the stuffing-box, let down by six rods, was begun on February 4th, the rods having been, on account of safety, retained until the 24th ring was put in, although calculations showed that the tubbing must float on the 15th ring being added. As the further rings were added, water was allowed to flow into the tubbing so as to keep it at a determined height. By March 13th, all the rings with the cover had been inserted; and the tubbing was then forced down with the sinking apparatus, until it was found that the layer of concrete had become covered with about 10 feet (3 metres) of mud, etc. There was then great hesitation about opening the valve in the cover, because of the doubt as to a tight stopping-off of the water having been effected; and the question arose whether the whole tubbing should be taken out and the ledge cleared, or whether, on the valve being opened, the tubbing would force its way down upon its bed. It was ultimately
decided to open the valve, when the stuffing-box went down about 10 feet (3 metres)
so that apparently a tight joint had been formed; and, therefore, concrete was run in
between the tubbing and the inside of the shaft.
After the lapse of six weeks, attempts were made to take the water out by water-tubs;
but, on the cover of the tubbing being reached, at the depth of 744 feet (227 metres),
and unscrewed, it was found that the upper lengths of the equilibrium-pipe were filled
at the top with unhardened concrete and underneath with the mud from boring, which
led to the supposition that either the stuffing-box and concrete still allowed water to
pass, or that the box had not descended upon the ledge. On the third length of pipe
being taken down, water issued at the rate of 286 gallons (1.3 cubic metres) per
minute, when the attempts made to take the water out by tubs were resumed. This
course was, however, abandoned as the quantity of water increased; and it was
determined to bore a hole from the Coal-measures to the bottom of the shaft, which
rendered necessary the erection of a powerful pumping-engine at No. 1 shaft, in
order to preserve the mine from the danger of flooding.
Under great difficulties a hole was bored upwards, from a chamber blasted out of the
hard sandstone at the end of a curved drift from No. 1 shaft, into the bottom of No. 2
shaft, which was thus at length cleared of water, the hollow boring-rods being left in
the hole for that purpose. After the moss stuffing-box had been securely fixed, the
shaft was sunk deeper; and it was found, on the layer of concrete being removed,
that the box had sunk 1 foot 7 inches (0.50 metre) into the concrete which, though
hard in the middle, could be taken out by the pick at the outside, while the box had
also arrived within 19 inches (0.50 metre) of the Coal-measures.
The want of tightness is attributed to the following causes:—The space between the
stuffing-box and the inside of the shaft was about 4 inches (10 centimetres) wide,
whereas the moss-packing was only calculated for a width of 2 3/8 inches (6
centimetres). At the place where the box allowed water to pass, the concrete had not
hardened owing to the presence of mud; and, when the water was taken out to the
depth of 787 feet (240 metres), the marly water, subjected to a pressure of more than
10 atmospheres, forced through the soft concrete to the inside of the shaft,
derneath the stuffing-box, made its way into the hollow space, and passed out by
the equilibrium-pipe.
A double wedging-crib was laid 20 feet (6 metres) underneath the moss-box to carry
seven tubbing rings, that were screwed up and backed with concrete, and the space
between the uppermost ring and the under side of the box was carefully wedged
tight, so as to completely stop off the water. For greater security, a second double
wedging-crib was laid in hard sandstone 18 feet (5 1/2 metres) deeper, and
connected with the other in a similar manner. Ultimately, the sinking and lining of the
shaft were completed down to the return-airway 1,181 feet (360 metres) deep, after
having occupied 4| 1/2 years.

J. W P.

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COMPARISON OF PROPS FOR MINE-TIMBERING.
Ueber die Gebrauchsfähigkeit einiger Holzarten zum Grubenausbau. By Ch.
Dutting, Gluckauf, 1898, vol. xxxiv., pages 797-803.
The main object of the experiments made at the Prussian State collieries,
Saarbrucken, was to ascertain the value of beech-props and the suitability of acacia
(Robinia) for timbering. Beech-props are reproached with having but slight
resistance, being brittle and breaking off short under crushing-strain, of being heavy
so that they are difficult to handle underground, of tendency to rapid decay, and of
giving no warning by a cracking noise before yielding to pressure.
It was arranged, in the trials, to use only props of the dimensions usual in mines, i.e.,
about 5 3/4 feet long, and for compression-tests only sound props of as nearly
uniform diameter as possible. Props of various timbers were exposed for various
periods to both intake air and return air-currents, several specimens of each timber and also of each kind of prop being tested. Normal props were found to break with loads varying from 25 to 28 tons, under which they nearly all bent laterally, even if only 3 1/4 feet (1 metre) long and 4 inches (10 centimetres) in diameter, while breakage nearly always ensued through crushing. Calculations of the resistance to crushing-strain per unit of cross-section permitted the author to compile a series of tables, from which he deduces the following particulars.

The strength of the various timbers increased with drying. Some of the dried props were placed on the shale-tip, others in an intake air-way, and others again in a main return air-way; and after 3 months it was found that the strength of the first had increased, and that the second and third had lost in weight and strength, the third more than the second. As regards warning before breakage fir occupies the first place, followed in order by pine, beech, and oak. While the warning noise given by beech only begins with fracture, fir especially, and pine in a less degree, give a slight cracking noise before the commencement of breakage.

Beech-timber is indeed under-estimated as regards its strength and warning capability, while oak has been over-estimated—at any rate as regards its strength. When beech may be obtained at reasonable prices, this timber may certainly be used for props in the second working of coal when they only have to stand for a short time. Removing the bark favours drying, which increases the strength and capability of warning; and dry woods give earlier warning than those freshly cut. The more resin there is in a wood the slighter will be its strength; and fir props generally break at the resinous knots, while in deciduous trees the strength is less impaired by branches and cracks than by crooked grain.

The trials at the König colliery were extended to acacia, which is said to thrive well on poor soils, and to yield mine-props 15 or 20 years after the main stem is cut. It was found that acacia-props used in the second working showed a strength equal to that of fir-props; and still more favourable results were obtained by using the acacia for timber sets in places that have to be kept up a long while. Some return air-ways were timbered with fir, oak and acacia in succession; and, after 5 months, no change was noticed in the last-named, while decay had begun in the sap-wood of the oak, and some of the timbers in the fir sets were already broken. The advantage of acacia for mining purposes, however, must be sought less in its strength than in its power to withstand the underground atmosphere.

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SHAFT-CLOSING ARRANGEMENTS.

The mine regulations of the Dortmund Mines-inspection District provide that each separate winding-compartment shall be fitted at every landing with a sliding-door moved by the onsetter, or with a lattice-work door opened and closed by the onsetter or by the cage itself; and, in addition to this, every winding-compartment must be closed by an iron rod at a height of 8 inches (20 centimetres) above the top of the tubs, whenever a winding is being made.

The protection afforded by the rod is insufficient; and slight injuries, especially to the hands, may be directly attributed to its use. During the last three years, several collieries have been fitted with automatic fences, which meet all requirements, notably the following:—(1) The men are ensured against falling down the shaft; and with this object arrangements have been devised which compel the men to close the fence before the cage can leave the landing, and when once closed the fence cannot be re-opened by them. (2) A thrusting out of the head, hands, etc., into the shaft is rendered impossible when the cage is in motion. (3) The cage is made fast while the
tubs are being pushed on and drawn off, so as to prevent accidents from occurring should the brakesman take off the brake during these operations. (4) Winding in the shaft is not interrupted by the closing arrangement. And (5) the fences are so constructed that their working is not interrupted by slight displacement of the shaft-lining owing to thrust of the measures.


This shaft-closing arrangement, invented by Bergassessor Morsbach, may be applied to either swing or sliding-doors; and the fence is constructed so that the arrangement can only be opened when the brake is applied, and movement of the cage in the shaft is only possible when all the gates are closed. The desired result is attained, on the one hand by means of an iron rod attached to the brake-lever, provided with cranks or recesses, and on the other by a projection fitted to the gate preventing the latter from being opened until a slot comes opposite the projection into which the latter can enter. For this purpose, the rod must be raised to a certain point for each landing, because the cranks or recesses are so arranged that only one door can be opened at the same time. Moreover, the brakesman cannot take off his brake before the door is closed, otherwise the gate-projection within the recess would immediately be held fast by the bolt-rod of the brake. Provision is made for preventing any failure of the arrangement in the event of displacement of the shaft-lining as the result of pressure. The advantages claimed are as follow:—

(1) The brakesman operates the brake and fence by one and the same movement of his hand. (2) The cross-section of the shaft remains entirely open. (3) The arrangement is so simple that it may be made in the smithy of any colliery. (4) A positive, exact action, and therefore certain working, of the fence is secured. (5) Neither the onsetter nor banksman can clamp any part fast so as to impair the efficiency of the arrangement. (6) The fence may be opened by the brakesman before the cage comes quite down to the landing—for instance, when timber is being taken down.

J. W. P.

NEW HYDRAULIC KEPS.


Each cage, with four decks carrying two tubs end to end on a deck, comes down upon four keps carried by plungers, each moving in its cylinder; and the cylinders corresponding with the two keps on one and the same side of the cage communicate with one another by a pipe of sectional area equal to that of the plunger, and bolted by flanges to the undersides of these two cylinders. Two 3/4 inch (19 millimetres) brass pipes, laid horizontally inside the shaft, also connect this system of two cylinders with that of the two other cylinders diametrically opposite in the other winding compartment. Each of these brass pipes is provided with a cock; and their two keys, or spanners, are so connected that they can be worked from the landing by a single crank handle, for intercepting or re-establishing hydraulic communication between two of each of the four sets of keps. Supposing the cocks worked by the crank handle to be closed, and the four keps corresponding with one cage at the top of their travel, ready to receive a cage at the level of the lower floor of the landing; then the remaining four keps, corresponding with the other cage, will be at the bottom of their travel. When two decks of the descended cage have been loaded, the cocks will be opened by the crank handle to a certain extent; and the four keps that are at the top of their travel will, yielding to the weight of the cage, descend 3 feet 7 inches (1.1 metres) which is the distance between two decks, and will cause the remaining
four keps to rise correspondingly, so as to be ready to receive the next cage, the
cocks having been closed.
The above-named diameter of the brass communication pipes is calculated so as to
oblige the water within it to acquire a speed of 69 feet (21 metres) per second, the
friction of which sets up a resistance that about balances the weight of the cage and
its load, and permits the plungers to come down gently. The cylinders, which were
tested to 779 lbs. per square inch (53 atmospheres) are fitted with a safety-valve,
which rises under a pressure of 735 lbs. per square inch (50 atmospheres), in order
to prevent breakage in the event of the cage coming down too sharply upon the keps.
In such a case, the water escaping by the valve would be restored at the next
operation ; and the decks that passed the landing-level would not be loaded, the
other decks only being loaded by letting down the kep-plungers to the bottom of their
stroke by opening the cocks. The keps of the other winding compartment would rise
to a certain height, but not to the top of their travel on account of the water that had
escaped. The two communication pipes would then, by the opening of cocks, be
connected with a head of water, under the influence of which the kep-cylinders not
loaded would be brought up to the top of their stroke, owing to the weight of the cage
keeping the others at their lowest position. J. W. P.

WINDING ACCIDENTS IN THE OBERHAUSEN DISTRICT.
Betriebsstorungen bei der Schachtforderung. By D. Gluckauf, 1898, vol. xxxiv.,
page 987.
In the first case, the cage was drawn with great force up to the pulleys, while the
other was shot into the sump. Inasmuch as, before this occurrence, the engine
had worked regularly, it was supposed that the engineman had made a mistake in
handling the lever ; but when winding was resumed it was found

impossible to control the engine. On the valves being examined, a piece of wooden
board as large as the hand was found on the seats of the two admission-valves,
which prevented their closing. It is supposed that these pieces of board had been
forgotten when new steam-pipes were inserted some time previously, and had been
carried along by the steam.
Soon after this accident, the engineman at another shaft noticed an irregularity in the
running of his engine during the lift, and, fortunately for the men in the cage, he had
the presence of mind to stop the engine without shock. It was found on examination
that both of the shaft-guides, for a length of about 130 feet (40 metres) above the
place where the descending cage stopped, were much injured on one side by the
eccentric safety-catch, and that one of the iron cotters for fastening the eccentrics on
their spindles had fallen into the cage, so that, on the latter descending, the safety-
catches came into action by their own weight. It is supposed that the cotters had
become gradually loosened, and that this circumstance had escaped notice during
the usual inspection of the cage before winding was begun; and, for preventing the
reoccurrence of such an accident the author recommends that the cotter be secured by
a split pin. J. W. P.

SELF-ACTING INCLINE FOR LARGE OUTPUTS.
Disposition speciale pour un Plan Incline a grande Production. By — de Lachapelle.
Comptes-Rendus Mensuels de la Societe de l'Industrie Minerale, 1898, pages 147-
150, and 4 plates.
When the whole of the winding-plant at the Saint-Eloy colliery was transferred from
the old Sainte-Barbe shaft to the Puits du Manoir, it was found necessary to drop the
coal from the level of the landing in the Sainte-Barbe shaft to that of the new landing,
whence arose the necessity for the use of self-acting inclines; and, in order to
prevent a large increase in the number of workmen, the inclines were made of as large capacity as possible. The first incline erected, entirely in the seam and approximately following its dip, is 328 feet (100 metres) long; and the gradient, though 20 degrees at the top and bottom, is only 15 degrees in the middle. The line of way, laid with flange-rails, is 41 inches (1.05 metres) between the centre lines of the rails; and, except where the carrying-trucks pass at meetings, there are only three rails, screwed down to the same sleeper.

Two tubs are placed, end to end, instead of side to side, upon the cages or carrying-trucks, an arrangement which has the disadvantage of preventing the possibility of serving an intermediate landing; but, on the other hand, the great advantage of increasing the rapidity of handling the tubs, the two tubs linked together being pushed on, and running off, by one and the same movement; and the sharp gradients at the top and bottom of the incline, facilitate these operations, the latter being automatic.

The catches, set sufficiently apart to receive between them the outside axles of the two tubs end to end, consist of fingers turning in a vertical plane along the centre line of the tub and sufficiently long to hold the axle: the catches, counter-weighted below their axles, assuming a vertical position so soon as the tubs run off or are pushed on. Since this incline was started, it has, without ever failing, let down on an average 150 tubs per hour, or 1,500 tubs daily, with two men at the top and two men at the bottom in addition to the brakesman. When it was required to send down 180 tubs per hour, an additional man was stationed at the top of the incline.

J. W. P.

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WIRE-ROPE LUBRICATING MACHINE.
A simple and efficient apparatus for cleaning and lubricating wire-ropes consists of a hollow iron cone-shaped box, divided in the centre horizontally by an iron-plate covered with felt, and having two semi-circular openings. The box is made of two symmetrical halves turning on a hinge, and fitting together when closed. Each half consists of an inner semi-cylindrical lining, through which the wire-rope slips, and an outer part containing the lubricant, and the two communicate through a valve at the bottom of the box. As the rope passes through, the valve opens and allows oil or grease to fall on to it. The apparatus is supported by props on a platform to which it is hooked. The cleaning apparatus is placed above and below the lubricating arrangement. Two sets of semicircular rubber discs are riveted one below the other to the inner walls of the box, and close round the rope as it is hauled up. Below these are two iron arms, and the three successively scrape the rope, and wipe off the water and slime. Thus cleaned, the rope is greased as it passes through the lubricating-box, and two other projections above remove any excess of oil. All the arms carry small indiarubber brushes with springs, and their distance from the rope is adjustable by screws. As the rope is greased according to the rate at which it is wound, it is best to affix the apparatus when the cage is full of men, and is drawn up slowly. Any kind of lubricant can be used.

It was found that to grease the rope on this system at the Pribram colliery required a much shorter time and much less lubricant than formerly. In one shaft, 40 pounds were used for a length of nearly 3,000 feet of rope, as against 132 pounds before. In another, 77 pounds were used instead of 198 pounds as heretofore, for a rope 7,216 feet long. The apparatus is very simple and easy to work, weighs only 92 1/2 pounds, is easily transported, and the rope is thoroughly cleaned and greased without stopping the winding.

B. D.
SUSSMANN ELECTRIC LAMP.
The Sussmann secondary battery consists, as is well-known, of two elements coupled in series, each consisting of one positive and two negative leaden plates contained in an ebonite box, while the electrolyte is a plastic mass consisting of paper pulp soaked in sulphuric acid.
In the British pattern, this battery is contained in a round sheet-iron casing to which a cover is hinged ; the glass bulb and its protecting cylinder are bolted to the cover, and the lamp can be pad-locked by means of a hasp. Such a lamp is not permissible in the fiery mines of Belgium, because it does not satisfy the conditions laid down in the report of October 20th, 1894, which stipulates that: (1) Incandescent lamps shall be enclosed in a thick glass globe hermetically closed ; and (2) the cases enclosing the generators of the electric current shall be impervious to air or to liquids. The British type, while satisfying fairly well the conditions of clause 1 fails entirely as regards clause 2 ; hence the pattern used by the Compagnie des Charbonnages Beiges has been devised. The battery is introduced through the bottom of the protecting-box, a false bottom being soldered in ; this has to be unsoldered when the battery requires repairs or renewals ; and the lamp proper with

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its reflector is attached firmly to a metal cone, through which connexion is made with the battery. The glass, with a metal cap and the fastening of an ordinary Mueseler lamp, are screwed on to the upper portion of the box, a modified ratchet lock being adopted, held in place by a leaden rivet. This lamp satisfies the conditions of the above report, gives a good light, and is said to be liked by the men. It is, however, heavy, weighing 4 3/4 lbs. The author considers this a trivial objection, as the Marsaut type used in the Pas-de-Calais weighs 3 1/2 lbs. Over 200 of these lamps have been in use for a few months in Belgium.

H. L. and J. W. P.

INSTRUMENTS FOR RECORDING THE SPEED AND WATER-GAUGE OF FANS.
The instrument for recording the depression consists essentially of a water-gauge formed by two brass vessels of very unequal sectional area, connected by a pipe fitted with a three-way cock. One vessel, of prismatic form, is connected with a tube leading air from the fan-drift by a pipe which terminates inside it, a little above the level of the water; and in the other vessel, of cylindrical form, a hollow balanced float plunges freely, being suspended by a brass wire from the lever of a Richard recorder on which a diagram is traced. Before the first-named vessel is put in connexion with the mine, water is poured into the other until the level in the two communication-vessels is at least 0.40 inch (1 centimetre) below the end of the pipe ; and the length of the brass wire is so regulated that the style shall bear upon the paper band at the highest point (or the lowest in the case of compression). The wire is kept in slight tension ; and the movements of the float are reproduced by the style, preferably full-size.
The speed-recorder depends upon the variations of level between two vessels, communicating with one another and filled with the same liquid, the variations being produced by a small turbine whose speed of rotation is proportional to that of the fan or engine to which it is applied.
The speed-recorder described depends upon the displacement of a disc movable along its axis of rotation, which disc on the one hand is constantly drawn towards a fixed point with a speed proportional to the distance between the disc and the fixed point, and on the other hand has a tendency to be drawn in the contrary direction with a speed proportional to that at which the engine revolves whose speed it is desired to record and control, so that the disc's position of equilibrium is at the exact point of its travel for which the two opposing speeds imparted to it are absolutely equal.
The pressure-recorder consists of a flexible metal box, enclosed in an air-tight metal case, in communication by a small tube with the place in which it is desired to register the variations of pressure. This box is attached to the cover of the outer case, and communicates freely with the atmosphere by means of another small tube, while its flexibility and superficial area are increased by its having a bellows or accordéon form. A rod, attached to the bottom of the box, transmits the variations in the position of this bottom through a series of levers to a style, which traces a diagram on a drum revolving on a vertical axis. J. W. P.

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RATIONAL MEASUREMENT OF THE USEFUL WORK OF FANS.
For ascertaining the work done by fans and obtaining a correct idea of the anomalies and differences experienced in the yield of one-and-the same fan under different circumstances, it is necessary to keep in mind the fact that air is a highly compressible fluid whose density is continually changing. In fact, meteorologists know that when the wind strikes the earth in an inclined direction, or when it encounters mountains or clouds, a compression of the air ensues and the barometric pressure rises at the place of impact. What takes place on the earth also occurs in the workings of a mine. Wherever the air encounters an obstacle to its passage, whether in the form of a bend or a restriction, its density, and therefore its pressure, increases for the time, to expand again after passing the obstacle.
As is wellknown, the useful work done by a fan in causing a volume of air, Q, to circulate through a mine is generally expressed by the approximate formula Q h, h being the loss of pressure suffered by the air through friction against the sides of the workings ; and this depression, or loss of load, h, is measured by a water-gauge placed at a point in the drift leading to the fan-inlet. If the air's property of recompression be borne in mind it will be concluded that, for measuring the depression, the following precautions must be taken :—
(1) For the water-gauge to indicate correctly the difference of pressure between the outer atmospheric air and the air-current passing through a mine, the end of its tube, bent to a right angle, must be placed in the air-current; and the mouth of this tube, surrounded by a disc, must be placed in a plane parallel with the direction of the current. Without this precaution, the air might strike against the mouth of the tube and become recompressed there, giving false indications, while it might also strike against the vertical portion of the tube, descend it and reach the mouth recompressed.
(2) The air-current, at the place where the pressure is measured, must not have been subjected to a shock that may have temporarily recompressed it, as would be the case near a sharp bend or obstacle.
As may be supposed, by taking into account the compressibility of the fluid, which causes the depression to disappear in proportion to the square of the current's speed, it is almost impossible, except under unusually favourable circumstances, in a long drift leading in a straight line to the fan-inlet, to exactly measure the depression or loss of load undergone by the air, i.e., the factor \( h \) of the useful work.

In order to obviate these difficulties and to obtain a practically correct measurement, it is sufficient to run the fan very slowly, to note the volume and the depression indicated by the water-gauge at this slight speed, and to compare the values obtained with the volume and the depression ascertained at the fan's maximum speed. If the water-gauge indicates correctly, the depression at the maximum speed ought to have increased, as compared with that at the slow speed, in the proportion of the square of the volumes, or of the number of revolutions, since the latter are proportional to the volume. Should this not be the case, it may be concluded that the air has undergone a temporary recompression near the water-gauge, and therefore that the indications of this instrument are erroneous.

Let it be supposed, for instance, that a fan running at 40 revolutions per minute causes the gauge to show the depression corresponding with 0.04 inch of water; then at the speed of 240 revolutions per minute the water-gauge ought to be 1.44 inches, because 40 revolutions: 0.04 inch = 240 revolutions : 1.44 inches. If at this maximum speed, a volume of 60,000 cubic feet, for instance, has been produced per minute, the useful work given out by the fan will be \((60,000 \times 1.44 \times 5.20 = )\) 449,280 foot-pounds. The volume of air found at the minimum speed of 40 revolutions per minute should also have increased as the square of the number of revolutions; i.e., having been 60,000 cubic feet at 240 revolutions it ought to be 10,000 cubic feet at 40 revolutions per minute. The measurement of these two volumes therefore constitutes one more method of checking.

This easy method, which can be employed by anyone, is based on the invariability of the temperament of a mine, which may in fact be regarded as an air-pipe or passage, and also on the fact that at low speeds the influence of a bend or obstacle upon the recompressibility of the fluid may be regarded as nil, which influence increases as rapidly as the square of the volume or of the speed. J. W. P.

EXPLOSIVE MIXTURES OF ILLUMINATING-GAS AND AIR.

The essential parts of the apparatus used in the experiments were: — A cast-iron cylinder for holding the mixture; a manometer-tube used in making the mixture; a power pump used in clearing the cylinder of the products of explosion; an exhaust-pump for rarefying the air in the cylinder; an indicator; a tuning-fork for obtaining a time-line on an indicator-card; two storage batteries, one wired to the terminals in the cylinder to give the electric spark for the ignition of the mixture, the other being used in connexion with an electro-magnet to keep the tuning-fork in vibration while an indicator-card is being taken; a metallic point attached to the end of one arm of the fork tracing a wave-line upon the card; and an induction-coil.

The following table contains the results of tests of explosive mixtures of illuminating-gas and air: —

[Table omitted]

M. W. B.
The Detection and Estimation of Carbon Monoxide in Air.


The author bases his method on the discovery, by Prof. Ditte, that pure carbon monoxide, when heated in presence of iodic anhydride, decomposes the latter, liberates iodine, and itself becomes converted into carbon dioxide. He finds that this reaction commences below 30° Cent., is active at 40° or 45° Cent., and complete at 60° or 65° Cent., no matter to what extent the carbon monoxide is diluted with nitrogen.

As 5 molecules of carbon monoxide and 1 molecule of iodic anhydride are concerned invariably in the reaction, and as the volume of the carbon monoxide consumed is equal to that of the carbon dioxide formed, it follows that each cubic centimetre of carbon monoxide corresponds to 0.00227 gramme of iodine liberated; and it is on this basis that the determination of the percentage of the gas in question is effected, the measurement of the gas liberated being checked by titrating the free iodine.

The air to be tested is freed from carbon dioxide, then dried by passage through sulphuric acid, and led through a coil filled with asbestos and iodic anhydride, kept at 65° to 70° Cent. by a water-bath. The effluent gas traverses a tube filled with powdered copper—to retain the iodine—and enters a Muntz tube, where the carbon dioxide is absorbed by potassium carbonate. The gas is afterwards liberated by dilute sulphuric acid, and is measured in a gas apparatus.

Typical analyses made with known mixtures of carbon monoxide and air show that the method gives accurate results up to dilutions of 1 part in 30,000 or even in 300,000 parts of air.

The presence of acetylene, ethylene, and some other hydrocarbons, however, reduces the accuracy of the method, both by themselves undergoing oxidation, and, in the case of ethylene, by retarding the oxidation of the carbon monoxide. On the other hand, methane, ethane, and hydrocarbons of the CnH2n + 2 series have no action upon iodic anhydride at the temperature employed in the method, and are therefore without influence on the results.


The potassium permanganate reagent prescribed by Prof. Marmet,* although delicate, is liable to become decolorized not merely by carbon monoxide alone, but also by other reducing substances present in the sample of air. The author consequently prefers to employ a solution of cuprous sulphate, which is not attended with this disadvantage. On causing the sample of air to bubble through a tube filled with this solution, a characteristic red precipitate is formed by the reducing action of carbon monoxide. This method also has the advantage, that it enables comparatively large samples of air to be tested, and hence minute traces of the monoxide can be detected.


This gravimetric method is based on the liberation of iodine from iodic anhydride by the action of carbon monoxide, and on the affinity existing between the halogen element and copper.

* Annales de Chimie Analytique, 1897, page 163.
The sample of air to be tested is filtered, passed successively through potassium hydroxide and barium-hydrate solution, then dried over phosphoric anhydride and conducted into a tube about 12 inches in length charged with iodic anhydride. The iodine liberated enters an absorption-tube, which, together with the decomposing tube, is heated to between 100° and 105° Cent., and contains a 7 inches stratum of copper reduced, from the state of oxide, in an atmosphere of hydrogen, the latter—which would falsify the test—being eliminated by cooling the copper in an atmosphere of carbon dioxide.

The increase in weight of the absorption-tube during the experiment, multiplied by 0.441, gives the volume of carbon monoxide present in the sample of air, since 0.00441 cubic centimetre of carbon monoxide liberates 0.01 milligramme of iodine.

A source of error is introduced by the presence in the air of the hydrocarbons of the CnH2n and CnH2n-2 series, these bodies being able to reduce iodic anhydride at temperatures between 65° and 100° Cent., though no action is exerted in this respect by hydrogen or the saturated hydrocarbons. In presence of the first-named gases, the method therefore requires a slight modification, the decomposing and absorption-tubes being dried by a current of air at 220° Cent. and weighed. A phosphoric-anhydride tube is attached to the absorption-tube in order to determine the amount of water evolved, and a set of three tared tubes—containing known weights of phosphoric anhydride, barium hydroxide and phosphoric anhydride in the order named—is also attached. This arrangement enables the amounts of water and carbon dioxide formed during the reaction to be determined, and the oxygen therein estimated. The oxygen given up by the iodic anhydride is estimated by deducting from the final weight of the latter the iodine found in the absorption-tube, the difference between the two weights of oxygen gives the amount referable to the initial carbon monoxide, and, when multiplied by the factor 1.75, furnishes the weight of the latter.


When allowed to bubble slowly through a dilute solution of palladium chloride, carbon monoxide decomposes and decolorises the liquid. The volume of air containing the carbon monoxide being known, the percentage of the latter can be ascertained by the degree of dilution requisite to reduce another portion of the palladium solution to the same shade as that decolorised.

The apparatus employed by the authors is a long tapered tube connected with the supply of gas under examination, and dipping to the bottom of an outer tube containing the reagent (10 cubic centimetres of a 1/10000 solution of palladium chloride, and 2 drops of hydrochloric acid). The space between the tubes is closed by an indiarubber ring, and the outer tube being attached to an aspirator the air is drawn slowly through the reagent which forms a column of liquid about 8 inches in depth—from which palladium is precipitated, in the state of fine powder, by the carbon monoxide present.

No heat is required. One part of carbon monoxide in 10,000 of air can be detected, and in even greater dilution if the volume of the sample be large enough. The air should be freshly sampled, to prevent loss of carbon monoxide by oxidation.

C. S.

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LIMITS OF INFLAMMABILITY OF COMBUSTIBLE VAPOURS.

In the case of very volatile liquids, e.g., ether, carbon disulphide, benzene, etc., small weighed quantities are shaken up in flasks containing air, and the mixtures are tested until two weights with a difference of not more than 10 per cent. are found, the one inflammable and the other not; the mean of these gives the limit of inflammability within a margin of 5 per cent.

For heavier liquids, the air in the flasks is saturated with the vapour, and the temperature corresponding to the limit of inflammability is determined to within 1°, the amount of vapour present in the mixture at that temperature being ascertained by a separate experiment.

The authors have drawn up the following table of inflammability, the figures in italics being experimental, the others calculated therefrom in conjunction with known data of the heat of combustion and the molecular weight:—

[Table omitted]

In these columns, t is the temperature of saturation; p, the weight of water per litre of mixture at 15° Cent.; v, the percentage volume of vapour in the mixture; o, the volume of oxygen required for complete combustion; and q, the amount of heat evolved by the combustion of 1 molecular volume of the mixture, i.e., 23 1/2 litres, at 15° Cent.

C. S.

LIMITS OF INFLAMMABILITY OF CARBON MONOXIDE.


Though the heat generated by the combustion of carbon monoxide gas is great, it opposes a certain unanticipated resistance to oxygen, as is evident from the slow propagation of the flame and the high limit of inflammability. This condition was investigated by the authors who, working with a tube 10 inches (25 centimetres) long and 1.57 inches (4 centimetres) wide, found the range of inflammability to lie between 74.5 and 15.9 per cent. On reducing the width of the tube to below 0.091 inch (2.3 millimetres) the mixture could not be ignited, whatever the proportion; and other tests showed the direct influence of the diameter on the result: 16.1 per cent. of carbon monoxide giving an inflammable mixture in a 0.54 inch (13.8 millimetres) tube, whilst 61.7 per cent. was required to produce ignition in a 0.26 inch (6.6 millimetres) tube. The influence of barometric pressure is also considerable, the tendency to ignite disappearing when the pressure recedes below 3.15 inches (80 millimetres) of mercury, whereas 15 per cent. of lighting gas is inflammable even at 2.52 inches (64 millimetres) of pressure.

An endeavour was made to ascertain whether in mixtures of carbon monoxide and acetylene the formula applicable to the limits of inflammability in mixtures of two gases of similar composition, holds good. An affirmative result was obtained. On the other hand, mixtures of carbon monoxide and hydrogen do not follow this rule, the deviation being about 4 per cent., i.e. beyond the limits of experimental error.

C. S.

COLLIERY EXPLOSIONS IN PRUSSIA DURING 1897.

Upper Silesia.—The Explosion at the Hedwigswunsch Pit on April 1st, 1897—Here three seams of highly bituminous coal had been worked for about 18 months, and no signs of spontaneous combustion were detected, so long as operations were confined to the west of a fault which cuts off a triangular area in the southwestern portion of the property. When, however, some headings had been driven east of the fault in the Heinitz seam, breaking through to the "old man" in the Reden seam, against which the first-named is faulted, an evolution of fire-damp was observable in the Reden seam for the first time on March 25th. The dangerous area was closed off by timber dams, and the further extension of the workings was limited to the westward of the fault. Six days later, on March 31st, a great deal of inflammable gas came off along the edge of the "old man" in the Heinitz seam east of the fault and in the Reden seam west of it. By reversing the ventilation, and setting a fresh ventilator to work at the August shaft, the dangerous gases were led off without passing through the workings. More timber dams were put up to shut off the area of conflagration, and nothing of any consequence took place till 1/2 hour after midnight (March 31st to April 1st), when a noise resembling the fall of rock was heard in the "old man," and blue flames burst out through No. 8 dam. The people there had begun to spray the dam with water when suddenly an explosion took place, followed at very short intervals by two others, destroying nine dams. Two miners sustained slight burns, while others merely had their hair singed. In the forenoon of April 1st, the dams were built up again, and the normal course of the ventilation was re-established. About 3 p.m., a fresh explosion took place, destroying 5 dams, and killing 6 persons who had gone down the pit to procure samples of the gas for analysis. The ill-fated party consisted of the manager of the mine, a viewer and an underviewer, two analysts, and a laboratory assistant. The efforts of rescue-parties to reach the victims were rendered nugatory by the continual outpour of poisonous gases. It was not until 8 p.m., when the 5 dams had been put up again, that the bodies were recovered. As a smell of burning became more and more perceptible even in the rear of the rescuers, showing that gases were still oozing through the dams into the workings, it was considered prudent to withdraw the rescue-party and suspend any minute examination of the site of the disaster. The actual cause of the ignition of the gases has not been ascertained. Possibly it may be traced to the naked lights carried by the victims of the accident.

Further damming operations were being carried on, but with masonry, when on the morning of April 5th still another explosion occurred, in the Heinitz seam. The workmen fled for their lives, and, fortunately, nothing more disastrous happened than the overthrow of some of the dams, whereby all control of the ventilation was lost for the time being. Finally, the whole area of conflagration in the three seams was walled off by two masonry-dams, and the Holz shaft was closed down. By the end of February, 1898, it was found possible to re-enter this area; the dams are being pushed farther and farther in, and it is expected that before long the last remnants of the fire will be extinguished.

Dortmund District.—1. Coal-dust Explosion in the Pluto Pit, March 17th, 1897.—This took place at the sixth level (1,767 feet below bank) in No. 5 south seam, which belongs to the upper bituminous coal group. This seam gives off very little gas, but makes a considerable amount of dust when worked. Shot-firing with guhr-dynamite, blasting-gelatine and gelatine-dynamite is allowed by the regulations, only on the condition that safety-cartridges are used. Moreover, continual abundant watering of the coal-dust is prescribed. But it appears that the last-mentioned precaution had been pretermitted at the very spot whence the explosion subsequently started. Two dynamite-cartridges were fired, to help in clearing out an area obstructed by fallen
coal and timbering, and this evidently caused the accumulated coal-dust to explode with fatal results, 8 men being killed. The formation of coke-crusts was comparatively slight, and no wreckage of timbering, etc., is recorded. In view of this disaster, the Royal Mining Bureau at Dortmund issued the following order:—"All persons whose duty it is to fire shots are bound to look to it that the blasting-cartridge is provided with proper stemming. It is forbidden in all collieries to fire shots unprovided with stemming, or to ignite loose blasting-cartridges which are not enclosed in a bore-hole."

2. Fire-damp Explosion in Shaft II. of the Count Bismarck Pit, March 23rd, 1897.—Nine men suffered more or less serious injury as a consequence of this explosion, which reads a striking lesson on the foolhardiness of which miners are too often guilty in dangerously fiery workings. The seam belongs to the gas-coal group, has an average thickness of 2 1/2 feet, breaks into cubical masses, and shows very little tendency to dust-formation. There is not, on the whole, much evolution of gas observable; but when at times it is found necessary, in making up the height of the galleries, to bring down the clay-shale which forms the roof, considerably more gas comes off: this is less noticeable in the case of the floor.

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During 5 days the inspector of ventilation had noticed, in the haulage-road belonging to that portion of the workings which became subsequently the starting-point of the explosion, daily increasing accumulations of fire-damp. On the day preceding the accident, there was a volume of explosive gases extending over a length of 22 feet or more, and over the entire height of roof (39 inches) which had been taken out for the haulage-road. The working-face itself was clear of gas, and more or less temporary ventilation was afforded by lifting now and then the brattice-cloth which closed the gallery. Working was continued uninterruptedly, and, in disobedience to all the regulations, no report was made to the manager. On the day of the accident still more gas was found coming off, and the under-viewer (in the absence of the viewer through illness) warned the miners and emphatically forbade any shot-firing. They paid no heed to this order, and continued drilling shot-holes in the presence of the subordinates who brought them the message. The result was such as might have been predicted: the gases, which were being drawn outward by the ventilating-current past the working-face, were ignited either by the sparks proceeding from a gutta-percha fuze or by the flame from a lamp which was afterwards found lying unlocked near a coal-tub. Under the circumstances, the author considers the former alternative the most probable. The victims of the accident suffered very serious burns, from which four of them subsequently died. In the workings themselves no destructive effects were visible, nor does there appear to have been ignition of coal-dust.

As a consequence of this disaster, the Royal Mining Bureau issued on August 10th, 1897, more stringent regulations for the working of seam C. Shot-firing was to be undertaken only under the direct supervision of officials specially deputed for that purpose. Locked safety-lamps, safety-igniters, and safety-explosives were alone to be used; and for each man employed below ground at least 105 cubic feet of air must be the ventilation-allowance.

3. Fire-damp Explosion at the Oberhausen Pit on April 14th, 1897.—This took place a few moments before the day-shift started work in the bituminous Carl coal-seam (30 inches thick), in a district of the mine where all shot-firing was forbidden by Government order. Improvements in the ventilation-system were being carried out at the time, and a vertical shaft was sunk which passed through an unworkable seam that gave off a considerable amount of gas; this was got rid of by temporary makeshifts. In this shaft 3 men were at work; they, with 7 others, were the victims of the explosion. Some died from burns, and others from suffocation by after-damp.
Coal-dust played a very small part in the explosion, which evidently started in the above-mentioned shaft, and must have been due to some carelessness in the handling of the lamps, as the men had no materials with them for shot-firing.

4. Fire-damp Explosion at the Westphalia-Verein Pit, Kaiserstuhl II. Shaft, on December 22nd, 1897.—This was the most considerable of any accident that took place in the Dortmund district in the course of the year. It occurred in seam No. 12 during the afternoon shift, between 4 and 5 p.m., and of the 23 persons employed in that portion of the mine 20 were killed and the others severely injured. Seam No. 12 is regarded as the least dangerous of the generally fiery group to which it belongs, and the average proportion of marsh gas present in this abundantly-ventilated pit was only 0.33 per cent. The coal is very dusty, and the regulations consequently prescribe the systematic watering of working-places and roads. On account of the great pressure of the strata in the area where the explosion occurred, permission was given, however, to dispense with watering there, on the following conditions: — Shot-firing to be prohibited; safety-lamps with double wire-gauze alone to be used; and the number of workpeople to be restricted to 20. Through

some misunderstanding spraying was stopped in another part also. The exact sequence of events in the disaster has not been ascertained. Crusts of coke were found in many working-places, but not on the inclined haulage-planes, although here dust lay about in enormous quantity. In proportion to the amount of coal-dust noted as present in the mine after the explosion, the amount actually ignited was very small. Great falls of rock took place, and ventilation-doors and brattices were half-burnt or otherwise damaged. After-damp interfered considerably with the rescue-operations, and if portable breathing-apparatus, such as oxygen-inhalers, etc., had been at hand, there is no doubt whatever that many of those lives that were lost would have been saved.

Neither the cause nor the starting-point of the explosion are certainly known, but it is proved that there was no shot-firing, no surreptitious opening of lamps; and it seems probable that the gases struck through to the flame of a single-gauze safety-lamp, which had been accidentally brought in with the double-gauze lamps.

L. L. B.

THE EXPLOSION AT THE SZECHEN PIT, DOMAN, HUNGARY.


In view of the disastrous experiences of the last few years, the Resicza-Doman collieries of the Austrian State Railway Company must be classed in the category of dangerous mines. In 1894 there was a fire-damp explosion in the Almasy pit of the Doman colliery; this was followed, on December 18th, 1896, by a most disastrous explosion in the neighbouring Szechen pit, about 1/2 mile away; and at 10 p.m., on January 24th, 1898, another explosion occurred in the same pit, whereby 10 persons lost their lives. This catastrophe only escaped being as overwhelming as the former one, because the highly explosive pit-gas, charged with excessively fine coal-dust, did not ignite as in the previous case.

The scene of the explosion was No. 6 level, 1,300 feet below bank. Here the uppermost of the two seams worked is 13 feet thick, and dips 50 degrees southward. The lower seam at this horizon is split into two portions, known as "roof bench" and "floor bench," one being 195 feet above the other. It appears certain that these benches are merely portions, faulted asunder, of one and the same seam, and the coal hereabouts betrays signs of great disturbance. In estimating the causes of the
recent disaster, the existence of accumulations of gas at high pressure must be noted in connexion with the cracks, fissures, and hollows frequent in these disturbed strata.
The coal in the Szechen pit, and still more so in the Almasy pit, is extremely friable—so friable that it can hardly ever be brought out of the workings in big lumps. As might be expected under such circumstances, enormous quantities of very fine coal-dust are constantly formed in the mine, and water-spraying was prescribed many years ago by the authorities. In the Almasy pit, watering-cans have up till recently been used for this purpose in the dustier workings, but, as the dust forms with extraordinary rapidity, this method must be regarded as inadequate. A new watering-system is now being laid down, in which the Sezechen pit-waters are made use of, no other water-supply being available for the purpose.
The Almasy pit is ventilated by a Pelzer fan 8 feet in diameter, and the Szechen pit by a Guibal fan 29 1/4 feet in diameter, 6 1/2 feet wide, and with a maximum capacity of 36,000 cubic feet per minute. The course of the ventilation is such that the air-current passing out of No. 6 level after the explosion brought the fre-damp even into the upper workings which lay in the path of the air-current, and thence to the surface. The circumstance that, in addition to the main current, the Szechen pit is also ventilated by an auxiliary current coming from the Almasy pit, diminished in no inconsiderable degree the fearful violence of the explosion, and, besides facilitating the escape of the miners, rendered the task that lay before the rescue-parties less arduous. No. 6 level is in communication with the Franz Josef gallery 822 feet above it; and here steam-haulage has been replaced by electric haulage, on account of the danger of ignition of the pit-gases and coal-dust by sparks from the locomotive. Nevertheless, the steam-engine is still used whenever the electric apparatus gets out of order; and it happened very fortunately on the day of the accident that the locomotive had been removed from the mine 3/4 hour before the explosion took place. Until quite recently, the Franz Josef gallery has been used as an airway to take the foul air out of the pit, besides being a haulage-road; but great improvements are being made in the ventilation-system of all the pits in the district.
The average quantum of air per minute per man passing through the Szechen workings at the time of the disaster was 176.5 cubic feet, or 35 cubic feet more than the amount prescribed by the regulations; while in the Almasy pit the corresponding amount was 229.5 cubic feet. In this respect 1 horse is reckoned to require as much air as 4 men.

Turning from ventilation to lighting, the safety-lamps used in these collieries are of the Wolf benzine type, with double gauzes and magnetic locks: they are very strictly checked, carefully cleaned, and kept in good repair. As a proof of the perfect control kept over the lamps, it is sufficient to mention that scarcely one of those picked up in the pit after the disaster was found to be in the least damaged. Three only, found near the immediate starting-point of the explosion, were in an abnormal condition, being choked up with coal-dust, which appeared to have been forced through the meshes of the wire-gauze by the enormous air-pressure.
The night shift on January 24th numbered 141 men and boys, 15 of whom were at work in No. 6 level. The evidence given by the 6 survivors out of these 15 shows that a series of violent detonations were accompanied and followed by great rushes of gas mixed with coal-dust, which knocked some of the men down and deprived them of consciousness. All the deaths appear to have been due to suffocation, and very few traces of external injury were found on the bodies. The violence of the explosion may be gauged from the following details:—The western gallery of No. 6 level was choked up for a length of 52 feet with coal which had been hurled along and mostly ground to powder, and the whole gallery itself fell
in. In the upper airway, coal-dust was blown right into the eastern district, a distance of 367 feet. The volume of gas set free must have been enormous, when one bears in mind also that the return-air at the exit of the Franz Josef gallery was still highly explosive 1/2 hour after the disaster, while the ventilator was working at forced speed (2.6 inches depression). As a consequence of the 1896 disaster, very special precautions had been taken in this pit, and only minute quantities of fire-damp were ever noticed. But now and then various miners would tell the officials that they often heard a report — louder at some times than at others— proceeding from that portion of the workings where the outburst afterwards started. The investigations conducted by a committee, a few days after the disaster, showed that the gases had torn an opening in the coal about 11 feet square and 10 feet long. L. L. B.

EXPLOSIONS IN COAL-MINES, AND THE CONSEQUENCES OF AN EXCESSIVE ARTIFICIAL VENTILATION.


Dr. Haldane's report upon the experiments made in consequence of the explosions at Tylerstown colliery, at Brancepeth colliery, on April 13th, 1896, and at Micklefield colliery on April 30th, 1896, permit a comparison with the accident which happened in February, 1895, at Carolinengluck colliery, Westphalia, where 120 workmen were killed, most of them suffocated at a distance of more than 3,000 feet from the place of the explosion, and at a much higher level, about 650 feet, in the mine. Dr. Haldane's report, addressed to the Home Secretary, stated that a mixture of 1.8 per cent. of carbon monoxide in air caused faintness, with loss of consciousness in 8 to 10 minutes, and followed by death in 30 or 40 minutes to human beings, owing to the absorption of carbon monoxide by the blood. At Brancepeth and Micklefield collieries, it is stated that 80 per cent. of the victims were suffocated by carbon monoxide. Explorations did not prove that the explosions were caused by fire-damp, which in this case might have ignited the coal-dust, but experiments made upon the inflammability of coal-dust suspended in air suggest the opinion that in this case, as in almost all those in which we can establish the combustion of dusts, the presence of fire-damp had caused their ignition.

In the explosion at Carolinengluck colliery, we may ask how an explosion which occurred at a depth of 1,600 feet could cause the death of workmen occupied in the mine at such distances from the site of the explosion. If the energy of the explosion be the cause, we should find damage throughout the gallery in which it occurred, timber reduced to splinters, and the victims mutilated. On the contrary injuries were found only upon a small number of the bodies lying in the vicinity where the explosion originated. The timber of the galleries was found covered with a material having the appearance of coke, and due to the distillation of the coal-dust. It is impossible that all the workings and galleries of the mine should have been filled with coal-dust in suspension sufficiently dense to carry the fire to distances of thousands of feet. There can be no doubt that artificial ventilation has carried throughout the mine with a rapidity proportional to the energy of the ventilators, air charged, it may be, with 20 per cent. of carbon monoxide, and this gas is the cause of the suffocation of the workmen employed at distances of 3,000 feet, and in galleries situated about 650 feet above the level of the explosion. As these injurious effects are produced within an interval of not more than 10 minutes, the explosion, having broken and destroyed the doors erected in the galleries to direct the ventilation, the atmosphere charged with carbon monoxide almost immediately reaches the most distant galleries, it may
be diluted to 1.8 per cent. which is sufficient, according to Dr. Haldane, to knock
down a man in 8 minutes, and to suffocate him in 30 or 40 minutes.
There can be no doubt that the gaseous products of the explosion, and especially the
carbon monoxide which is formed by the combustion of coal-dust suspended in the
working-places, by expanding rapidly throughout the mine produce these injurious
effects. Owing to these facts, one must ask whether a point has not been reached in
the volume of artificial ventilation which cannot be exceeded except with great
danger. Atmospheric air can be charged with 15
to 20 per cent. of fire-damp without becoming irrespirable, but 1.8 per cent. of carbon
monoxide will suffocate a man in a few minutes.
An energetic ventilation is certainly an efficacious means of diluting fire-damp and
making it harmless; but experience unfortunately proves that the most energetic
ventilation will not prevent explosions. Explosions generally destroy the ventilating-
doors and the galleries between different levels. The current of air must then take
another route than that assigned to it, and the suffocating gases are quickly diffused
throughout the whole of the mine. The more energetic the ventilation the sooner the
gases produced by an explosion will spread and produce the injurious effects which
occurred at Brancepeth, Micklefield and Carolinengluck collieries. The question
should therefore be asked: at what point should one limit the volume of ventilation?
Mr. G. Kohler, director of the School of Mines at Clausthal, in a paper upon the
explosion at Carolinengluck,* proposes to make arrangements by which, irrespective
of cost, oxygen may be distributed into all the workings after an explosion. The writer
thinks that this project presents almost unsurmountable difficulties. Although it will be
useful to have oxygen at one's disposal in all coal-mines to be used in cases of
suffocation, he thinks that it will be difficult to diffuse this oxygen in a gaseous state
into the workings in a mine within a period of less than 10 to 30 minutes after an
explosion. Mr. Kohler remarks that an energetic ventilation is the best means of
removing dust, but experience proves that the upper portions of galleries are scarcely
reached by the most energetic ventilation. An excess of air has, however, another
consequence: the coal-dust is very rapidly dried, and this is especially the case
where the dust is resting upon timbers in the upper portion of the galleries. We find
heaped-up accumulations of dust, many inches in thickness, resisting the most
energetic ventilation, and it does not contain any moisture. An explosion is required
to set the dusts in motion, and if the ignition produces enough carbon monoxide to
make a mixture containing 1.8 per cent., an energetic ventilation will comprize the
whole mine in a catastrophe, which would otherwise have remained within
reasonable limits. Energetic ventilation is therefore an imminent danger, or at least
an augmentation of the danger.
The water-spraying of galleries as well as of all the places where dust may be
produced is a good method of preventing, or at least of diminishing, the effects
produced by the sudden combustion of coal-dust, but the watering of dust deposited
upon timbers, etc., requires a very costly plant, which few mines can adopt.
Moreover, the operation of water-spraying should be continuous, as an energetic
ventilation quickly removes the moisture communicated to the quiescent coal-dust.

M. W. B.

NEUPERT RESCUE APPARATUS.
Ueber Athmungsapparate beim Bergbaubetriebe und speciell uber den Rettungs-
Oesterreichische Zeitschrift fur Berg- und Huttenwesen, 1898, vol. xlvi., pages 1-4,
17-22, and 34-38, with 1 plate.
The author states that the Walcher-Gartner pneumatophore† has the disadvantage that, being carried in front of the wearer, it tends to encumber his arms, particularly when stooping, and also prevents him from carrying a rescued miner or other weight in the easiest position. Moreover, there being


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no mask, but only a nose-clip and mouth-piece—both liable to get out of place while in use—the apparatus cannot be regarded as perfect, more especially since there is no valve to prevent re-inhalation of unabsorbed carbon dioxide, to say nothing of the defective absorption of this gas by caustic soda and the inconvenience arising from the necessity of shaking the air-bag now and then to secure better distribution of the liquid.

In order to remove some of these objections, the Neupert apparatus has been constructed from the author's instructions.

The new appliance consists of an indiarubber or leather air-bag, in the shape of a short shoulder-cape, surmounted by a helmet of similar material, with a glass mask fitting over the face. The helmet is loose, but the edges of the mask fit tightly against the face, communication between the latter and the air-bag being effected by a couple of valved tubes, one for inhaling, and the other for the expired air. The air bag only extends about 6 inches below the wearer's chin, and hence does not incommode or restrict his movements.

Air is supplied to the bag by a pipe leading from a bottle of compressed oxygen—the capacity being about 5,400 cubic inches (90 cubic centimetres) and the pressure 100 atmospheres—which is supported at the wearer's side or back by a bandolier, and can be removed and replaced in 5 seconds. The supply is adjusted by suitable check- and reducing-valves.

The air-bag is charged with some solid, such as stick caustic potash or soda, or granulated soda-lime, capable of absorbing carbon dioxide, these being found preferable to liquid absorbents, inasmuch as they at the same time dry the air and do not raise the temperature within the mask. In experiments made by the author it was found that in two instances, after 2 hours' wear, this temperature was 25° and 31° Cent., whilst that of the absorbent solid potash itself was 38° and 57° Cent. respectively, thus showing that most of the heat developed by the chemical action of the materials is retained by the absorbent and not radiated.

Experiments made to ascertain the most suitable absorbent show that there are several factors influencing a decision, the most important being the physical character, relative effective weight, and rapidity of action—this latter tending to reduce the temperature and consequently the perspiration. Thus, quick- and slaked-lime, though the best absorbents, must be discarded because the lumps tend to fall to pieces and become powder. Again, whilst caustic soda is relatively lighter than potash—the proportion being as 80 : 112—and is also cheaper, it nevertheless is less suitable, by reason of its less energetic and rapid absorptive faculty.

For example, when 7 ounces (200 grammes) of water—i.e., about the quantity liberated in the apparatus, from the breath of an average man, from the formation of potassium carbonate, and by perspiration during 2 hours—were placed in contact with 171 ounces (500 grammes) of caustic potash in a jacketted vessel which was tested for rise of temperature, the figures obtained were 85°, 95°, 74° Cent. at the end of 2, 10 and 90 minutes. In the case of caustic soda, the temperatures recorded at the corresponding periods were 48°, 80° and 61° Cent.; hence caustic potash exhibits a greater degree of energy in action.
To determine the charge required, it is known that a man engaged in active work
requires 1.4 ounces (39.8 grammes) of oxygen per hour and exhales 1.9 ounces
(53.5 grammes) of carbon dioxide in the same time. On this basis, a charge of 4.8
ounces (136 grammes) of caustic potash would be necessary; but in order to leave a
sufficient margin, for contingencies 17 1/2 ounces (1/2 kilogramme) of potash are
employed for 2 hours' work, the oxygen supply also being arranged at threefold the
theoretical requirement.

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The total weight of the apparatus is 15 1/4 pounds (6.94 kilogrammes), of which the
air-bag, helmet, valves, etc., account for 4.53 pounds (2.06 kilogrammes) and the
oxygen bottle for 8.8 pounds (4 kilogrammes). If, however, a smaller oxygen bottle
of 36 1/2 cubic inches (0.6 litre) capacity be used the total weight is reduced to 11.08
pounds, or only about 1.2 pounds heavier than the pneumatophore.

C. S.

FIRE IN THE ZOLLERN PIT, WESTPHALIA.

Der Schachtbrand anf Zeche Zollern in Westfalen am 22. Mai, 1898. By
Bergassessor Hundt. Zeitschrift fur das Berg-, Hutten- und Salinen-Wesen im
Preussischen Staate, 1898, vol. xlvi., pages 294-300, and 1 plate.

At 2.30 a.m. on Sunday, May 22nd, 1898, a fire broke out in the Zollern pit, and
resulted in the loss of 44 lives.

At this pit there is only one shaft, divided down to the fourth or bottom level (1,140
feet) by a timber partition. One division, 58 square feet in sectional area, serves as a
ventilating-shaft, while the other is used for the purposes of winding, etc. Down the
ventilating-shaft run steam-pipes, compressed-air pipes, and the pumping-rods
connected with two engines. There is, however, a second outlet from the pit to the
surface by means of the winding-shaft of the neighbouring Germania II. pit. This
communicates with an airway on the uppermost level (513 feet) of the Zollern pit.

The number of persons employed below bank in the last-named colliery is no less
than 1,100; out of these, however, only 217 were at work in the night-shift at the time
of the disaster.

Direct winding in the winding-shaft only takes place down to the third level (890 feet).
From the bottom level most of the coal is raised up to this point by means of a steam-
winch in a small blind shaft which runs up from the fourth level to the third level in the
immediate vicinity of the main shaft. As will be afterwards shown, it was from the
neighbourhood of the steam-winch that the fire started, and two points in this
connexion are noted as especially significant: (1) To increase the friction of the
winding-cable a hempen rope had been laid in the groove of the pulley-sheave upon
which the winding-cable ran; (2) the engine-room was fenced off from the blind shaft
by a thick timber staging, pierced by one large opening and two small apertures (for
the winding-cable). On this staging there was generally a considerable amount of
lubricating-material lying about in the form of accumulated droppings.

Open petroleum-lamps were in use as fixed lights. It is true that the engine-man
carried with him a safety-lamp when lubricating the steam-winch, but naked lights
were used when executing repairs in the shaft or when making a round of inspection.

Now, some tram-rails were being sent down to the bottom level, and, as the 13 feet
lengths protruded beyond the small cage, they were made fast to the winding-rope by
a hempen cord. In order to facilitate the unfastening of the bundle by the man whose
duty it was to unload the rails at the bottom level an open lamp had been hooked on
to the cord. This lamp was of metal, with a cylindrical reservoir 4 1/2 inches high and
the same in diameter, with a wick about 4/5 inch in diameter, and was provided with
an iron hook for facility in carrying it or slinging it when necessary. The use of lamps
of this type was freely allowed, in view of the exceptionally good ventilation in the
shaft.

After the rails had been unloaded, the empty cage was sent up again with the lamp in
it, and a hempen rope-end protruding from one of the above-mentioned openings in
the timber staging (probably part of the extra rope laid on the pulley-sheave for
increasing friction) caught fire at the lamp-flame. Before the blazing rope had been
dragged down, the flames leaped on to the timber staging saturated with lubricant,
and were fanned by the air-current which ventilated the small engine-room. The fire
then spread to the timbering of the blind shaft (down which poured every minute
60,000 cubic feet of air for ventilating the bottom level), the lightning rapidity with
which the flames travelled being helped by the strong air-current. Later on, the
timbering in the main cross-cut of the bottom level became also involved in the fire.
On the news of the outbreak being conveyed to him, 1/4 hour from the start, the
manager wisely ordered the immediate stoppage of the ventilator. Most of the miners
sought to reach the main shaft by means of the haulage-ways of the third level, but
meanwhile the choke-damp was increasing to such an extent in that level that the
sole chance of safety lay in fleeing by the long airway (1 1/4 miles) communicating
with the Germania II. pit, and all those who followed the advice of the viewers to use
this means of escape got off uninjured. Many deaths were due to a foolhardy neglect
to follow this advice.

Water raised by the pumping-engines was poured into the shaft from above the top
level, and an unsuccessful attempt was made to close off the northern and southern
cross-cuts on the third level, but the working party was driven back by dense clouds
of smoke. On the other hand, by opening a shutter in the ventilating-shaft below the
second level, the greater portion of the combustion-gases were drawn out direct.
About 6 a.m., while a rescue-party was still engaged in the north-western district
(farthest away from the shaft), there was a sudden reversal of the air-currents, and
the uppermost level got so full of smoke that it was deemed advisable to set the
ventilator going again. Fresh rescue-parties volunteered to go in search of those
remaining in the pit, lest they should be overcome by the gases now being drawn
through at an increased velocity. By means of the most heroic persistence, and, at
the ultimate cost of several lives, the missing men were brought out.

At a later stage of the proceedings, rescue-parties arrived from the Hibernia pit,
equipped with air-breathing apparatus, and rendered good service in helping to
quench the flames. Nevertheless, in two cases, the apparatus proved faulty, and the
wearers were brought to bank in a state of unconsciousness.

The workings were, on the whole, very little damaged by the fire, and the ordinary
course of work was resumed in the pit after an interval of 4 days. As a consequence
of the disaster, the following regulations have been promulgated: —

1. The use of naked lights is forbidden in all places underground where machinery
driven by steam is set up, unless all timbering is kept constantly so wet that its
ignition is practically impossible. Moreover, all easily combustible material, such as
cotton-waste, etc., must be conveyed thither in closed packages. The use of naked
lights is also forbidden in underground stables and such like places, where hay and
straw may be lying about.

2. In all mines which depend for their second outlet on the shaft or adit of another
mine, a permanent notice must be set up informing the workpeople of the situation of
this second outlet, and the way thither must be marked by indicators.

L. L. B,
UNDERGROUND PUMPING ENGINES.
The author passes in review underground pumps driven directly by a steam-engine, those put in motion by hydraulic transmission of power, and those actuated by electrical transmission, arriving at the following conclusions:—The three methods of driving are of about equal value as regards steam-consumption; but in this respect those with transmission of power are more economical when, with a view to future eventualities, the pumping-engine has been put down of greater power than that ordinarily required. In such a case the pump is not worked continuously; and, if it be driven directly by a steam-engine, the consumption will increase in inverse proportion to the number of hours that it works daily. In many cases the advantages of lower consumption and the suppression of underground steam-pipes compensate for the higher first cost of pumps driven by power transmitted from the surface.
Hydraulic transmission of power has the advantage of great simplicity as regards both the plant and its maintenance. The pressure-pumps run slowly with a long stroke, and may be provided with very perfect valve-gear, so that the steam-consumption may be reduced below 16 1/2 lbs. (7.5 kilogrammes) of steam per horsepower in water raised; and, with hydraulic pumps not consuming more than 14 lbs. (6.5 kilogrammes) of steam per indicated horsepower, the consumption of pumps driven by hydraulic transmission will be less than 22 lbs. (10 kilogrammes) per horsepower in water raised.
Electricity requires high-speed motors—or those of moderate speed (100 to 125 revolutions per minute) if the generating dynamo be driven directly—engines with short stroke that are often less perfect as regards their steam-distribution; but otherwise the dynamo must be driven by belt or rope, which is not so favourable as regards the general useful effect. The management of electric plant appears more difficult than that of hydraulic pumps; but the transmission of electric current by cables is more economical than that of water under pressure in pipes; and cables are more easily laid than rigid pipes. It follows, therefore, that electric transmission is better suited for long distances, while lending itself more readily to driving appliances of various kinds. The conditions of each case will, moreover, determine the nature of transmission to be employed; and, accordingly as it may be required to drive only one pump, or various machines, preference will be given to water or electricity.

J. W. P.

PREPARATION PLANT AT THE SAINT-ELOY COLLIERIES.
The Saint-Eloy coal, long-flame, non-bituminous and containing from 36 to 40 per cent. of volatile matter, is non-pyritous and leaves an almost infusible white ash, so that it only yields a light and porous coke; but, apart from its industrial applications, this coal is excellent for household use.
When a new winding-shaft was started it became necessary, in order to meet trade requirements, to take measures for permitting of at any time varying the sizes of the coals, of sending them off dry, or of passing on to the washing-plant the whole or part of the various sizes made, and also of mixing them—in any proportion required—by mechanical means,

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The mouth of the shaft is connected with the upper floor of the screening-plant by an iron bridge provided with endless-chain haulage, the fingers of which catch the tubs by their axles and take them up to the tippler-floor, that has an area of 4,300 square
feet (400 square metres), sufficient to store 1 1/2 hours' production, and thus affords means for regulating the out-turn of the screens however the output of the shaft may vary. Indeed, the whole of the storing bins permits of stocking nearly a day's output, which was one of the principal objects aimed at in designing this plant. The 4 side tipplers, worked off the general shafting, are thrown into gear by a hand-lever, while the stoppage is automatic.

In order to avoid a choking of the No. 3 Coxe screens, the coal is first passed over an inclined grate with bars 6 inches apart, a roller 2 feet in diameter, which makes 4 revolutions per minute, being placed below the tippler-hopper for regulating the feed of coal. The various qualities of coal are separated underground, so that each screen serves for one quality only, except the third which generally requires two screens; but, in the event of break-down, screening can be continued while one screen is out of use.

As the proportion of lump coal with adherent shale is considerable, namely, 5.3 per cent. of the whole output or 14.7 per cent. of the lump coal and cobbles, a special department has been arranged for its treatment, the pickers breaking the pieces and removing the rock.

The cobbles and pea-coal fall on to one set of carrying-belts and the slack on to others, moving at the rate of 2 feet and 2 1/4 feet respectively per second, there being three belts for each size, while slides, worked from the floor, permit of sending the products of a screen to any one of these three belts, which are reversible and pass over six large storage-bins each holding 80 tons; and the slides, placed over each belt and above each hopper, ensure the delivery as may be desired of the coal from each of the belts on to that of the storage-bin required. This triple combination permits of directing to any given bin the coal of each of the four screens and of each size, so that any size may be washed separately, or any mixture made that may be called for.

The four lines of way, two for the lump coal and two for the cobbles, pea-coal and slack, are connected, by a traverser, with the siding from the Saint-Eloy station; and a series of switches and turntables permits of turning all the loaded wagons on to a single line of way. Below all the points where coal is discharged are spouts movable in three directions, while they can be raised or lowered, lengthened or shortened; and they are also capable of a lateral displacement equal to the width of a wagon, in which, therefore, the load can be distributed very regularly.

The whole screening and washing-plant is driven by a 75 horsepower engine making 32 revolutions per minute; and the exhaust steam may be sent at will into the condenser, into the open air, or into a warming pipe extending throughout these departments. J. W. P.

KREISS OSCILLATING CONVEYER.

This conveyer consists simply of a sheet-iron channel mounted on inclined timbers forming springs, and receiving a rapid reciprocating motion. The very principle of such a motion, even if of slight amplitude, would appear to exclude the use of this form of conveyer for transport to any considerable distance; but the difficulty has been surmounted by thoroughly balancing the moments of inertia in the following manner:—

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The conveyer is divided longitudinally into an even number of equal lengths or sections; and a single crank-shaft drives two consecutive lengths in inverse directions (this for each group of two lengths), which completely annihilates the momentum, that cannot be transmitted to the framework supporting the channel.
Motion is transmitted by rope from one shaft to another; and each length of channel may be 130 feet (40 metres) long, so that the distance between two consecutive crank-shafts is 260 feet (80 metres). A conveyer so arranged, 575 feet (176 metres) long, mounted on supports 13 feet (4 metres) high, has been put up for stacking coal; and slides, arranged every 6 1/2 feet (2 metres), permit of delivery at any point in the length of the conveyer. J. W. P.

LOADING OR STACKING PATENT FUEL BY AN AIR-LINE.


As the site of the screening-plant and briquette-fuel works affords no room for stacking on the spot, land was bought on the other side of a public road, and 8 feet (2.5 metres) above the screening-floor level. The products of two briquetting presses, about 10 tons per hour, are conveyed by a travelling-belt of double that capacity for either direct loading on to waggons, or stacking and again taking from stock.

A travelling-belt, 151 feet (46 metres) long when extended, and 2 feet (60 centimetres) wide, driven directly by the press, receives the products of the latter, and conveys them either directly to waggons or, if for stacking, to a second carrying-belt, the upper or forward part of which serves for delivering them on the stack, and the lower or following part, that passes through an underground passage, for taking from stock, in which latter case a bucket-chain raises and loads them into waggons.

When the briquettes have to be loaded directly, instead of being stacked, an oblique rake causes them to fall through one of several spouts into a waggon; but when, on the contrary, they have to be stacked, they fall from the end of the first belt on to the second, 1 1/4 feet (40 centimetres) wide, and the extended length of which is 722 feet (220 metres), that is made to travel at the rate of 3 1/4 feet (1 metre) per second by means of a small steam-engine.

At the point where it is desired to make the briquettes leave the belt, there is an oblique rake with wooden roller for raising the belt a little, so as to permit the briquettes to pass from the belt on to a lateral channel for preventing breakage at the commencement of the heap; and this channel is formed of sections, having various lengths, reaching almost clown to the ground at the commencement of stacking. Each section is removed as the height of the heap increases; and when the top of the heap reaches nearly up to the belt, the drum carrying it is shifted from time to time so as to give the heap an elongated form. In this manner, a heap of 380,000 cubic feet (10,725 cubic metres) is formed, equal to a weight of about 8,260 tons.

For taking out of stock, one or more of the slides that cover openings about every 6 1/2 feet (2 metres) in the roof of the underground passage are withdrawn, when the ovoid briquettes fall directly on to the lower or following end of the belt which draws them along until an oblique rake obliges them to fall into a hopper, whence a bucket-chain raises them to the waggon. In this manner 20 tons may be taken from stock per hour. J. W. P.

SALLAC COAL-TIPPLER.


A new tippler has lately been introduced by Mr. Sallac, which, although it has an equal speed during a whole revolution, does not run empty at all, but delivers continuously on to the screen. The discharge of the coal is independent of the time of emptying. The tippler has two tyres, each provided with a pair of U-irons and stop-forks. They run upon four rollers, and the back tyre is connected to a toothed wheel with a rack gearing into a friction-pulley. The tippler is thrown on and off automatically
by a lever. The frame is made to receive a truckload of coal at a time, and the bottom is specially shaped to prevent the coal from sticking as it is tipped down the shoot on to the screen. The tippler carries from 6 to 8 shovels affixed to it at different points, which, as it gradually turns over, successively help to push down the coal. The last shovel checks the coal in its descent, and deposits it gently in the shoot, thus avoiding breakage. When the full tub has been pushed on to the tippler, it is set in motion by a lever, and the shovel at the bottom begins to rake the coal still remaining from the last load, about half a tubful, down the shoot. As the tippler turns, the other shovels are brought round one by one, and act upon the coal. By the time the full waggon is tipped over and emptied, all the coal left in the shoot has passed on to the screen. The shovels push down the fresh coal till about half has descended, and the tippler, having completed a revolution, is seized by the forks, and brought to a stand. Thus the screen is fed uninterruptedly, and the tippler never runs empty. When the tubs are changed there is a pause of 2 to 5 seconds, but as at this point the shovels are closer together and send more coal on to the screen, the tippler still continues to deliver without intermission. By accelerating its speed of revolution, four waggonss per minute may be emptied without difficulty.

A test was made at a mine in Austria with this rack-and-clutch gear attached to an ordinary tippler, and gave excellent results. A new tippler was started in November, 1896, and has already tipped more than 200,000 tubs so successfully that it has been found possible to reduce the length of the screen by one-third. The shovels do not break up the coal, and the shoot is never clogged, even when pieces of large coal (23 inches) are passed through it. Complete drawings of the apparatus are given in the original paper.

B. D.

HUMBOLDT COAL-WASHERS AT THE BLANZY COLLRIERY.


Owing to the constantly increasing output of the Blanzy colliery, the washing-plant, twice increased, still proved insufficient. Accordingly, the order was given for the erection of two Humboldt plants, each capable of washing 800 tons in 10 hours, and the first of these is on the point of completion.

A large bucket-chain raises the coal of 0 to 2.37 inches (60 millimetres) gauge to a large hopper at the top of the building, whence it falls into a Humboldt trommel, or sizing-drum, fitted with spirals, where it is separated, dry, into three sizes, namely, from 2.37 inches to 1.77 inches (60 to 45 millimetres), from 1.77 inches to 1 inch (45 to 25 millimetres), and from 1 inch to 0.39 inch (25 to 10 millimetres).

The coal does not remain in the trommel during more than a single revolution, only one size, that from 1.77 inches to 2.37 inches (45 to 60 millimetres), turning backwards after the first revolution and making its way out on the following, so that the pieces are not broken by the screening. Under this first trommel is a line of five washers each receiving a size of coal, slack from 0 to 0.39 inch (10 millimetres) gauge being alone received in a channel with a stream of water, which carries it along to the second trommel with spirals to be separated, wet, into three sizes, from 0 to 0.12 inch (3 millimetres), from 0.12 inch to 0.28 inch (3 to 7 millimetres), and from 0.28 inch to 0.39 inch (7 to 10 millimetres), each of which sizes is passed on to one of five piston-washers.

This washing plant is noteworthy on account of the first summary classification and also the re-washing of all the "shales" produced during the first part of the operation, as well as the suppression of schlamm, sludge or coal-dust mud, which is
incorporated with the fine coal in the following manner:—Near the hopper for receiving the washed fine coal there is a large chamber, into which the water falls from the hopper in a cascade; and this chamber, sufficiently large for the speed of the water to be almost nil, has below it eight hopper-shaped boxes wherein the mud settles, while the opening of cocks in which the boxes terminate allows the muddy water to pass, on its way to a storage-chamber. This water is delivered into the channel of the washed slack, which is carried along by it to the storing towers; and, on a tower becoming full of coal, the sluice-valve through which coal and water enter is closed, and the water in the tower drains through the wire-mesh terminating its point. The wash water, forming a complete circuit, is put in motion by centrifugal pumps and a pulsometer; and it is estimated that the quantity to be renewed per minute is only 55 gallons (2 1/2 hectolitres), which may be furnished at will by that draining from the pea-coal, by the overflow of the condensation-water or by the warm water of condensation.

J. W. P.

WUNDERLICH COAL-WASHER.


The Wunderlich system of washing coal has for some years been adopted with the best results in several of the principal mines in Bohemia. There are two types of the apparatus. In the first, the shale and rubbish fall through openings in the purifier, and are raised by an elevator to a second washer where they are separated, the rubbish being carried off, and the shale passing on to an endless belt. The two washers are similar in construction, but the second serves two or three purifiers. The advantage of the double process is that the coal does not require previous sorting, and low-grade coal can be dealt with in any quantity.

In the second type, the design is the same, but the two washers are combined. The water is raised by a centrifugal pump to the trough, in the bottom of which are separate openings for the rubbish and shale, and a divided space below to receive them as they fall. The rubbish is then carried off by a small elevator, while the shale passes to a belt, where the water is drained from it, and the clean coal is conveyed along another belt worked by an endless chain, to a hopper. One washing suffices to separate the coal from the impurities, but it must be previously sorted to a certain extent, and only a given quantity can be treated at a time.

Both kinds of washers may be used singly or coupled. In a double washer, the water is raised by a centrifugal pump, and sent on to two troughs, each of which is fed separately with coal. There is one elevator and draining-belt for the rubbish and shale, and a single transmission-shaft, while two belts carry off the coal. These duplicate washers are compact, only about 18 inches wide, yield a large output of good coal, and require little power. A Wunderlich coal-washer has been in use at two of the principal mines in Austria for 2 1/2 years, and 200,000 tons of coal have been treated. The best results are obtained with high-grade coal carefully sorted, while low-grade unpicked coal is not so suitable. The output varies with the size of the coal. With coal in pieces from 1 to 2 inches, the maximum output is 550 pounds per minute per washer; with coal 1/2 to 1/5 inch it is 330 pounds per minute, the latter being the approximate mean output for all sizes. The centrifugal pump delivers 740 gallons of water per minute. The yield from these washers is about 80 per cent. of pure coal, 3 per cent. of grits, 7 per cent. of shale, and 10 per cent. of waste and rubbish. Coal of medium size, from 1 to 1 1/2 inches gives the best results. The cost of washing is about 10d. per ton, and two men are required to work the washers. The original paper is illustrated by a drawing.

B. D.
PURIFICATION OF COAL WASH-WATER AND ARTIFICIAL FORMATION OF SHALE.


After the water used for coal-washing has passed through three hopper-shaped boxes, in which it leaves the greater part of its mud, it flows into a precipitation-tank, where it becomes completely freed from argillaceous slime, and is pumped up, only a little thick, for use over again in the washers; but the tank must be cleared of slime every two days, while, notwithstanding the auxiliary precipitation-tanks, the effluent fouls the channel leading to the canal, so as to cause complaint from the canal-management.

The idea was then conceived of pumping up the muddy water of the tank (this being necessary on account of the relative levels) so as to filter through a large heap where the refuse from coal-working and the boiler-ashes are tipped ; and, during the seven months that this natural filter has been in operation, the water has flowed off from the tip in a sufficiently limpid state, while the complaints have ceased.

About 20,000 gallons (900 hectolitres) of muddy water are poured over the tip during the day of 10 hours ; but this quantity is more than necessary, because the water of the precipitation-tank is renewed three times in that period. Small walls are made with boiler-furnace clinker at a suitable place on the tip, in such a manner as to form two separate basins into which the muddy water is delivered alternately. When one is choked up, the mud is thrown over the side of the tip, while the other basin is used as a filter. In this manner, a very good water for coal-washing is obtained ; and the muddy water flows over the tip, which is on fire.

At the same time, shales more or less carbonaceous are formed artificially ; and, by introducing sand into the stream of water, all Coal-measure rocks have been reproduced. The shales are found to be stratified with lines changing their direction, so as to represent sections of natural shale ; and drying goes on so rapidly in the open air that in a few days a shale of remarkable hardness and compactness is obtained.  

J. W. P.

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DETERMINATION OF CARBON IN IRON AND STEEL.


The amount of carbon in iron and steel is generally determined by analysis, and the method used should be accurate, simple and rapid. The Eggertz process of making the determination according to the colour of the iron is useful, but it has the disadvantage of being dependent, not on fixed quantities, as weight or volume, but upon the eye of the observer, and it is not of general application. To estimate the quantity of carbon in iron from its weight is a complicated and lengthy process, and the suggestion was made by Prof. Wiborgh to determine it by measuring the gaseous volume of carbon in the carbon dioxide. This method has been applied for 6 years at the Technical Chemical Laboratory at Brunn, in Moravia, and its accuracy has been checked by analysis by weight. The Wiborgh apparatus is, however, too small, and the absorption of the carbon dioxide with caustic potash takes place in the measuring-tube itself. The process has been modified by introducing the gas into a Hempel sampling-apparatus, and eliminating the volume of carbon dioxide by absorption with caustic potash in a separate pipette. Further improvements, especially in simplicity, have been made by Dr. von Reis. The simpler the instrument, the better for the chemist of a foundry, who has often to analyse and determine the percentage of carbon in about six charges of steel daily. As at present constructed,
the Wiborgh-Reis apparatus has advantages which ought, in the opinion of the writer, to make it more generally adopted by metallurgical chemists, who still look with distrust upon this method of analysis.

It consists of a small bulb with narrow neck, a measuring-tube or burette, and an absorption-bottle. Communication is made between the three vessels by a three-way cock. The burette has a volume of 170 cubic centimetres and a scale graduated to 0.10 cubic centimetre. It is surrounded by an outer tube filled with water and carrying a thermometer. The neck of the bulb is closed with a tight glass joint, made in one with the tube of a filter above. The quantity of iron tested varies from 4 grammes for 0.3 per cent. of carbon to 0.2 gramme for 3 1/2 per cent. of carbon. To each 1/2 gramme of iron 5 cubic centimetres of a saturated solution of blue vitriol is added, the mixture being well stirred, and the carbon separated. By raising the levelling-bottle and manipulating the cock, the carbon dioxide is passed over into the burette; communication is then made with the absorption-bottle, which is partly filled with caustic potash. To every 0.001 gramme of carbon about 0.1 gramme of solid chromic acid is allowed. The carbon dioxide is sampled under a mixture of 20 parts of water to 100 parts of concentrated sulphurous acid, and absorption proceeds in the same way as in the Orsat apparatus. From two to three determinations are required so that all the carbon dioxide may be absorbed. The apparatus is easy to manage, and the caustic potash does not often require renewal. As the same water is used over and over again, it becomes saturated with carbon dioxide, and ceases to absorb it. Mercury is sometimes used for making the joint, but is not so convenient as water. Drawings of the instrument are given in the paper. B. D.

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DETERMINATION OF PHOSPHORUS IN IRON AND STEEL.

It is usual to determine the presence of phosphorus in iron and steel by the molybdenum process. A solution is first made of nitric acid, the strength of which must be carefully chosen, in order that it may dissolve all the phosphorus, although the latter is never completely oxidized to phosphoric acid. Experiments made by the writer on both iron and copper containing phosphorus confirm this view, in spite of some chemists who maintain the contrary. Solutions of three different strengths of nitric acid were used; 0.10 gramme of phosphate of copper was mixed with each, boiled for 10 minutes, and after cooling, 100 cubic centimetres of molybdic acid was added to it and left to stand 24 hours. The deposit was then filtered, weighed, and treated with permanganate of potash, when it yielded a phosphorus precipitate varying in quantity according to the solution used. Thus the addition of some chemical, preferably manganate of potash, is necessary to reduce all the phosphorus in iron to phosphoric acid.

To precipitate the latter, about 4 times its amount of molybdic acid and one-eighth the quantity of nitrate of ammonia are added, and the process is hastened by heating and frequently stirring the mixture. A table in the original paper gives the relative proportions of the three chemicals, which should be carefully determined, to ensure complete precipitation. About 5.5 per cent. of molybdic acid and from 7 to 30 per cent. of nitric acid are the right quantities; the proportion of nitrate of ammonia does not greatly affect the results. Precipitation should, if possible, take place at ordinary temperatures. The precipitate thus obtained is filtered and washed with nitric acid, nitrate of ammonia and pure water. It is then dissolved in ammonia in a porcelain crucible, steamed, acidulated with a little weak nitric acid and heated for 1/4 hour over a gas-burner. The chemical formula of the deposit is $12\text{MoO}_3\text{PO}_4\text{(NH}_3\text{)}_3$. 
To determine the chemical composition of the precipitate rapidly, the proportion of molybdic acid is ascertained by titration, and the percentage of phosphorus calculated from it. This is, however, a difficult operation. The writer proved that molybdic acid can be completely reduced to molybdic sesquioxide, but the latter is easily oxidized afresh by contact with the air. In his experiments, titration with manganate of potash, however carefully carried out at different temperatures, always yielded less of the chemical constituents than the formula. The differences depended on the quantity of molybdenum, and the rapidity of the process. If the molybdic acid be reduced under hydrogen gas, and the proper amount of manganate of potash be added from an air-tight bulb, the right quantities will be obtained, but if air penetrates during titration the oxide in the acid combines with the oxygen in the air, and affects the results. If hydrochloric acid be used, the air must be excluded in the same way.

Some writers maintain that soluble glass saturated with nitric acid and treated with ammoniated molybdic acid shows the same reactions as fluids containing traces of phosphoric acids. The writer proved by experiment that this is not the case, and that if such reactions take place they are due to the presence of a minute quantity of phosphorus. Under certain conditions, arsenic acid combined with solutions of molybdic acid yields a finely-powdered yellow precipitate. This was tested by mixing it with the three solutions of molybdic acid of different strengths

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already used. After 24 hours at an average temperature none of the three showed any precipitate, but from one of the solutions a yellow deposit was obtained after heating. However small the proportion of arsenic, a part of it appears to be always precipitated with the phosphorus.

B. D.

UTILIZING THE WASTE HEAT OF COKE-OVENS.


The plant consists of (a) 16 Bernard ovens, firing two water-tube boilers at a pressure of 78 pounds per square inch (5.5 kilogrammes per square centimetre); (b) 16 Coppee ovens, firing two semitubular boilers at a pressure of 114 pounds per square inch (8 kilogrammes per square centimetre), the steam being expanded, however, to the above-named pressure; and (c) 20 Coppee ovens, firing three water-tube boilers, larger than those of group a, and generating steam at the lower pressure abovenamed. The boilers of groups b and c are alone employed in normal working, the heating-surface utilized being about 6,000 square feet (555 square metres) over which are distributed the gases yielded by 145 tons of coal, containing 28 per cent. of volatile matter, charged per 24 hours; the heat given out by the gases being nearly 1,924,560 British thermal units. The author observes that the determination of the weight of gas required for vaporizing a weight-unit of water constitutes a method which has the advantage of permitting comparison between boilers whose heating-surfaces may be of quite different kinds. In this manner he found that for evaporating 1 pound (or 1 kilogramme) of water 0.313 pound (or 0.313 kilogramme) of gas was required with the water-tube boilers of group a, 0.246 for the semi-tubular boilers of group a, and 0.164 for the large water-tube boilers of group c. He therefore considers that this group is the most economical, while it affords the following advantages. It permits the use of muddy or chemically impure feed-water. By substituting for the flues a few vertical baffle-plates, it offers no resistance to the passage of the gases utilized, while facilitating the examination of the boiler. By the large dimensions given to the combustion-chamber, it permits of placing the boiler in a hot place, where the gases have no appreciable speed and thus the plates are not subjected to burning, even during sudden and rapid disengagements of gas. Owing to the combustion-
chambers, the gases are completely burnt, and the chimney never smokes; and it may be supposed that the gases are thoroughly utilized, since the yield of the plant is equal to that of the best boilers. The difference between the maximum and minimum vaporization is less than that with other forms of boilers, thanks to the large mass of water, which acts as a regulator; and, as the charges of coal and the hours of charging are approximately constant, this regulator, instead of creating a danger that might be feared with coal-fired boilers, affords, on the contrary, a guarantee of security that is wanting in multitubular boilers subject to sudden variations of pressure.

The author concludes that a well-designed water-tube boiler gives as high a useful effect as one of multitubular type, without possessing its many disadvantages, and that it also affords a greater measure of safety. 

J. W. P.

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DRYING FIRE-CLAY.


The methods in use for drying fire-clay depend on the purpose for which it is intended. If it is to be freed from moisture by indirect heat, and not baked in a kiln, the hot air or gases must be raised to a high temperature. As the fire-clay is chiefly used as cement, care must, however, be taken that it is not dried till it ceases to be adhesive, and a good circulation of air should be kept up. The higher the temperature of air, the more water will it absorb. Thus, saturated air at 212° Fahr. (100° Cent.) will contain nearly 35 times as much water as at 68° Fahr. (20° Cent.), and air with 60 per cent. of moisture will contain relatively about the same proportion of water.

To dry fire-clay thoroughly, it must be brought into close contact with air circulating at a high temperature, therefore the roof of the drying-chamber should be low, and the floor heated, so that the water in the clay may be evaporated by the vertical ascending currents of hot air. If the temperature of the latter be high, a smaller quantity will be required, and all the heat in it will be utilized to evaporate the moisture. At an air-temperature of 212° Fahr. (100° Cent.), about 30 per cent. fewer heat-units are required to dry the fire-clay than at 68° Fahr. (20° Cent.). The fire-clay should also be kept moving in an opposite direction to the hot air.

The ordinary drying-kilns are made large enough to admit a man, and are filled and emptied by hand. This arrangement involves much labour, the furnace must be periodically put out, to re-charge it, and only a small quantity of fire-clay can be dried at a time. The writer has therefore designed a new furnace to dry the fire-clay used for making pots for crucible steel, and in it these difficulties are avoided. The roof of the drying-chamber is low, the furnace occupies little space, is fed mechanically and continuously, and the hot air is admitted in the contrary direction to the moving clay. The type followed is that of the Moser furnace, with an inclined floor, for roasting ore. The type followed is that of the Moser furnace, with an inclined floor, for roasting ore. The fire-clay passes through the drying-space in one direction, the hot air rises to meet it, and the lumps of clay are turned over in their passage. The drying-chamber has an inclined surface, and is about 15 inches high. The clay breaks a little as it dries, but, as it must be remoulded, this does not signify. At the side of the furnace is a space into which the dried fire-clay falls, and where it is stored dry, ready for use. An economy of heat results from working the furnace continuously, and never allowing it to cool.

No difficulty has been experienced from the clay sticking and becoming clogged in its passage. If the angle of inclination be suitably chosen, it ought, although damp, to slide down easily. This angle was determined after repeated experiments, and is always near the angle of repose of the clay. An angle of 32 degrees was originally
chosen, and as soon as the iron plate was a little worn, the clay slid easily over it. So long as the furnace is properly supplied with fire-clay, there is no fear of the inclined drying-plate becoming clogged. To make the clay turn over in its passage, the inclined surface is broken by a step half way down, and the angle for this step has also been carefully determined.

In the original paper, the writer gives three drawings of different types of his drying-furnace. In the first, to economize space, the upper half of the inclined plane on which the clay rests slopes in one direction, the lower half in the opposite. The lumps of fire-clay turn as they fall from one to the other, but it is rather difficult to heat the plates. At the bottom of the furnace is a horizontal grate for small coal, and the combustion-gases are carried under the plates and heat them, before passing through several coils on their way to the flue. Air is introduced above the grate, and after being thoroughly heated, rises through a passage, and circulates over the clay. To prevent overheating, a large quantity of this cold air can be admitted below the plates, according to the indications of a maximum thermometer connected with an electric bell. The clay is introduced at the top of the inclined plane, and slips easily down; the lower half of the plate rests upon iron arches. This arrangement is compact but costly, as so much iron is used in its construction. In a larger but less expensive type, there is only one inclined plane at two levels, with a step between. The air for heating is admitted above the furnace by a small fan, and passes through a kind of regenerator before reaching the fire-clay. The drying-space has valves above and below for admitting and discharging the clay. The lower part of the inclined plane rests on fire-brick, and the flames play directly upon the upper part. In a third type, the clay is not turned as it slides down, but falls into a vertical shaft at the side of the furnace, which is heated by the hot air.

To dry 10 waggon-loads of fire-clay in 4 weeks, a drying-surface of about 1,000 square feet was required with the old system. With the new furnaces, the same quantity can be treated with a drying-surface of about 400 square feet. The quantity of air required for drying at different temperatures may be calculated. Formerly from 2 to 4 cwt. of fire-clay were dried per hour. Taking these as a basis, 4 cwt. or 448 lbs. of dry fire-clay corresponds to 539 lbs. of damp clay, or 18.4 per cent. of water, and 91 lbs. of water per hour must be evaporated. As the power of absorption of air is proportioned to its temperature, which determines its volume, it is only necessary to know the former in order to calculate the number of cubic feet which should be admitted per hour to dry a given quantity of fire-clay, containing a given percentage of moisture.

PYROMETERS.

The Mahler calorimetric bomb for determining rapidly and accurately the heating value of coal is wellknown. These determinations are usually checked by the Dulong formula calculated from the chemical analysis of the coal, namely: \(8080 \, C + 34462 \, (H - 1/3 \, O) + 2250 \, S\), and the two generally agree. Prof. von Juptner proposes another method for obtaining the same results simply and rapidly, and with close approximation to the calorimetric data. The proportions of moisture \(W\), of volatile matter \(G\), of fixed carbon \(K\), and of ash are determined in a crucible, and the total quantity of oxygen required, \(S\), by the Berthier test. The quantity of oxygen required for the combustion of the carbon is \(S = 8/3 \, K\); for the combustion of the gaseous
distilled products \( S_2 = S - S_1 = S - \frac{8}{3} K \). The ratio of the oxygen required for the volatile products to that needed for the combustion of the carbon is

\[
S_2 / S_1 = (S - \frac{8}{3} K) / \frac{8}{3} K = \frac{3}{8} S - K / K.
\]

The heat of combustion of carbon is taken at 8,000 Cent., while the (variable) heat of combustion of the oxygen required to burn the gaseous products we will call \( C \). Thus the heating value of the combustible will be

\[
p = 80 K + C(S_2 / 100).
\]

The heat of combustion of the sulphur is taken at 2,500° Cent. In the original paper, the values of \( C \) for hard coal with values of \( S_2 / S_1 \) varying from 0.2 to 8.0 are given in a table. The heating values of fifty kinds of American coal are calculated according to this formula, and differ slightly from the calorimetric results, but agree sufficiently for practical purposes. The method has also the advantage of determining the heating-value of the gases which escape during the dry distillation of the coal, and the calorimetric value of the latter can thus be more easily determined.


It is wellknown that if two thermometers, one with its bulb blackened, be exposed to the same source of luminous heat under the same conditions, that with the blackened bulb will rise higher than the other; and the difference will be so much the greater as the temperature is higher.

The Latarche actinometric pyrometer consists essentially of a bent thermometer, of which the blackened bulb and horizontal arm are fixed in a tube terminating on the furnace-side in a diaphragm, which allows a pencil of luminous heat-rays to impinge on the pyrometer, passing through an aperture in the furnace-wall in such a manner as not to intercept the radiation. The apparent (visible) vertical arm is graduated; but the absolute temperature of the thermometer may vary, while it is the difference of temperature that must be measured. The tube passes through a cast-iron box filled with water, brought to boiling-point by the heat of the furnace, the temperature of which is measured by the difference between the temperature shown by the thermometer and the boiling-point of water.

APPLICATION OF OXYGEN IN THE CYANIDE PROCESS.


In the cyanide treatment of concentrates, tailings or slimes, the necessary oxygen must be either:—(1) dissolved in working-solutions, or (2) applied during treatment. The working-solution may be aerated by blowing air into it from a compressor or blower, allowing the air to be delivered near the bottom of the sump, through a pipe perforated with small holes, of which the sum of the areas should approximate to the area of the cross-section of the pipe conveying the air. Another method of aerating working solutions is circulation by means of a centrifugal pump. Such a pump always draws, at the glands and joints, more or less air, which in its passage through the pump must attain a very fine state of division; hence the air presents a very large surface, and, being under increased pressure in the delivery-pipe, all conditions are favourable for its solution. Apart from leakages, which are variable, the author by a special air-valve supplies air to the suction-pipe of the centrifugal pump.

The diagram, given in the above-mentioned journal, illustrates a centrifugal pump, sucking from the bottom of a vat and delivering into the same vat. Between the pump and the vat is a Peet valve; between this valve and the pump are one or more small air-valves, opening inwards only, and closing whenever the internal pressure equals or exceeds the external pressure.
Now, assume the pump to be working, close the Peet valve slightly, the supply of liquid becomes less than the capacity of the pump. If the small air-valve is

now slightly opened, air will be continuously drawn into the suction-pipe, and will undergo ideal contact with the solution during its passage through the pump. The quantity of air drawn in will be, within certain limits, proportional to the closing of the Peet valve. It is essential that the lift of the pump should be as small as possible and free from unnecessary bends, etc., or more power is required and greater speed on the pump. The pump being flooded, the air drawn through the air-valves can never stop the pump from working; the air-valves being only slightly opened, the pump does not get as much air as it could take, hence there is no alternate opening and closing of these valves. They are constantly open.

The author then describes the advantages of double treatment and of dry leaching. In treating slimes, current-slimes (i.e., those direct from the battery without intermediate storage) contain comparatively little organic matter or oxygen-absorbing substances, and hence present fewer difficulties in treatment than is the case with accumulated slimes. Mr. W. A. Caldecott was the first to aerate accumulated slimes by means of compressed air. Results are quoted showing the advantage of aeration by a centrifugal pump (as described above) in the treatment of old slimes from various sources.

ECONOMIC TREATMENT OF SLIMES.


For the past 3 years, the author had been specially engaged on the problem of recovering gold from the slimes produced by battery-crushing, and, at a recent meeting of the Chamber of Mines of the South African Republic, the President (Mr. Geo. Rouliot) stated that the treatment of slimes was now an economic success at Johannesburg.

It was observed that if slimes were allowed to be deposited in dams for a comparatively short time, even for a few days, decomposition of the pyrites took place, and thus it was found much more economical to treat slimes directly as received from the mill. Now, the slimes in battery-water are coagulated by means of lime, concentrated by spitzkasten and then settled in collecting-vats. These settled slimes, containing about 50 per cent. of water, are now ready for treatment, and another great advantage is gained by the separation of the slimes from the plate-water, as the latter can at once be returned to the mill for re-use.

In slimes, a substance was found which could not be leached, or through which the solution would not percolate: it was, therefore, found necessary to wash by decantation. A combined process of decantation and leaching by means of vacuum-pumps was tried by the Rand Central Ore-reduction Company, at their Robinson slimes-works. Such a process for rich slimes, running 15 dwts. or more to the ton, is well adapted to give a high extraction; but, for the treatment of low-grade slimes as produced on the Rand, this combined process was too expensive.

The process adopted by Mr. J. R. Williams, at the Crown Reef slimes-plant, known as “natural settlement,” and afterwards adopted at the Robinson works, is now the method generally used. The principle of oxidation of the reducing substances in slimes by means of aeration was put into practical use by Mr. W. A. Caldecott, who, in a paper read before this society, has given the reasons that render this operation specially necessary in the treatment of accumulated, or acid, slimes.
In concluding, the author thinks that the main features of this new metallurgical process will be practically retained, wherever adopted in other parts of the world. The use of lime for settlement, the use of spitzkasten for collecting-tanks for natural settlement, dissolving the gold by means of agitators or centrifugal pumps, the decantation of the liquid, and a precipitation by an electrolytic method are, he thinks, permanent features, which in detail may be modified to some extent, but which will remain with us.

J. W.

REDUCTION OF ZINC-GOLD SLIMES.

By E. H. Johnson. South African Mining Journal, June 29th, 1897, with 2 figures.

This paper describes the method used by the author at the Princess cyanide works, Roodepoort. Not having a filter-press, he converted one of the two 6 feet diameter clean-up vats into a filter-vat, by putting in a grating, having holes 1 inch square, covered with fine, closely-woven canvas.

The sheet of 2 drawings shows sections of the filter and acid vats. Through the side of the vat below the filter-bed, a 1 1/4 inches pipe is led, connected with a small suction-pump bolted to the side of the vat. From the delivery of the pump, a light movable launder leads the filtered solution back to the top of the precipitation-boxes. The zinc-gold slimes (including such small zinc as may have passed the grating of the zinc-boxes) are bucketted direct into the filter-vat, and as soon as one box is cleaned-up and the washed zinc replaced, the pump is started and the solution returned by means of the launder back into the box. The pump is kept going gently, after the boxes are completely cleaned-up, until only the slimes are left on the filter. A water-wash is then pumped through till the slimes are free from cyanide. The gross weight of the slimes, including moisture, is then determined, as they are transferred in buckets to a large sheet-iron tray near the acid-tank. The object of weighing is to find the amount of sulphuric acid necessary to destroy the zinc. The second of the two clean-up vats is fitted with a wooden stirring-apparatus and cover, the parts being made detachable so as to be moved easily when action has ceased. A 3 inches pipe leads the irritating fumes outside the building. Having found the approximate weight of slimes to be treated, sufficient water is run into the acid-vat to form, on addition of the acid, a 10 per cent. solution. The author found that 1 pound of acid to every pound of moist slime gave good results. Having the requisite amount of water in the vat, the weighed quantity of acid is then added and the vat is closed down tightly. The stirring is kept going continually, as the slimes are gradually fed in, and should be continued for 1/2 hour after the action has, apparently, ceased. The feed-hopper has a sheet iron slide-door, in addition to the closely-fitting cover on the top; thus the slimes can be charged without permitting any appreciable escape of fumes, within the building. After charging the slimes, the hopper and everything used in the clean-up are rinsed by a jet of water. The stirring-apparatus is then removed and well washed in the vat during removal. The vat is then filled with water and allowed to settle. Without heating, a perfect settlement was obtained in 1 hour. When heating by a steam-jet, settlement was much more difficult. The clear liquor is siphoned off, and the vat filled repeatedly with water, until the solution is neutral to litmus paper. The resultant gold-slime is dried, on an open drying-hearth, in large cast-iron enamelled dishes; then the cakes are broken up, and subjected to an increased heat, in thin layers on small sheet-iron trays. When cool, the slimes are ground, fluxed, and transferred to the crucible, yielding 50 to 60 per cent. of their weight as bullion. The average fineness of the bullion over the year was 820. The cost of reduction, including acid, was 6.7d. per fine ounce. The advantages of this method are:—Elimination of the zinc without recourse to calcination—the loss from which is
so difficult to determine; the handling, except in the final operation, is of wet slime and secures consequent immunity from dusting; and the time from commencing to clean-up to having the bar in the safe need not exceed 3 to 3 1/2 days. The slag assayed (after panning out prills) only 23 ounces per ton.

J. W.

SILVER REDUCTION-WORKS IN MEXICO.
The ores treated here are complex, containing grey copper, blende, galena, copper-glimmer, arsenical and antimonial sulphides, etc., all argentiferous, the gangue being mostly quartz. The ores are treated by smelting, for which ores carrying mainly copper with some galena and blende and 350 to 600 ounces to the ton are selected; by milling, for ores in which zinc blende predominates, containing 48 to 72 ounces of silver; by concentration when the silver is below 27 ounces to the ton; and by lixiviation, for ores carrying 60 to 400 ounces to the ton.
The ore for lixiviation is crushed dry in a ten-stamp mill of 813 lbs. stamps through a 16 meshes screen. The washed ore is roasted in reverberatory furnaces of the ordinary type measuring 14 feet by 9 feet, with fan-stepped hearths, the total time of roasting of a 1,200 lbs. charge being from 8 to 12 hours; salt to the amount of 4 to 8 per cent. is added in the last hearth. The chlorination averages 97.5 per cent. There are nine vats 20 feet in diameter and 5 feet high, and the entire plant can treat 37 to 47 tons. The ore is first leached with water which dissolves base metals (copper) and a little silver, and then with a solution of hyposulphites of calcium and sodium. The cost of chlorination and lixiviation is $17.87 per ton. The best strength of leaching-solution is found to be between 0.55 and 0.60 per cent. The silver is precipitated by calcium polysulphide. The accumulated sulphides of silver are collected twice a week, filtered off, calcined at a very low heat, and then mixed with litharge, producing argentiferous lead for cupellation.
The solution of base metals is run over the mattes produced in smelting, by which means the mattes are enriched from 35 to 40 per cent. of copper, and also reduces all the silver contained in the solution.
The concentrating ore is wet-crushed in a ten-stamp mill, and the pulp is sized and concentrated on frue-vanners and buddies; this operation costs $1.52 per ton. The concentrates are made into bricks with clay, roasted in stalls, and smelted with the complex smelting-ores in a water-jacket furnace 39 inches in diameter, of 40 tons capacity, with 6 tuyeres; the blast-pressure being 1 1/2 inches, and the volume about 1,400 cubic feet of air per minute. Iron-ore and limestone are the fluxes used, but in as small an amount as possible, in order to produce together with base bullion a matte rich enough to export, and a slag with only 1.3 ounces of silver to the ton. The cupellation is conducted on an English cupel, made of decomposed rhyolite and limestone in the proportion of 46 : 100; the cupel 46 by 59 inches in area.

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requires 1,579 lbs of the mixture; its capacity is 3,500 lbs. of bullion. It lasts 40 days, the loss of silver is 0.7 per cent., and the average fineness of the silver produced is 990.

In 1896, the cost of an ounce of fine silver was as follows:—

<table>
<thead>
<tr>
<th>Description</th>
<th>Dols.</th>
<th>Per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost in mining</td>
<td>0.391</td>
<td>36.0</td>
</tr>
<tr>
<td>&quot; milling</td>
<td>0.286</td>
<td>26.4</td>
</tr>
<tr>
<td>&quot; administrative expenses</td>
<td>0.075</td>
<td>6.9</td>
</tr>
<tr>
<td>Profit</td>
<td>0.333</td>
<td>30.7</td>
</tr>
</tbody>
</table>
Utilization of Tin-Plate Refuse and Cuttings.
Verwerthung von Weissblechabfallen im Bleihuttenbetriebe. By Dr. August Harpf.
The writer proposes to utilize tin-plate refuse in lead-works, instead of old iron. In the
smelting-works at Pribram, in Bohemia, the raw ore is first roasted, then melted down
into working-lead by the addition of suitable fluxes. Formerly, from 5 cwts. to 6 cwts.
of metallic iron was used for nearly 10 tons of the ore, as a flux. In these mines, the
ore is chiefly treated by roasting, and during the process the proportion of sulphur is
reduced from 12 to 1.5 per cent., but cannot be wholly eliminated by this method.
Therefore, the small residuum left in the roasted ore is soaked in the iron flux, to
extract the lead. At Pribram, the lead thus obtained is first liquated, then freed from
silver by the Pattinson-Rozan process, and the tin and antimony are separated by
smelting in a refining-furnace with injections of air. The residuum of lead is very pure,
and quite free from tin ; the scum is collected, and melted down into an alloy. The
Parkes process is also used in Bohemia, and sometimes no iron is added, but iron-
bearing slag is taken from the roasted ore itself. Iron is also present as oxide in the
roasted pyrites, and this is sometimes reduced and used as a flux.
Raw lead from the blast-furnace contains 0.5 per cent. of silver, 0.9 per cent. of
copper, 0.2 per cent. of tin and sulphur respectively, and other metals. It is first
purified by liqation and freed from copper, then refined, and the silver is separated
by the Pattinson-Parkes method. The scum contains only 18 per cent. of tin, and is
too poor for commercial purposes. It is therefore generally enriched by the Plattner
process, namely, by heating it with 5 per cent. of coal in a refining-furnace, and
subjecting the product to successive refinings. This does not seem, however, to be a
wholly satisfactory method of treatment. At the Pribram works, the separation of the
silver is said not to be complete, and the refined product still contains antimony. The
process is also lengthy and costly, but as far as the writer is aware, it is the only one
in use to extract the small quantity of tin in many lead-ores, and to make alloys poor
in tin and therefore unsaleable into rich and marketable products.
To enrich these alloys with tin the author proposes to utilize tin-plate refuse as a flux.
The project is not new. Various methods have been suggested, all based upon the
separation of the tin from the iron, either by mechanical means, by liqation and the
application of heat, or chemically, by dissolving in soda-lye or acids. Electrolysis has
also been proposed, but although the price of tin is relatively high none of these
systems seem to have found general acceptance, and

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in many places tin-plate cuttings are still thrown away, which might, in his opinion, be
usefully employed as a flux, instead of cast-iron, in lead-furnaces. Good tin-plate
contains about 6 per cent. of tin, the rest being iron. As tin melts at 446° Fahr. (230°
Cent.) it could soon be separated, and the iron would then act upon and decompose
the galena. The tin would form a rich alloy with the lead which melts at 633° Fahr.
(334° Cent.). The process is simple, and a valuable tin-alloy would be obtained, with
no bye-products. The lead in the alloy would not cause any difficulty.
Against the process three objections may be raised :—
(1.) Whether the tin-plate refuse would be deposited and act in the same way as
cast-iron refuse. This would certainly be the case. As soon as the temperature of the
charge reached 446° Fahr. (230° Cent.) the tin would melt into drops and form an
alloy with the lead already in the furnace. Liquid tin oxidizes easily when in contact
with the air, and then readily forms a slag, if the tin has been extracted with acid slag
and at high temperatures. Such oxidation of the metallic tin is not impossible, although it is generally assumed that, before this can take place, it is melted down with the lead and further oxidation is arrested. The proportion of tin in the ore is in any case not large, varying in the Pribram mines from 0.11 to 0.09 per cent. Before liqutation was employed to reduce it the proportion was higher. We may further enquire whether the residuum of iron-plate left in the furnace after the tin had melted would scorify in the same way as cast-iron. Probably it would, because the iron does not melt by itself, but combines with other fluxes which melt more easily.

(2.) How will the tin act in the working-lead when liquated, treated by the Pattinson or Parkes method, or refined? According to experience it will during liqutation remain in the lead, because of the low melting-point of the tin, its affinity with lead, and its readiness to combine with it to form alloys. The melting-point of pure tin is 446° Fahr. (230° Cent.), of pure lead 633° Fahr. (334° Cent.), and alloys of the two vary in their melting-point between these temperatures, according to the percentage of either metal. With the Pattinson method, large quantities of tin are injurious because they hinder the precipitation of the silver in the lead, but the small quantity found in liquated lead does not signify. Another point to be considered is the quantity of tin which would be found in the lead, if tin-plate refuse were used. The raw ore contains about 24 per cent. of lead. This is reduced in the furnace by the fluxes, and litharge or lead oxide is therefore added to bring up the proportion to about 19 per cent. Assuming that this percentage can be extracted if a flux of tin-plate refuse be used containing 6 per cent. of tin and 94 per cent. of iron, the tin will increase the lead by 0.32 per cent. If the impurities exceed 0.67 per cent., the ore should be either liquated or refined. Treated by the Parkes process, which is cheaper and now more generally used, the tin is said to have no injurious effect on the lead. Whichever method is employed, the writer urges that tin-plate refuse should be used as a flux in all mines in which the ore contains no silver.

(3.) Can a sufficient quantity of tin-plate refuse be procured to use in the way proposed? Certainly in large towns, though perhaps not in small ones. Birmingham alone produces nearly 20 tons per week, and Paris 54 tons per month. Such a utilization of refuse which is now often thrown away would be highly desirable. The tin in it could be turned to account in rich alloys, and the iron would replace the more valuable old-iron refuse now used in smelting-furnaces. If when charging the furnace, it were found that a large quantity of the tin scorified and was lost, or that much refining was needed to get rid of the silver,

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the writer suggests that part of the tin should previously be extracted by either the Edmunds or Patterson dry process, and only the residuum used for the alloy. Both processes are recommended. The Edmunds process yields pure tin or tinned lead; with the Patterson process, alloys poor in tin may be enriched, but by neither method can the tin be completely separated from the iron. If an alloy perfectly free from tin is desired, the two processes may be successively employed. The whole question of substituting tin-plate refuse for iron as a flux turns upon the output from the smelting-works under consideration, and the difference in price between the two metals. The cost of smelting must also be taken into account.

B.D.

IMPURITIES IN ALUMINIUM AND ITS ALLOYS.

In attempting to ascertain the forms in which iron, copper and silicon occur in commercial aluminium, the author treated the metal with dilute hydrochloric acid, and then subjected to analysis both the solution and the insoluble brown residue. The
products of the action of aqua regia and dilute hydrochloric acid on an alloy containing 100 parts of copper and 3 parts of aluminium were also examined. In the first two instances, the residue was found to possess the properties of impure silicon, whilst that from the action of dilute hydrochloric acid on the alloy yielded aluminium, iron, copper and silicon. Silica was detected in all the solutions, and was presumably formed by the decomposition of metallic silicides present. Owing to the circumstance that the impurities are distributed in both the soluble and insoluble portions of the substance, their separation by means of dilute acids is an impossible task.

C. S.

ALLOYS OF GLUCINUM [BERYLLIUM].
Although the metal itself has not been prepared in a pure state, owing to the great heat necessary for the reduction of the oxide, conjoined with its volatility and tendency to form a carbide, successful attempts have been made to obtain it in the form of alloys. To this end, nitrate of copper and nitrate of glucinium are intimately mixed, reduced to the state of oxides by calcination, mixed with carbon and exposed in the electric furnace for 5 minutes. A rose-red coloured ingot is obtained, which, on fusing, yields a yellow alloy containing 5 to 10 per cent. of glucinium. With the lower limit of this metal, the alloy is malleable and can be filed or polished; it does not tarnish on exposure to air, but is discoloured by sulphuretted hydrogen. The alloys resulting from the fusion of the preceding one, with copper, are sonorous in a high degree.

C. S.

TESTING OF SULPHUR.
Sublimated sulphur is obtained from refined sulphur, or in Italy direct from volcanoes. For ordinary purposes the cheaper sulphur, which is easily reduced to powder in grinding-mills, is preferred to the sublimated, and this flower of sulphur is chiefly used in chemistry. Powdered sulphur is a product of metallic sulphides and sulphates, and is obtained by the Chancel, Mond, Hoffmann and other processes. It resembles sublimated sulphur, but has not its beautiful yellow colour, and differs in being wholly soluble in bisulphide of carbon.
The quality of sulphur depends upon the geological stratum from which it is extracted, whether limestone, argillaceous marl or bituminous rock. The purest Sicilian sulphur is yellow, with whitish streaks. There are various kinds of sublimated sulphur, differing in price according to their appearance, colour and purity. Raw sulphur contains sometimes 20 per cent. of lime, magnesia, iron, clay, sand, bitumen and other impurities. If refined sulphur be heated in the open air it kindles at a temperature of 479° to 511° Fahr. and burns with a pale blue flame. It has a great affinity for oxygen, and volatilizes at ordinary temperatures. For this reason, sublimated sulphur is sometimes spread out near pans of water, as an antidote against mercury fumes. This property is due to the moisture in the sulphur combining with the oxygen in the water, but pure distilled water has no effect on it. As sublimated sulphur is much used in medicine, its purity is an important point, and is tested in many ways. It is often determined by its colour, which should be a bright yellow; manufactured powdered sulphur is of a greyish hue, owing to the earthy particles in it. The moisture in pure sulphur is known by weighing it carefully, before and after dryings as a rule it contains very little. Its specific gravity varies from 1.98 to
2.10. The incombustible residuum which it contains is determined by burning a given quantity to ashes in a crucible, and weighing the result. Care must be taken not to heat the sulphur much beyond its ignition-point, otherwise it will escape as vapour. The mean residuum thus obtained is usually about 0.033 per cent., and this is further analysed for impurities. To test the solubility of pure sulphur in alkalis it is carefully heated with caustic soda, the mixture cleared and filtered, and the undissolved residuum dried and weighed. The fineness of powdered sulphur is sometimes determined in a Chancel sulfurimeter. A given quantity is shaken up with ether in a glass tube, and the height to which the layer of sulphur rises in the ether when allowed to settle shows its fineness. It is also sometimes tested mechanically by the touch, or rubbed through a very fine silken sieve, and all that does not pass the sieve is examined under a microscope. Its combustibility is determined by burning various samples carefully in a porcelain crucible, and comparing the time that each takes to burn.

Tests are also made to determine the chemical constituents of sublimated sulphur. The proportions of sulphuric and sulphurous acid which it contains are known by first boiling a given quantity in distilled water, to which a few drops of alcohol are added, the a filtering the result, which, when thus treated, shows practically no trace of these acids. Arsenic is sometimes found in sulphur, especially if it be produced from Spanish pyrites, and reddish or dull yellow sulphur is always suspicious. To detect it, the sulphur is boiled with nitric acid, soaked in water, filtered, and carbonate of ammonium and a few drops of solution of nitrate of silver are added. If the product shows a yellow deposit, arsenic is present. Another way is to treat it with sesquicarbonate of ammonia and hydrochloric acid ; or it may be tested with aqua regia, and the filtrate converted into a gas. The rare metal selenium is also occasionally found in volcanic sulphur. To test for it, the sublimated sulphur is boiled with concentrated potash lye. A dark red solution is obtained, and after long exposure to the air, or the addition of hydrosulphite of ammonia or of potash, the selenium is separated and forms a thin film on the surface. The same result may be obtained with a solution of cyanide of potassium diluted with hydrochloric acid. Another way is to treat with nitric acid, and evaporate the product with hydrochloric acid, when the selenium will be precipitated. This reagent has little effect unless heated. The presence of thallium is shown by the orange colour of the sulphur extracted from pyrites, and is detected by treating it with bisulphide of carbon, when nearly all the sulphur is separated. The residuum, when tested, is found to be chiefly thallium. Arsenic, selenium and thallium cannot be separated from the sulphur by rectification only. The presence of bituminous and organic substances is shown by treating the sulphur with sulphuric acid, and filtering the product through asbestos.

ANALYSIS OF BLACK TELLURIUM.

Black tellurium or tellurium-ore has often been submitted to quantitative chemical analysis, but the results have varied so widely that it has not hitherto been possible to define its chemical composition. The formulae given by Dr. Rammelsberg are based upon electro-chemistry, and show only the proportions by weight of the positive components, gold and lead, to the negative components, sulphur, tellurium and antimony. The formula of Prof. Gmelin-Kraut is equally inapplicable for black tellurium because, as the writer proceeds to show, the proportion of white antimony in the ore, on which the formula is based, is probably mixed with grey antimony. In analyses
made by different chemists, the proportion of tellurium varies from 13 to 32 per cent., and of sulphur from 3 to 11.7 per cent. Some give silver, some antimony, as present, and the quantity of gold also increases from 6 to 12 per cent. These differences might almost lead to the conclusion that black tellurium varies in its composition, and is formed of a mixture of compounds which fluctuate in their relative amounts. Probably, however, these discrepancies are produced, partly by impurities in the samples, partly by the difficulty of analyzing them. Even with the utmost care, the results obtained are often contradictory. The writer, therefore, undertook a series of trials with samples as pure as possible, to check analyses made at the Gottingen chemical laboratory. The results agreed fairly well, the chief difference being that the Gottingen trials gave 1.13 per cent. more gold. The quantities used were 1.1038 grammes of finely powdered mineral, yielding 0.0172 gramme of quartz, 0.0881 gramme of gold, 0.8138 gramme of sulphate of lead, and 0.4902 gramme of telluride of sulphur. These tests having shown that black tellurium is a chemical compound of well-defined composition, the formula hitherto used was revised, and a fresh one substituted for it, namely Te12Pb12AuS16, founded on analyses which gave about 30 1/2 per cent. of tellurium, 10 per cent. of sulphur, 8 to 8 3/4 per cent. of gold, and 50 per cent. of lead.

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According to Dr. Wohler, black tellurium is a mineral composed of telluride of sulphur, galena, telluride of lead and telluric gold. Taking these as a basis, its composition may be expressed as follows: — 4 PbS, 2 PbTe, AuTe2 + 2 TeS2,.. The three latter compounds may be present in varying quantities, combined with small amounts of telluric silver and copper. The writer, however, is of opinion that the composition of black tellurium cannot be represented graphically. The actual chemical structure of a body, that is the arrangement of the atoms in the molecules, cannot be given by a formula, because the latter takes no count of their division in space. Here a combination of no less than 21 atoms of 4 different kinds takes place, and it may safely be asserted that the so-called structural formulas are not so desirable in mineralogy as in organic chemistry. B. D.

REFINING OF TELLURIUM.


Tellurium, as prepared in different ways from the tellurium-ore found at Nagyag in Hungary, is not sufficiently pure for scientific purposes. It is still in a raw state, and contains lead, copper, antimony, arsenic, bismuth, iron, manganese, sulphur, and even limestone and magnesia. Precipitated tellurium has also tellurous acid mixed with it. In a sample of light-grey pulverized tellurium tested by the writer, 40 per cent. of tellurous acid was found, and in another, said to be pure, 6 per cent. of gold. The presence of the rare metal, thallium, combined with tellurium, has also been verified by different chemists. Several quantitative analyses of raw tellurium have been published, and these show that sulphur, selenium, arsenic, antimony and bismuth are the impurities most frequently met with, because the tellurium cannot be freed from them by smelting, but their proportions vary greatly. When zinc was used to precipitate solutions of tellurium, they were found, after treatment, to contain from 60 to 80 per cent. of impurities, namely, 13 per cent. of lead, 14 per cent. of copper, 11 per cent. of antimony, 1 per cent. of zinc, about 5 per cent. of iron, 2 per cent. of sulphur, 1 1/2 per cent. of water, etc.

Without a chemical analysis, the purity of precipitated tellurium cannot be known, but, if smelted, defects in its composition may be detected at a glance. If impure, it is earthy looking and dark, while pure tellurium is steel-grey, has a metallic appearance, and the surface, as it cools, is beautifully marked. In colour it is not "silvery-white" as
often described. Pure liquid tellurium, and tellurium sublimed in hydrogen gas, is steel-grey, with a metallic glitter. An expert will never mistake it for any other mineral, although in colour and brittleness it is like antimony.

Since this remarkable chemical element, which resembles a metal in its physical, and sulphur in its chemical properties, is only used for scientific purposes, it is very important to have it pure. Sixty-grade powdered tellurium is sold in Austria at about 28s. per pound, while liquid tellurium costs 64s. per pound. Small bars of sublimated tellurium are actually worth more than the same weight of gold, being sold at 8s. per gramme, or nearly £182 per pound.

The methods hitherto used to purify raw tellurium are to dissolve it and then separate the tellurium from the clear solution by precipitation. The foreign substances remain in the solution, and are withdrawn by filtration or by pouring them off. There are four ways of thus treating tellurium, according to the reagent employed; to each of them a special chemical formula belongs and each has been tried by different eminent chemists. At the Hungarian Government refining-works at Schemnitz compressed fluid sulphur dioxide is used, contained in cast-iron cylinders, and it is also sometimes applied in a gaseous state. If this method be followed, the raw tellurium is first dissolved in hydrochloric acid, to which nitric acid diluted with an equal quantity of water is added. The solution is greatly diluted, and a little tartaric acid is sometimes mixed with it, to prevent separation of the white antimony and telluric acids. If sulphurous acid be used in a gaseous form to precipitate the solution of tellurium, a curious phenomenon takes place. If the solution contains much hydrochloric gas, only a small part of the tellurium will be precipitated, and no further separation takes place, even if the solution be reheated and boiled. But if water be added, separation immediately begins afresh, and all the tellurium will be precipitated if sufficient sulphurous acid has been absorbed. This interesting fact is important, because if precipitation be incomplete much of the tellurium may be lost.

In view of the effect produced by the hydrochloric gas, Dr. Brauner recommends, when treating solutions of tellurium in hydrochloric acid, to dilute first with water and afterwards with gaseous sulphurous acid. By these means, he succeeded in precipitating 53 per cent. of the original raw tellurium. Many chemists doubt whether tellurium can be purified by precipitation with sulphurous acid. Prof. Berzelius says that it may be thus reduced, but not purified, because selenium, gold, copper, bismuth and iron may be found in it after precipitation. This case, however, need not be considered here, because in commercial tellurium there is no gold. If the solution of tellurium contains selenium it can be completely freed from it by exposing it in a molten state for a long time in hydrogen gas, when the selenium will be evaporated. If the tellurium-solution be not diluted till it has absorbed an excess of sulphur dioxide, the precipitated powder will be purer than if this precaution be not observed, otherwise telluric acid, copper, lead, etc., will be found in it, and will render it much more difficult to smelt.

Alkaline sulphates may also be used cold to precipitate tellurium. The liquid is left to stand from 12 to 24 hours, filtered, and the precipitate washed with diluted sulphurous acid and water. The solution should always be strongly acid. The filtered liquid is then well boiled, and again similarly treated, when a little more tellurium is extracted. Another method to purify tellurium is first to obtain tellurous acid (or dioxide of tellurium) from the raw mineral, and by oxidation with chromic acid to transform this into telluric acid, which is then reduced.

It is evident that if all these processes of repeatedly dissolving and precipitating tellurium be employed, a purer product will be obtained than by a single precipitation. The last particles of foreign substance may be eliminated by electrolysis, by distilling the tellurium in hydrogen gas, by bringing it to a red heat in an ordinary blast-furnace,
and distilling it over in a small porcelain retort, or by fractional distillation. At
Schemnitz, it is melted down in clay crucibles in the muffle of an assaying-furnace,
and various fluxes are added to it. If hydrogen gas be used, however, the sulphur
and selenium escape, the tellurium acids and their compounds are completely
reduced, and pure tellurium is the result.
Liquation, or fusing the mineral in hydrogen gas, cannot be applied to raw tellurium
which contains 40 per cent. of impurities. If thus treated, it forms separate drops, but
they will not fuse, because of the unmelted tellurides. The writer has liquated
tellurium in small quantities in glass and porcelain tubes. As soon as the tellurium
began to melt, the tube was so manipulated as to separate

the melted tellurium from the unmelted powder. If a little borax, which melts at 1042°
Fahr. (561° Cent.) be added, it absorbs the foreign elements, and adheres with these
to the glass. From 1 pound of raw Hungarian 60 grade tellurium, the writer obtained,
by liquation, pure tellurium, which was then remelted in glass tubes in hydrogen.
Upon cooling, it yielded smooth hemispherical buttons, the surfaces of which were
covered with beautiful markings. The congealed tellurium in the globular part of the
tube separated naturally from the glass by shrinkage, with a slight noise as if the
glass had been struck. The buttons weighed from 24 to 37 grammes each. The
delicacy of their tracings and their metallic glitter made them excellent samples for
chemical collections, while the little cracks in them showed the crystalline structure of
the metal.

SALT-PRODUCTION OF SIBERIA.
The production of salt in Siberia is very far from adequate to the demand, and it is
found necessary to import considerable quantities of the commodity from European
Russia (via Odessa and Vladivostok), from Mongolia, and other countries. In the
ports on the Pacific seaboard, foreign salt is imported free of duty.
In such districts of Siberia as possess workable salt-deposits, the placing of the salt
on the market is often greatly hindered by the vile state of the roads, when there are
any, and, as a consequence prices rule high. It is true that the State has established
in various localities salt-storehouses, whence the inhabitants may supply their needs
at a comparatively moderate cost. Even so, however, prices vary greatly from place
to place.
In Western Siberia, the only local sources of salt are the innumerable salt-lakes
scattered over the Government of Tobolsk, in the south-west of the Government of
Tomsk, and in the provinces of Akmolinsk and Semipalatinsk. In very hot summers,
salt deposits on the lake-shores to a thickness of 4 inches. The entire surface of the
country between 47° and 55° latitude north and 63° and 73° longitude east of Paris
forms a vast basin which at one time was covered by the sea.
As to the northern portion of this basin, in the Barabinsk and Kulundinsk steppes,
no one lake yields common salt free from the admixture of other compounds, such as
sodium sulphate. In the southern portion of the basin, on the other hand, in the
waterless steppes of Akmolinsk and Semipalatinsk, the lakes yield a very pure salt,
immediately available for edible purposes. Among the most notable of these lakes is
that of Karyakovsk, which extends over an area of 9 square miles : the portion
covered by salt-deposits measures about 4 square miles, and, in the middle of the
lake, the thickness of the salt-layers exceeds 40 inches. In 1896, 11,834 tons of salt
were got from this lake, but this is by no means the greatest amount produced in one
year. Moreover, the official statistics represent only about a quarter of the actual
output, as the Imperial authorities allow the Kirghiz nomads who range these
southern steppes to take from the lakes without check or hindrance as much salt as they choose.
Mention must also be made of the Borovie and Burlinsk lakes in the south-west of the Government of Tomsk, in the so-called "salt steppe." The total

length of the shores of Lake Burlinsk exceeds 19 miles: the inhabitants of the neighbouring country, after selling their grain at Pavlodar, usually take salt as a return freight, and the commodity finds its way thence far into Eastern Siberia.
Glauber's salts are got from the Great and Little Marmishansk lakes in the same Government (Tomsk), 125 miles south-west of Barnaul. The total area of these two lakes is about 212 square miles, and the layers of sulphate attain a thickness of 2 feet even at a couple of hundred feet from the shore. The annual production averages 1,610 tons, part of which goes to the soda-works at Barnaul, part is used for smelting ores in the Altai, and the remainder in glass-manufacture.
Eastern Siberia is rich in common salt, which is mainly got from rock-salt deposits. These occur, however, in sparsely-populated districts, and are at present worked only on a small scale. In the Governments of Yenisseisk and Irkutsk, brine-springs were tapped at Tumanshetsk (20 feet deep), Troitsk, Ust, Kut, etc. Numerous bitter-salt lakes occur in the first-named Government; while in Yakutsk, in the Vilyuiisk district, are three rock-salt deposits.
The author tabulates the annual statistics of salt-production in Siberia from 1887 to 1896 (both years inclusive) From these it is seen that the Siberian output, averaging 35,000 tons, is hardly more than one-fortieth of the total salt-production of the Russian Empire. The labour statistics show that in 1894, in the salt-works of the whole of Siberia, 1,581 workpeople were employed, most of whom were convicts whose good conduct had secured them a mitigated form of penal servitude.

L. L. B.

MANUFACTURE OF SALT-BLOCKS.
Block-salt has hitherto been used in Austria as an article of food, but as a marketable commodity it is not satisfactory. It is coarse, irregular in shape, difficult to transport, absorbs much water, and there is great waste in cutting it. It cannot be closely packed for sending to a distance, nor can the weight of each piece be accurately known, when judged only by the eye or touch. These disadvantages disappear if it is prepared for use by mechanical means. The Austrian Government therefore determined to introduce a better system of supplying salt for domestic purposes. Instead of bringing it into the market in the rough state, they resolved to have it manufactured into blocks of a given weight and shape. This was not a new process. The history of block-salt manufacture dates back in Austria to 1858, in which year its production by mechanical means was first advocated. Practical experiments were made in 1873, and various systems of hand-presses introduced at Ebensee. From that date their manufacture steadily improved: the first machine-press was made in 1891.
Two standard shapes were selected by the Austrian authorities. The first, in use at the Ischl salt-works, was a prism measuring 2.9 inches by 3 inches by 5.8 inches, and weighing 2.2 pounds. The second, employed at the Ebensee saltworks, was a cube measuring 3.7 inches each way, and made in two sizes, weighing respectively 2.2 and 11 pounds. At the Ischl works, the Meyer machine, introduced in 1896, is used, and the Muller, brought out in 1895, at Ebensee.
It was impossible to sell such small blocks of equal weight at a profit, unless produced by machinery and in large quantities. To turn out blocks of refined salt

of a certain quality and without a flaw suitable machinery was required, and these conditions were provided by the hydraulic salt-press made by Messrs. Muller & Cie., of Prague. The machine consists of a cylindrical hydraulic block-press, two hydraulic delivery-presses, an accumulator, and a high-pressure pump. The main hydraulic and two delivery-presses are all placed on the same baseplate, the hydraulic press being in the centre, and the delivery-presses, which it serves alternately, on either side of it. The piston of the hydraulic press is 14 inches in diameter and 4.3 inches stroke, and each up (motor) stroke compresses 12 blocks. Above the piston is an iron plate connected by two vertical columns to a weight at the top of the engine, which is so adjusted that the downstroke of the piston takes a shorter time than the upstroke. Four strong columns support the fixed cover of the mould, the lower surface of which forms a 12 celled bed-die of phosphor-bronze. The cast-iron mould resting on the hydraulic piston is square, and contains 12 four-sided divisions or cells of the same metal. The bottom of each cell is closed by a piston 3 1/2 inches in diameter, which forms a kind of die or stamp-cutter, worked upwards from below, and all these pistons rest on one plate. As the lower part of the mould filled with salt is brought beneath the upper part, or stationary cover, it is gripped by a 4 armed lever, the hydraulic piston rises, the upper weight descends, the two halves, upper and lower, of the mould are brought together, and the salt is cut out into cubes, and greatly compressed by the continued upward movement of the main and the stamping pistons. The cylindrical press is provided with valve-gearing, and when the process of compression begins, the valve sends the water into the piston from the accumulator, whereby it is returned to the high-pressure pump. The mould can be easily withdrawn from the machine if required, or the number of cells in it can be varied.

The cylindrical press is connected to the delivery-presses on either side by slides, along which the mould is run easily and quickly from one to the other, and back again. In these presses, the cubes are turned out of the mould, and each seized separately by small aluminium pincers, and placed in sets of three upon an iron plate, to be conveyed to the drying-oven. The operation takes only 2 seconds. The pistons of these presses work upwards, and have a stroke of 7.3 inches. The upstroke discharges the blocks, the downstroke corresponds with the downstroke of the main piston, carrying the empty mould, which is then filled afresh with salt. Each delivery-press is worked by valve-gear, similar to that of the main press.

The working of the salt-press is as follows:—The purified salt is first weighed by two workmen in two small gauged trucks, which, when full, contain the right weight. The salt falls into a leaden box with 12 partitions closed below with a slide-valve. This box is made in two halves, corresponding to the two sides of the hydraulic main press. When filled with salt, it is placed above the emptied mould, at the top of one of the delivery-presses, the slide-valve is withdrawn, the mould filled automatically, and pushed along the little rail to the main press, where the process of compressing and delivering another set of blocks has just been completed. The piston of the latter is now in its lowest position. The mould is run on to it, the valve-gear connected to the water in the accumulator, and the piston begins to rise. Four hooks at the corners of the mould are caught by tappets on the 4 armed lever, the mould is raised to the bed-plate, and the two lock together. As the piston continues to rise, the 12 stamping-dies or cutters are driven up, and the salt in each cell is forced up into the bed-plate, where the actual process of compression takes place. This completed, the valve opens to
discharge the water, and the piston falls. The mould is drawn down by the hooks till it reaches the rails, along which it is pushed by hand on small wheels. As soon as it reaches the delivery-press, the water is again turned on, the delivery-piston rises, and the blocks are discharged from the machine. As the latter is in duplicate, the mould is emptied and refilled on one side of the hydraulic press, while, on the other, the blocks are stamped and compressed.

The efficiency of the machine depends on the play of the mechanism, and the number of cells in use. The time occupied in the different processes is as follows: — Weighing and filling the box 8 seconds, filling and cleaning the mould 10 1/2 seconds, upstroke of the pressure-piston 6.3 seconds, downstroke of the pressure-piston 8.2 seconds, discharge of the 12 blocks 2 seconds, and complete compression-stroke, and interval till beginning of next stroke 1 minute. The total output during a 10 hours day with a 12 celled mould in duplicate is 14,515, or say 15,000 blocks. Five men are required for the work, 2 to weigh the salt and fill the box, 2 men, one on either side of the machine, for pressing and discharging the blocks, the fifth helps the last two, alternately. Each truckload of blocks for drying contains 500. The blocks weigh 2.2 and 11 pounds, respectively; the edges are slightly rounded, and the surfaces scored at proper intervals, in order that the blocks may be easily divided into pieces of one-half and one-quarter of the original weight.

The efficiency was submitted to careful tests by the writer. The machine was experimented on with moulds containing 12, 9 and 6 divisions, and the results plotted on a curve in the original paper. The number of divisions formed the abscissas, the efficiency the ordinates during a 10 hours working day. With a mould with 6 cells 10,000, with 9 cells 12,800, and with 12 cells 15,000 blocks of 2.2 pounds weight were turned out per day. The quantity of water required per block to work the compressing and the delivery-presses was 61 cubic inches (1 litre). As, however, the water is used in a continuous cycle in the high-pressure pump, it is only necessary to calculate one filling of the accumulator, and the supply to replace loss by waste.

The mechanical work required for the different operations was determined in each successive phase of work from the total time occupied, the dimensions of the machine, load and total quantity of water per cycle. To obtain a pressure of 54 atmospheres the load on the main piston, deducting friction, was 20,275 pounds, and total horsepower per stroke 12.3. Of this, 0.3 horsepower was expended at the beginning of the stroke, while the piston did no external work, 10.3 horsepower during the period of compression, which occupied 5.8 seconds, with a mean effective pressure of 44 atmospheres, while 0.59 horsepower must be assigned to the delivery-pistons. The balance, namely, 1.1 horsepower, was expended in overcoming the frictional resistance of the moving parts, making a total of 12.3 horsepower, or in round numbers 1 horsepower per block produced. The static pressure of 54 atmospheres sank to 44 atmospheres at the end of the stroke, a fall due principally to friction. The various data thus collected are plotted on curves in the original paper. The efficiency of the hydraulic press varied from 93 to 96 per cent., and the coefficient of friction from 12 to 19 per cent.

The writer tested the blocks in a technical mechanical laboratory, in various ways, for uniformity of composition and resistance to pressure. The results showed that their elasticity of compression increased from the top of the cube, where the pressure was greatest, downwards. The prism-shaped Ischl blocks were also tested, of course with greatly differing results owing to their different shape. The line of least compressive strength was, however, in both kinds found to be
next the lower surface. To determine the resistance of the blocks to a sudden strong pressure, upon which the efficiency of the machine depended, and therefore the output from it, the time required for the piston of the machine to reach the end of its stroke, that is, the actual duration of pressure was noted. It was found that a period of 6.3 seconds was needed to produce 12 blocks, this being the maximum number which could be satisfactorily manufactured at one time. The pressures used in the laboratory were from 10 to 175 atmospheres, and they were applied from 15 to 75 minutes. Irregularities in the speed of the pressure-piston were also tested, and, with the output of the machine and other data, were plotted on curves.

B. D.

HASSELMANN METHOD FOR PRESERVING TIMBER,

Inasmuch as unimpregnated timber is not suitable for use in mines on account of the special conditions of temperature that prevail underground, and its tendency to rapid decay from damp, some preservative process becomes necessary; but the three methods of timber-preservation most employed have given but little satisfactory result. Whereas efforts have hitherto been made to fill the wood cavities with a more or less antiseptic substance, in the Hasselmann method not only are the cell-walls and the wood-fibre penetrated, but even a chemical combination is directly set up between them and the dissolved chemical constituents of the impregnating substance. This is effected by two boilings, each of which lasts from 3 to 4 hours, during which solutions—in the first case of cuprous sulphate of iron and subsulphate of alumina, and in the other of calcium chloride and corrosive sublimate— are injected into the wood so as to chemically combine with it, in a close chamber at a temperature of 275° to 284° Fahr. (135° to 140° Cent.), corresponding with a pressure of about 41 pounds per square inch (2 1/2 to 3 atmospheres) above atmospheric pressure, the effect being very remarkable. The resin in the wood is dissolved and decomposed; the fibre spores are completely destroyed; and all the cells, even the innermost in the false heart of beech, are penetrated, and enter into indissoluble chemical composition with the impregnating substances.

Not only all species of timber - mine-timbers and railway-sleepers, for instance—but also vegetable and textile substances generally, may be treated by this process with the most manifold advantages; and that timber so impregnated really does resist decay in a remarkable degree is conclusively proved by the trials conducted by Prof. Rosler, Director of the Austrian State Testing-station, Klosterneuburg, the conditions having been rendered as severe and unfavourable as possible for a short period, in order to compensate amply for the usual influence of long duration. In a water-course, dry in summer and generally frozen in winter, piles impregnated according to this method were driven alternately with others not impregnated; and about a year afterwards it was found that the treated piles of all the woods chosen were perfectly sound, the portions that were in the ground having even become harder, while fir, beech and oak piles not treated showed various stages of decay.

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The author endorses the assertion made by Prof. Heinrich Mayer, that Hasselmannized timber retains all the properties which are so important for amplification in the arts, especially elasticity, that it attains a degree of hardness apparently impossible without great increase of weight, and that its combustibility is considerably reduced.

J. W. P.

PROTECTION OF STEAM-HEATED SURFACES.
The method adopted, which the writer believes is original, in making the experiments, was as follows:—A length of steam-pipe was heated by electricity from the inside, the amount of electrical energy was measured, and consequently the amount of heat furnished was known. If the steam pipe be kept at a constant temperature by a given amount of heat, it is because that amount is just equal to the heat that it is losing; for if the supply were not equal to the loss, the temperature would fall. In other words, the heat put into the pipe is equal to the loss by radiation, convection and conduction. By measuring the electric energy supplied one can determine the heat used and consequently the heat given out or lost.

The apparatus used in making the tests by this method comprised several lengths of steam-pipe of different diameters and lengths, heated electrically from within by means of coils of wire immersed in oil. The oil was stirred vigorously, and served as a carrier of heat from the wire to the pipe. Table I. shows the results of the first series of experiments.

Table II. shows the varying loss from bare pipes when their surfaces were in varying conditions as regards rust, dirt, paint, etc.

Table III shows the varying loss from a bare pipe with the change in pressure.

ELECTRIC PLANT AT THE BLANZY COLLIERIE.

This important power and lighting-plant comprizes four lines, two of which were brought into operation last year. At the central station, steam is raised in six MacNicoll boilers, with forced draught, and fired for the most part with refuse from the washing-floors. The 300 horsepower Willans and Robinson steam-engine, making 350 revolutions per minute, is coupled directly with the generating dynamos by Raffard clutches, the yield in 5,000 volts current being 92 per cent. with full load. This high-tension current, led by overhead wires, uninsulated except when crossing public roads, is transformed, at each secondary centre of distribution, into one of 125 volts for driving small motors and lighting, and to 700 volts for driving the underground electromotors; the iron boxes of the transformers being connected with earth for preventing accident. The triphase electromotors are provided with rings and brushes, which permit of resistance-coils being switched into their circuit, either on starting or when it may be desired to reduce the speed of a running motor.

The principal electromotors already erected are one of 65 horsepower, making 580 revolutions per minute, for driving the chain-haulage of the Saint-Francois pit; another of the same power for driving an underground pump at the level of 843 feet (257 metres) in the Magny pit; a 40 horsepower and a 30 horsepower for driving a hoadage-plant in the same pit; a 15 horsepower driv ng an underground...
Mortier fan of 3 1/4 feet (1 metre) diameter, which delivers 212 cubic feet (6 cubic metres) of air per second, at a water-gauge of 1.2 inches (30 millimetres), and several small motors, including one at the Sonde gobbin-quarry, serving an incline and utilizing the high-tension current.

The transforming-stations also maintain, both underground and on the surface, a great many arc and incandescent lamps. The high-tension current adopted is justified by the length of the lines, one of which measures 5 miles (8 kilometres). The net useful effect obtained from the large continuously-running motors, like the pump, is 44.4 per cent. in water raised, and 70.8 per cent. of the actual transmission of energy between the engine-shaft and that of the electromotor, while it may be considered that the whole plant collectively, including the small as well as the large electromotors, affords a yield of 60 per cent.

J. W. P.

ELECTRIC DRIVING AT THE GLUCKAUF SALT-MINE, SONDERHAUSEN.

Where electricity can be employed it has entirely superseded compressed air, owing to its easier application and the high useful effect of the electromotors, but chiefly on account of the greater economy of electricity for intermittent working, such as that of rock-drills and mine engines. In the intervals between working, during which an electromotor does not require to exert any power, it receives no current from the conductors or generating-station, so that there is no loss; but on the other hand, with compressed air, even while the motor is standing, the loss caused by leakage still continues—a matter of no slight importance when the pipes are long and have several branches.

The central station, the mine-fan, the rock-salt mill, chlorate-of-potash works, coal-supply, waterworks, 20 cwts. lift at pit-bank, workshops, electric-lighting and underground working of the Gluckauf mine are described. The 500 volts current is led down the shaft to the landing by a steel-armoured cable 2.40 inches (61 millimetres) in diameter with three copper wires each of 0.108 square inch (70 square millimetres) cross-section. Current of the original tension is supplied to the electromotors for driving winches and small auxiliary fans, but reduced by transformers to that of 220 volts for rock-drills and electric lighting. Altogether there are 24 electromotors in the Gluckauf mine—16 on the surface and 8 underground—varying from 1 1/4 to 105 horsepower; and it is only the large types—those of 105 horsepower for the mills—that require constant attention, the others being looked after by men while going their rounds, which is quite sufficient, because all the motors are provided with ring lubrication. Every month, all the electromotors are thoroughly inspected, under the supervision of the engineer, while the resistance in the conductors is measured, so that any defect may be at once remedied. The electric plant, which was started on June 1st, 1897, has left nothing to be desired; and the dependence that can be placed upon it is as complete as it is possible to attain, while a maximum of safety is secured. Touching a conductor of 500 volts current is not fatal under ordinary circumstances; but nevertheless all the leads in buildings and places where the workmen pass are insulated, while danger of fire through short-circuiting is practically avoided. In comparing the first cost of mining plant with and without driving from an electric central station at first sight the outlay in the former case, with its carefully constructed engines and dynamos, would appear to involve greater expense, while the
electromotors underground are not much cheaper than steam-engines; but at the same time the fact must not be lost sight of that the electromotor only requires a slight proportion of the space necessary for a steam-engine of equal power, and consequently only smaller and simpler (if any) foundations and special engine-rooms. At the Gluckauf mine, there are electromotors which, if not simply laid down in the workings, are only separated therefrom by brattice. With electric driving, whether direct or in groups, there is no heavy gear for transmitting power, so that there is less brickwork; and the buildings may be of lighter construction.

J. W. P.

STAVE-PIPES: THEIR ECONOMICAL DESIGN AND THE ECONOMY OF THEIR USE.
At first, stave-pipes were principally used for penstocks in the development of water-power, and were built in tapered sections, which were put together after the manner of stove-pipes. The first instance of their use as a continuous tube was the 6 feet penstock constructed at Manchester, New Hampshire, in 1874, and which is still doing service.

The particular type referred to in this paper is that of a pipe which is built, continuously in the trench, of staves of variable length, having radial edges and concentric faces, and held together by metal bands, usually circular in section, and spaced in accordance with the strain imposed.

In the construction of a wooden pipe, the staves must be thin enough to secure complete saturation and to deflect readily to the degree of curvature employed, and they must be thick enough to prevent undesirable percolation through them. The bands must be of such a size that when spaced to secure the desired factor of safety against rupture, there will be at the same time no sensible flexure in the staves and no destructive crushing of the fibre beneath the band. While fulfilling these conditions, the proportion between the thickness of the staves and strength and spacing of the bands must be such that the swelling of the wood will not produce injurious strains upon what might otherwise be a properly proportioned band.

Table I. contains details respecting the construction of 12 existing sections of stave-pipes, and is self-explanatory.

In addition to the discharging capacities of stave-pipes being superior to those made of cast-iron or riveted-steel pipes, the economy of their use is shown by Tables II. and III.

It would appear therefore that stave-pipes stand unquestionably first in point of first cost and carrying capacity when contrasted with the two other classes of pipes which are employed, and second only to cast-iron in length of life.

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[Table I, Strains in some existing pipe-lines, omitted]

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[Table II, Comparative cost of pipe at Chicago, omitted]

[Table III, Comparative cost of pipe at San Francisco, omitted]

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MOTIVE POWER FROM BLAST-FURNACE GAS.
These experiments were undertaken for studying the actual conditions under which a large single-cylinder gas engine worked, when supplied with gas from a coke-fired blast-furnace; and a trial of sufficient length was made for proving that blast-furnace gases, used directly, permit of regular and continuous working, notwithstanding any variations in quality, richness and pressure, and also the large quantity of dust. It was decided to submit the 200 horsepower simplex gas engine, with a cylinder of 31 1/2 inches (80 centimetres) diameter, and 39 3/8 inches (1 metre) stroke, running at 105 revolutions per minute, to a trial of 24 consecutive hours, with its normal load and a maximum of 90 admissions per cent., supplied with gas as it left the blast-furnaces, either directly or after passing through a gasometer of about 10,000 cubic feet (300 cubic metres) capacity.

The engine produces 181 horsepower, measured by the brake, almost without variation during 24 hours, with a mean consumption of 117.6 cubic feet (3.329 cubic metres) per effective horsepower per hour of gas, the calorific power of which remained near upon 1,766 British thermal units per pound (981 calories per kilogramme), while consuming nearly 22 gallons (100 litres) of water and less than 1/2 ounce (18 grammes) of oil and grease, while the working was quite as regular as that of a steam-engine, and the dust in the gas did not interfere with its working.

J. W. P.

WIRELESS TELEGRAPHY AND TRANSMISSION OF POWER.


Rontgen or cathodic rays, Hertz waves, the emanations employed in wireless telegraphy by Messrs. Marconi and Chunder Bose, all result from one and the same manifestation of electricity. In accordance with Prof. Maxwell's theory, sound, light and electricity are only vibrations of luminous ether, differing from one another by the speed and amplitude of the undulations, which vary between a few thousands per second in sound, to 700 trillions in the violet ray, so that man may now be justly considered to possess a new element, the full application of which cannot at present be determined. If the manner in which electricity is outwardly manifested differ from that in which it has hitherto been applied, the results are very different, and sometimes, it may be said, opposed.

The effects of the Rontgen rays are well-known; but there is little doubt that they are susceptible of many other than their present applications. For instance, Prof. Ebert, who has made many experiments for utilizing the luminosity produced by these rays, declares that it will constitute the lighting of the future. The principle of wireless telegraphy, discovered simultaneously by Mr. Marconi in London and Mr. Chunder Bose at Calcutta, depends upon the production of electric waves by a current of high frequency, traversing a Ruhmkorff coil and actuating a Hertz resonator, the vibrations of ether, transmitted to a considerable height, being distributed through the atmosphere; and for collecting them a resonator is required, which afterwards transmits them to the telegraphic or telephonic apparatus. With this arrangement, a body, or substance, is obtained,

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normally non-conducting, but which becomes conducting under the action of the electric waves, and continues in this state until the coherence is destroyed by external shock, after the passage of each fraction of current necessary.

Wireless telegraphy by electric waves has not as yet received all the application of which it is susceptible; and there is little doubt that this new form of utilizing electricity will, in the more or less near future, be attended with very pregnant results, not only in telegraphy, but even in the transmission of power.

J. W. P.
OFFICIAL REGULATIONS AS TO FOREIGN-SPEAKING WORKMEN IN WESTPHALIAN MINES.

Bergpolizeiverordnung betreffend die Beschäftigung fremdsprachiger Arbeiter beim Bergwerksbetriebe im Oberbergamts-Bezirke Dortmund, (signed) Taeglichsbeck, January 25th, 1899.

In the interests of safety, foreign-speaking workmen may henceforth only be employed in mines and their dependencies (coke-ovens not coming under this regulation) provided they are sufficiently acquainted with the German language to understand the verbal orders of their chiefs and the communications of their fellow-workmen. In the responsible positions of overmen, shot-firers, leading and ventilation hands, onsettters, brakesmen, banksmen, enginemen, boiler-minders, engine-drivers, signal-men, pointsmen and a few others, foreigners may be employed only if they can speak German and read that language, written as well as printed, though this does not apply to men who may temporarily be called upon to discharge the duties of the abovenamed officials and workmen. Lists must be kept of all foreign workmen employed in mines, including the preparation-plants and fuel-works belonging to them; and the manager or his representative is held responsible for the correctness of such lists. Foreigners employed at the mines on the date of the order are, however, exempted from its provisions until after a lapse of 6 months; and that period may be extended by the Mining Authority to 18 months on the application of the mine-owner.

J. W. P.

DECIMAL MEASUREMENT OF TIME AND ANGLES.


The time has now arrived for applying the decimal system to the measurement of time and also angles for simplifying calculation, while with a little practice the time can easily be read in the decimal manner. In the author's system, the day and the circumference of the circle are divided into 100 equal parts, the new units being called respectively "ce" and "cir" with their decimal subdivisions "decice, decicir" and "centice, centicir," etc. The author showed some watches with double graduation, both horary and decimal, a miner's dial and a sextant decimally divided, and also maps and charts to decimal scales, with conversion-tables, and observed that the system might be applied to physics, navigation, mechanics and electricity. J. W. P.

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GOLD-MEASURES OF NOVA SCOTIA.


Since the gold-measures of Nova Scotia became known, about the year 1860, it has gradually become evident that the workable deposits of free gold are confined to the metamorphic rocks of the Atlantic coast, along which they form a continuous belt from one end of the province to the other, a distance of some 260 miles, varying in width from 10 to 75 miles. Although no well-defined fossils have so far been found in the sedimentary rocks constituting the gold-measures, most geologists agree to classify them, provisionally, as Lower Cambrian. The measures fall into two well-defined groups, viz., a lower or "quartzite-group" and an upper or "slate-group." The Geological Survey places the thickness of the quartzite-group, as far as denudation has exposed these rocks to view, at about 3 miles, and the thickness of the slate-group at about 2 miles. The beds of quartzite and slate forming the gold-measures were originally deposited horizontally, but they have
been bent and folded (roughly parallel with the sea-coast) to such a degree that they occupy only one-half of their former width, measured at right angles to the strike. Extensive denudation has worn away the measures to their present level. Some of the sharpest and highest folds have been truncated to a depth of over 8 miles, exposing at the surface a section of gold-measures over 5 miles thick. The most important feature disclosed is that all the rich veins, and the large bodies of low-grade quartz worked in Nova Scotia, with few exceptions, follow the lines of stratification, and occur at well-defined points along the anticlinal axes of the folds. In order to locate the auriferous quartz-deposits on the surface, and to develop them in depth, a thorough knowledge of the structure of the anticlinal folds is necessary. The rocks, on opposite sides of anticlinal axes, generally dip at angles of between 45 and 90 degrees, seldom less than 40 degrees, and overturned dips are frequently found. When the pitch inclines both ways from a central point, that point is the centre of an elliptical dome, and marks the position of one of the most favourable points on the main antinclines for the occurrence of quartz-veins. The average distance between one dome and the next along the same anticlinal axis varies from 10 to 25 miles. Most, if not all, of the gold-mining centres operated are situated on these domes. The quartz-veins are sometimes very numerous on both sides of the anticlinal domes. On the Goldenville anticlinal dome, some 55 different veins have been worked, or uncovered. In many cases, they extend on the surface for thousands of feet, and have been mined to depths of 700 feet in their vertical extension. The thickness of the veins varies considerably. The saddle reef-deposits are by far the largest bodies, those worked at Salmon river and other places attaining 15 to 25 feet in thickness. The veins along the legs of the folds are much smaller, averaging from 4 inches to 1 foot, but often thicker. Many quartz-veins are also found cutting the stratification at various angles; some are of great thickness; many are auriferous, and a few have been operated with notable profit.

In the interstratified veins, the gold is sometimes distributed uniformly over considerable areas; usually, however, it is more or less concentrated within certain limits, leaving spaces on each side comparatively barren. These enrichments are known as pay-streaks. Most pay-streaks are well-defined enrichments of 20 to 26 feet in breadth, often accompanied by enlargement in the size of the vein. They dip at low constant angles, and are approximately parallel with the anticlinal axis. Many of the pay-streaks have proved very rich; some have been traced from the surface along a gentle incline for 1,800 feet, and, in many instances, three pay-streaks have been determined in the same vein, lying parallel under one another for some distance. The laws governing the position and extent of the pay-streak are intimately connected with the structure of the anticlinal folds; and the partially solved problem of these laws only needs complete solution by mining engineers in order to place the Nova Scotia gold-field among the most productive in the world. A principal aid to this complete solution would be furnished by the systematic preservation and comparison of the various mine-plans. The author also gives several diagrams and geological sections of the neighbourhood, and advances theories of the geological history of the Nova Scotian gold-bearing strata.

X. Y. Z.

COPPER-ORE DEPOSITS IN LOWER CALIFORNIA, MEXICO.

The deposit with which the author is chiefly concerned is in the neighbourhood of the celebrated Boleo mines, and occurs 2 miles from the eastern coast of the peninsula, in latitude 27 degrees 30 minutes north, about 63 miles north-north-west of the small
The town of Mulege. The region is one of Tertiary volcanoes and volcanic sedimentaries: trachyte-cones range in a double chain, parallel with the coast-line, across the tuff-agglomerate plateau. Later than these acid trachytes are the basalt-sheets which in part cloak the acid rocks and overflow on to the plateau. Fossiliferous limestone-bands interstratified with the tuffs show these to be of Miocene or Lower Pliocene age. The metalliferous ores appear to occur as veins in the sedimentaries, and although they are got at depths of 100 feet or so below-ground, they are in the main decomposition-products. The author examined the ores microscopically and made chemical analyses of them, and he describes in detail the results of this study. He shows that the primary ores, consisting essentially of chalco-pyrite and copper-glance, associated with chalcedony, are present in comparatively small amount. The major portion of the ores was transformed into carbonates (malachite, azurite) by waters carrying carbonic acid in solution, but some portion of the copper recombined with the sulphur thus set free. Later on, thermal waters with silicic acid in solution came in, and the reactions thus set up produced black copper-ore, opal, native sulphur and gypsum. The hypothesis that thermal waters were largely concerned in the genesis of the ores as we now find them is the more probable that the district was for a long period the scene of volcanic activity. Another point to be noted in connexion with the deposit described by the author is the triple association of copper, manganese and cobalt, unique in Lower California. The association of copper and manganese alone is characteristic of many deposits in that area, but in some cases manganese is the more abundant ore of the two, while copper plays merely an accessory part.

L. L. B.

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NATURAL COKE IN THE SANTA CLARA COAL-FIELD, MEXICO.
Naturlicher Koks in den Santa Clara-Kohlenfeldern, Sonora, Mexiko. By Dr. Carl Ochsenius. Zeitschrift fur Praktische Geologie, 1900, page 21. The coal-measures of Santa Clara, Sonora, are underlain by igneous rocks: they are much disturbed, broken through, and overlain by eruptives and intrusives of various ages. The coal-seams are interbanded with sands and clays, and the first discovery of a small seam of impure natural coke was made at Calera Creek. Later on, several other coke-beds were discovered, each 8 to 10 feet thick, regularly bedded and extending over considerable distances. They are generally, as might be expected, associated with eruptive rocks, which either form the roof or floor, saving the interposition of a thin band of shale. Sometimes the eruptive rock and the coke are found intimately intermixed, and in other cases the former fills small fissures in the latter. Nevertheless, the coke does not appear to have originated solely from contact with the eruptive rock, for pockets of coke occur in 4 feet anthracite-seams; or coke and coal lie next one to the other in the same bed, separated by 3 inches of clay. Graphite occurs on fractured surfaces of the natural coke, and sometimes the anthracite is seen to pass into graphite. This would tend to prove that vegetable tissues are metamorphosed into graphite by passing either through the phase of anthracite or through the phase of natural coke. The natural coke is dark-grey, minutely porous, and more compact than oven-coke. It possesses the same fibrous structure as the latter, makes an excellent fuel, leaving a white ash, and is not more difficult of ignition than anthracite. Further particulars will be gleaned from the Chemiker Zeitung (1899), and from Mr. E. T. Dumble's paper.*

The present author regards this discovery of natural coke as an important confirmation of his view that graphite is the final term of the series beginning with peat, and passing through lignite, coal, anthracite and coke, and is therefore undoubtedly of organic origin.

L. L. B.
CALIFORNIA ASPHALTUM.


Of the great deposits of Santa Barbara county, those used for paving belong to the Alcatraz Asphalt Company, of San Francisco, whose properties in this county extend to 35,000 acres. They have large refining works at Carpinteria, where they extract the bitumen from the large deposits of bituminized sands on the seashore. The product is of high grade, running over 98 per cent. pure. They also operate underground mines to the west of Santa Barbara.

On what is known as the Sisquoc Giant, in the northern part of the county, occurs the Mesa deposit, located upon a plateau 1,900 feet above sea-level and 25 miles from the coast. This plateau is a spur of the main mountain-range, surrounded on three sides by valleys 250 to 500 feet in depth, where the surface has been eroded, the deposit remaining in place through the cementing quality of the bitumen. The deposit is exposed to the surface in some parts, overlain by 2 to 3 feet of earth in others. It is over 1 mile long, 1/4 mile wide, and nowhere less than 125 feet deep. It contains between 20,000,000 and 30,000,000 tons of crude material and between 4,000,000 and 5,000,000 tons of pure bitumen. Here the Alcatraz Company has large separation-works, which separate the bitumen from the sand, throwing away the sand, perfectly clean, into the valleys below. As the process involves the use of solvents, the bitumen is liquefied sufficiently to flow through pipes and is thus transported by gravity nearly 30 miles to the finishing-works on the Santa Barbara Channel. The bitumen arrives at Alcatraz Landing in the form of a fluid solution, from which the solvent is quickly separated under low temperature, leaving the bitumen in its natural state, nearly 100 per cent. pure, ready for market. It undergoes no other process. After separation from the bitumen, the solvent is pumped back to the separation-works at the mine by a system, which is a model of ingenuity and mechanical perfection. The output per annum is about 50,000 tons of practically pure bitumen.

X. Y. Z.

THE GRAND RIVER COAL-FIELD OF COLORADO.


One of the largest and most interesting of the great coal-fields of Colorado is the Grand River field, not only for its numerous and large coal-seams, but for the varied character of the coal, and the peculiar geological conditions which produced these varieties. These conditions are intimately connected with the degrees of heat developed by the extraordinary volcanic or eruptive activities to which the entire region has been subjected. The eruptive phenomena which have so affected this region are of that peculiar class known as laccolitic. Huge bodies of molten rock, rising from below, and failing to break through to the surface, pushed thick intrusive sheets between the layers of sedimentary strata, raising them up into hollow arches, and filling the space with molten lava. Subsequent extensive erosion has exposed the underlying mountain-mass of lava, with the sedimentary strata dipping off from it on all sides. Cretaceous shales are changed into crystalline roofing-slates; sandstones into hard quartzites; and, locally, Silurian and Carboniferous limestones are altered into some of the finest white and variegated marbles and serpentines to be found on this continent. The effects of greater
economic importance are those on the coal-beds, which here attain an extraordinary thickness and number of seams. As the coal approaches the centres of volcanic force, there is a gradual transition, first from bituminous to coking coal, then to semi-anthracite, and finally, at close contact with the eruptive rock, to true lustrous anthracite.

The Grand River coal-region is on the west of the Colorado range, and is drained by the Grand river. The coal-field is a portion of a larger field extending through eastern Utah to the base of the Wasatch mountains. The area is interrupted here and there by the intrusive laccolites, such as the series passing along the base of the Ragged mountains. The thickness of the Laramie coal-bearing strata on the western side of this range is from 2,000 to 3,000 feet—much greater than the thickness on the eastern slope. In the eastern portion of the field, there are 4 to 5 main workable seams; in the central part, there are 7 or more. The coal varies from bituminous to true anthracite, according to distance from the main eruptive centres. In the Grand River

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district, the coals are located along a very lofty hogback, as at Newcastle and Coal Ridge. The dip is from 57 to 60 degrees for the lower and from 25 to 40 degrees for the upper seams. There are 7 workable seams, the aggregate thickness of clean coal exceeding that found in any other portion of Colorado. In a thickness of 1,000 feet of strata are found 105 feet of clean coal of a semi-coking and domestic kind, viz., one 4 feet seam, two 5 feet seams, one 8 feet seam, and three thick seams of 18, 20 and 45 feet respectively. X. Y. Z.

SNAKE RIVER GOLD-FIELDS, IDAHO.

Snake River valley, exclusive of mountain-spurs, contains about 37,500 square miles. The lava-fields that cover a vast area of the Snake River country may, from the evidence of the fossils found underneath, be assigned to the later Tertiary or the early Quaternary period. The metallic values found in the Snake River country consist almost wholly of the gold found in the sands of the streams. The writer estimates the approximate value of the Snake River gold-placers at not less than £400,000,000. The source of the gold seems to be the Caribou, Snake River and Pierre's Hole mountains, whose waters flow entirely into the southern fork of Snake River. It is an extremely fine flour-gold, so infinitesimally small that each particle of it will float in a moderately rapid current. So far, the primitive methods of obtaining gold have here paid best, the method most successful in Snake River gold-mining being that known as the "burlap process." This is a simple and inexpensive method, and Snake River valley has well been termed the "poor man's mining country," inasmuch as the miner can always make a living, but rarely more than a living. Very expensive machinery has from time to time been prepared for saving the fine gold on this river, but has never produced adequate returns. X. Y. Z.

THE CUPRIFEROUS DEPOSITS OF MANDOR, WESTERN BORNEO.

In 1858-1861, some prospecting was done in the Mandor district by Mr. R. Everwijn, and the results of his researches were published in the Jaarboek for 1878, He opined that the copper-ores which he traced in no less than 24 localities would not repay working, and his views are fully confirmed by the present author, after careful
investigation. The following is a summary of the main facts upon which these conclusions are based.

Copper ores, associated here and there with small quantities of galena and zinc-blende, and always accompanied by iron-pyrites, are very widely distributed in the granite, which is the basement-rock, upon which rest the younger sandstones and shales. This distribution is restricted to the uppermost portions of the granite, especially where the rock has undergone much weathering. On the other hand, copper-ores occur only exceptionally in the sandstones and shales, these sedimentaries being, however, extensively impregnated with iron-ore or containing it in the form of fissure-deposits. There are no
cupriferous "main leaders," but rather infillings of thin cracks or clefts, which in places broaden out and strike generally east and west, or north-east and south-west, and pitch steeply eastward. There is no likelihood whatever that these cupriferous deposits will prove to be of economic value.

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THE ORIGIN OF THE BROKEN HILL ORE-DEPOSITS, NEW SOUTH WALES.


The author points out that, despite the exhaustive memoirs of Mr. E. F. Pittman and Mr. J. B. Jaquet, on Broken Hill, there still remained untouched certain points which are of great importance in regard to the genesis of the ore-deposits. Having at his disposal a large mass of material, he examined microscopically the country-rock. This is predominantly a garnetiferous gneiss, with which garnetiferous quartzite is frequently interbedded: both rocks contain fine scales of sericite, the presence and habit of which point to dynamo-metamorphism. With regard to the ores themselves, the author leaves aside those of the upper levels, the latest in date of formation, and limits himself to the consideration of the sulphides. These are chiefly argentiferous galena and blende, intimately associated with a peculiar grey-blue quartz, garnet, rhodonite and fluorspar (the last-named being generally invisible to the unaided eye). The ubiquitous presence of garnet is noteworthy: it occurs, first, both macroscopically and microscopically as a sort of breccia of angular fragments enveloped by the metalliferous ores; and, secondly, in idiomorphic crystals, evidently of fresh growth, amid the mass of ores, and containing inclusions of the ores. Rhodonite is not so universally distributed in the ore-body as garnet: the salient fact in the author's detailed description of its occurrence is the corrosion of the rhodonite by the solutions which brought in the ores. The blue quartz often exhibits a mosaic structure, and is bespattered with fissured garnets, the fractures being infilled with galena. All this points to dynamic phenomena resulting in various chemical reactions and recrystallization.

The author then describes the structure of the salbands, and shows that his observations confirm the hypothesis formed by Messrs. Pittman and Jaquet as to the manner in which the great Broken Hill deposit was formed. It is essentially the result of foliation on a grand scale in the overfold of a "saddle" in the gneiss: an irregular hollow was torn in the rocks, the walls of which broke away, the hollow being in part filled with crumbled rock-debris, and then completely filled by the inflow of metalliferous ores with fluorspar, secondary garnet, etc. In fine, the author ranks the Broken Hill ore in the category of vein-deposits, rather than in that of true bedded deposits. He thinks that it forms a type of itself, so far unique.

L. L. B.

QUARTZ REEFS OF THE HILL END AND TAMBAROORA DISTRICT, NEW SOUTH WALES.
By J. Alex. Watt. Annual Report of the Department of Mines and Agriculture, New South Wales, 1898, pages 9 and 172-177, with plans and sections. The Prospecting Board proposed to put down some bore-holes to test Mr. Watt's theory as to the occurrence of a saddle-reef formation at Hargraves and Hill End, somewhat similar to that worked at Bendigo, in Victoria. The

author was directed to visit Hill End and advise as to the best way of sinking for the lost reefs. Particular attention was directed to ascertaining the mode of occurrence and probable origin of the gold-bearing quartz-reefs. It had been shown that in the case of the Hargraves district (about 20 miles from Hill End), the movements to which the rocks there had been subjected have resulted in the production of saddle-shaped cavities between the strata, which have later become filled with auriferous quartz by the infiltration of mineral-bearing solutions. In this way, reefs have been produced which resemble in all their essential features the famous saddle-reefs of Bendigo. Before the examination of the Hill End gold-field had proceeded far, it became clear that the phenomena of the Hargraves saddle-reefs were there reproduced as far as the general facts of the mode of occurrence and origin were concerned, though there are some important differences.

After describing the nature of the rocks and the mode of occurrence of the reefs, the author states that taking these into account, together with the close resemblance of the general features of the district to those of Hargraves, where saddle-reefs had been proved to exist one under the other, it was extremely probable that the Hill End reefs, as now exposed at the surface, were principally the denuded east-and-west legs of saddle-reefs which at one time were continuous across the centre of the arch. Further, the gently curving or flat lying masses of quartz situated between the two series of reefs appeared to be the caps of saddle-reefs, which owed their appearance at the surface to the denudation of an immense thickness of rocks, comprising slates, sills, and the caps of overlying saddle-reefs. It was this process of denudation that had supplied the gullies with the enormous quantity of alluvial gold which had been obtained from them. The sources from which the gold was derived were in all probability, those portions of the saddle-reefs which had disappeared in this process, leaving the easterly and westerly dipping reefs as mere remnants of them. If this theory furnishes the correct explanation of the phenomena presented by the Hill End reefs, the following conclusions may be legitimately drawn from it: —

(1) The easterly and westerly-dipping reefs will decrease in size as they are followed down, until they finally pinch out altogether. This fact is even now to some extent recognized, for some of the reefs have already disappeared, or become greatly reduced in size in the deeper workings. Some, however, have already been proved to a depth of 800 feet from their outcrops without showing any appreciable diminution. This very important feature distinguishes these legs from reefs of a similar character at Bendigo, where, as a rule, they cut out at 100 feet below the saddle, and only exceptionally extend downwards 700 or 800 feet from it. This feature is not remarkable when we keep in mind the great breadth of the Hill End arch as compared with Bendigo, and should have an important influence favourable to Hill End, on the relative persistence in depth of the saddle-reefs of the two places.

(2) Saddle-reefs will be found, of which there are now no traces whatever on the surface, but which will make their appearance one under the other as the prospecting operations are conducted downward in the neighbourhood of the centre of the arch. It is only reasonable to suppose that, as the circumstances are so similar at Hill End and Bendigo, and as at Bendigo they have been proved to a depth of at least 3,350 feet from the surface, they will also be found to extend to a considerable depth at Hill End. (3) Other arches containing saddle-reefs will be found to the east and west of Hill End, i.e., in parallel folds of strata. The author, in fact, suggests that such reefs
have already been worked at Stuart Town on the west and at Sally's Flat on the east without their true nature being quite understood.

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The author claims that this theory (which the Prospecting Board had already decided to test) satisfactorily explains all the observed phenomena, and he thinks that the possibilities of the future of the district can hardly be exaggerated. He points out that the pioneers of reefing at Bendigo had to face the same problems as those now presented by the Hill End gold-field, and that it was not until they had solved these and proved the existence of saddle-reefs recurring one under the other that the permanence of that field was established. X. Y. Z.

DECOMPOSITION OF CARBON MONOXIDE IN PRESENCE OF METALLIC OXIDES.


The experiments were performed at a temperature of 445° Cent. with varying quantities of iron oxide and durations of exposure to the carbon monoxide. The latter—containing 95 to 97 per cent. of carbon monoxide—was produced by acting on sodium formate with sulphuric acid, and purified from carbon dioxide by passage through potash and baryta-water. The iron oxide was prepared in an extremely fine state of division by calcining pumice-stone steeped in ferric-nitrate solution, and was then placed in glass tubes drawn out fine at both ends, and heated in a sulphur-bath, through which tubes the carbon monoxide was passed until the complete reduction of the iron occurred and a deposit of carbon formed: the contents being analysed after the tubes had been left, sealed up, in the sulphur-bath for some time longer. The results obtained were as follows: —

[Table omitted]

The results show that the decomposition of the carbon monoxide depends on the time-factor and quantity of iron oxide present, the quantity of carbon dioxide formed increasing with regularity.

C. S.


In carrying his experiments further, the author finds that results similar to those yielded by iron oxide are furnished by other oxides. In the case of nickel and cobalt, the time required for the complete conversion of carbon monoxide into dioxide is 8 minutes when 0.15 gramme of nickel or cobalt oxide is used, increasing to 60 minutes and 255 minutes with 0.05 and 0.005 gramme respectively. On substituting wood-charcoal for pumice, as a carrier of the metallic oxide, the results obtained were similar, though a longer exposure to heat was found necessary, in order to complete the decomposition of the carbon monoxide.

C. S.

WITKOWITZ COLLIERIES IN DOMBRAU, AUSTRIA.
The coal-field is worked by means of four shafts, the Bettina and Eleonora, which are the older, and two newer shafts. The following are some data with regard to the sinking of the Eleonora winding-shaft. The area inside the walling was 237 square feet or 22 square metres. The depth sunk from April, 1893, to January, 1896, was 1,981 feet or 604 metres. The cost of sinking was:

<table>
<thead>
<tr>
<th></th>
<th>Per Metre.</th>
<th>Per Foot.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages</td>
<td>270.85</td>
<td>£ 8 5 2</td>
</tr>
<tr>
<td>Materials</td>
<td>169.74</td>
<td>£ 5 3 6</td>
</tr>
<tr>
<td>Totals</td>
<td>440.59</td>
<td>£13 8 8</td>
</tr>
</tbody>
</table>

The cost of walling the Eleonora shaft from April, 1894, to August, 1897, for a length of 1,611 feet or 491 metres was:

<table>
<thead>
<tr>
<th></th>
<th>Per Metre.</th>
<th>Per Foot.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages</td>
<td>126.49</td>
<td>£ 3 17 1</td>
</tr>
<tr>
<td>Materials</td>
<td>243.50</td>
<td>£ 7 8 6</td>
</tr>
<tr>
<td>Totals</td>
<td>369.99</td>
<td>£11 5 7</td>
</tr>
</tbody>
</table>

The total cost of the shaft in working order was:

<table>
<thead>
<tr>
<th></th>
<th>Per Metre.</th>
<th>Per Foot.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages</td>
<td>397.34</td>
<td>£12 2 3</td>
</tr>
<tr>
<td>Materials</td>
<td>413.24</td>
<td>£12 12 0</td>
</tr>
<tr>
<td>Totals</td>
<td>810.58</td>
<td>£24 14 3</td>
</tr>
</tbody>
</table>

The No. 2 air-shaft had an area inside the walling of 171 square feet or 15.89 square metres. The depth sunk from May, 1898, to January 31st, 1899, was 413 feet or 126 metres. The cost of sinking and walling was:

<table>
<thead>
<tr>
<th></th>
<th>Per Metre.</th>
<th>Per Foot.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages</td>
<td>144.76</td>
<td>£ 4 8 3</td>
</tr>
<tr>
<td>Materials</td>
<td>146.89</td>
<td>£ 4 9 7</td>
</tr>
<tr>
<td>Totals</td>
<td>291.65</td>
<td>£8 17 10</td>
</tr>
</tbody>
</table>

Each of the two winding-shafts is laid out for two sets of cages, double-decked cages, taking 2 tubs end to end, and small cages for one tub. Accordingly, at each lift, 5 tubs can be wound, carrying 8 cwts. of coal, so that in both shafts 40 cwts. can be raised per lift.

The dressing-plant is arranged to treat 1,400 tons in 10 working hours. It is erected between the two shafts, 558 feet (170 metres) from the Eleonora shaft and 820 feet (250 metres) from the Bettina shaft, with which it is connected by means of an iron gantry. The coal is conveyed to the dressing-plant by means of chain-haulage, driven by an electric motor. Each dressing-plant consists of a friction-driven cylindrical tippler, a Karop screen, and a Klonne gyrating-screen, by means of which lump, nut and small coal can be made. The Klonne screen produces a considerable amount of fine dust, to remove which an exhaust-fan has been erected, which carries the dust-
laden air through a series of dust-chambers, in which it is deposited. This dust has a very high calorific value, and on account of its fine state of division is especially useful for employment under dust-fired boilers, for which purpose it is drawn off from the dust-chambers and collected in sacks.

Electrical transmission is largely used at these mines, the plant consisting of 3 dynamos, each of 250 horsepower, and 10 motors of 5 to 180 horsepower each. The motor is a compound-wound continuous current machine, giving 170 kilowatts at a tension of 550 volts. Among other applications, a motor is employed for underground pumping, lifting 2.64 gallons (12 litres) of water to a height of 1,532 feet (467 metres) at 70 revolutions per minute by means of a triplex differential plunger-pump. The air-chamber is filled by means of a two stage air-compressor. The motor that works the pump has an efficiency of 180 horsepower at a tension of 500 volts, making 400 revolutions per minute.

In order to obtain suitable water for the boilers, two pumps have been erected at the Olza river, 10,710 feet (3,265 metres) distant from the central electrical station, by means of which water is pumped to a high-level reservoir erected near the Eleonora shaft. The two pumps can deliver respectively 330 and 528 gallons (1,500 and 2,400 litres) of water per minute.

For the sinking of the No. 2 shaft, a hoist and a sinking-pump are employed, worked electrically. The hoist is calculated to lift 8 full tubs per hour from a maximum depth of 1,640 feet (500 metres). Whenever, by any accident, the cage rises 3 feet (1 metre) above the shaft-collar, an indicator of the usual type touches a contact and thus closes a circuit, by means of which two electro-magnets are brought into play which actuate a very powerful brake and automatically cut out the motor.

The sinking-pump consists of three plunger-pumps, which force 22 gallons (100 litres) per minute to a height of 394 feet (120 metres). The pump is worked by a 6 horsepower motor, which is enclosed in sheet-iron, and carried, together with the pump, upon an iron frame, so that the pump and motor can be raised and lowered in wooden guides.

H. L.

COAL-MINING IN BOSNIA.

Since coal-mining commenced in Bosnia and Herzegovina, in 1880, it has undergone rapid developments, as is shown by the following table:

<table>
<thead>
<tr>
<th>Year</th>
<th>Production</th>
<th>Number of Workmen</th>
</tr>
</thead>
<tbody>
<tr>
<td>1880</td>
<td>499</td>
<td>16</td>
</tr>
<tr>
<td>1885</td>
<td>23,009</td>
<td>143</td>
</tr>
<tr>
<td>1890</td>
<td>59,342</td>
<td>215</td>
</tr>
<tr>
<td>1895</td>
<td>195,441</td>
<td>750</td>
</tr>
<tr>
<td>1898</td>
<td>268,700</td>
<td>830</td>
</tr>
</tbody>
</table>

Although the production is small compared with those of the larger works of the Austrian Empire, it must be borne in mind that the coal-mines of Herzegovina command but a small area within which their product can be distributed.

Zenica Colliery.—The Zenica-Sarajevo coal-basin contains, in the neighbourhood of Zenica, four coal-seams, three of which are workable, with respective thicknesses of 31, 13 and 24 feet (9.5, 4 and 7.3 metres). Allowing for the numerous calcareous
partings, the thickness of clean coal in these seams may be taken at 23 1/2, 10 and 13 feet (7.2, 3 and 4 metres) respectively, or 46 1/2 feet (14.2 metres) in all. The seams extend in the direction of their strike towards the south-east for a length of about 25 miles (40 kilometres), whilst towards their dip they also appear to cover a very considerable area. The coal is bituminous, of Oligocene or Miocene age. The latest analyses show 4,600 to 5,000 calories, 6 to 10 per cent. of ash, and 2.6 per cent. of sulphur. There are numerous faults, some of which are small hitches, whilst others are serious dislocations. The area worked by the Zenica colliery is at present limited by large faults of the latter nature, the southernmost one throwing up the seams about 260 feet (80 metres).

In mining the coal, care has to be taken to get it as completely as possible, on account of the danger of gob-fires. It is stated that not more than 2 per cent. of the coal is lost in mining. Pit-fires are, however, by no means uncommon, and in order to be better able to battle with these, ventilation has been arranged so that it can be reversed, so as to work either by pressure or by suction, as required. The mine is ventilated by a Capell fan, 6 1/2 feet (2 metres) in diameter, capable at 280 revolutions of exhausting 28,000 cubic feet (800 cubic metres) of air per minute, with a water-gauge of 1.8 inches (45 millimetres). The fan is placed so that its direction need never be reversed, and it can be transformed from a suction into a pressure-fan by simply altering the position of certain hinged doors.

Kreka Colliery.—Here, also, the existence of very large quantities of coal has been proved. The main seam contains 53 to 60 feet (16 to 18 metres) of pure coal, which increases in one of the pits to 79 feet (24 metres), in each case with numerous bands of stone. Attempts have recently been made to combat underground fires in this colliery by the introduction of liquid carbonic acid, which appears to have given satisfactory results up to the present, although the experiments upon it are not yet concluded. Ventilation is performed by means of a steam-jet and by an electrically driven Rateau fan, which has a guaranteed capacity of 14,000 cubic feet (400 cubic metres) of air per minute, with a water-gauge of 1.3 inches (33 millimetres) at 350 revolutions.

In addition, there are two small collieries owned by the State at Ugljevik and Banjaluka.

H. L.

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gave a contrary result. With the electric drill, the drift was advanced 9.8 feet (3 metres), and with the pneumatic drill only 8.5 feet (2.6 metres), in the same time. The experiments could not be concluded, as the electric drill then required repair. A definite decision could not therefore be arrived at, but it was found that the electric machine-drill, in its present form, could not be used everywhere with advantage in mining, as it was too long and too heavy.

An electric percussion drilling machine, made by Messrs. Siemens & Halske, was tried at the lead-and-zinc-mines of Glanzenberg. With 1 horsepower this machine was capable of drilling from 3 1/4 to 4 inches (8 to 10 centimetres) per minute in solid grauwacke, and up to 4 3/4 inches (12 centimetres) in grauwacke slates. Repairs are said to be very simple, and capable of being executed by any ordinary mine-smith.

Explosives.—In the König colliery, in Upper Silesia, exhaustive experiments were carried out with dahmenit A, by working a number of roads and pillars alternately for one month with powder and dahmenit. The results were so unfavourable to dahmenit, on the score of expense, that its further use had been abandoned. The additional cost of explosives came to 2.5d. (21 pfennigs) per ton in driving roads, and 1.2d. (10 pfennigs) in working pillars. The total costs were thus increased by 2.8d. and 1.8d. (23 and 15 pfennigs) respectively, whilst the production of round coal was notably smaller than when powder was used. It was shown in favour of dahmenit, when shots were fired, that the face was clearer of fumes than when powder was used. On the other hand, in the case of blown-out shots, nitrous-oxide gases were noticed to be very troublesome. This was especially the case when cartridges were used that had been stored for several weeks in the pit.

Walling of Shafts.—At the Gottelborn colliery, near Saarbrucken, the main shaft has been walled, not in the ordinary way with brickwork, but with concrete. This concrete consists of 1 part of cement, 3 parts of sand, and 6 parts of diorite, broken small. This mixture is moistened and stamped into the space between the excavated rock and a temporary lining consisting of iron rings 17.7 feet (5.4 metres) in diameter cased with wood, the depth of each layer of concrete being 6 inches (15 centimetres). The concrete is

rammed in and beaten down with iron stampers until it commences to sweat. The result was an excellent wall of very uniform strength.

Rateau Fan.—At the Consolidated Paulus-Hohenzollern colliery, an underground Rateau fan has been erected at the Gemander shaft. Its diameter is 7.87 feet (2.4 metres), and it is worked by a polyphase-motor of 32 horsepower, which receives its energy from a central station, situated some 1 1/4 miles from the shaft, by means of a special system of cables on the surface. At 180 to 190 revolutions per minute, this fan produces 65,000 cubic feet (1,850 cubic metres) of air with a positive water-gauge of 2.36 inches (60 millimetres). The airways are so constructed that by a very simple arrangement the direction of the ventilation can be rapidly reversed, which may be a considerable advantage in many cases, as, for instance, in the case of an underground fire, or of ice forming in the winding-shaft.

H. L.

MINERAL INDUSTRY OF PERSIA.

Die Bodenschatze Persiens. By Ludwig Hennecke. Zeitschrift fur das Berg-, Hutten- und Salinenwesen im Preussischen Staate, 1899, vol. xlvii.,pages 272-274. The apparent object of this paper is to call the attention of the author's countrymen to the splendid opportunities which the mineral wealth of Persia will afford, when the long-predicted, inevitable change in the political conditions of the country takes place.
One of the chief obstacles to the development of mineral industry is the want of decent roads. The mines of precious metals (turquoises, etc.) are State property, but the Government does not work them. Mining leases are granted for periods too short to attract serious enterprise. There is no timbering in the mines, nor is any suitable machinery brought into the interior of the country. Mining methods are, therefore, excessively primitive, and the annual output is incomparably smaller than it might be: the author reckons that only about £8,000 worth of precious stones is got every year in Persia.

In 1889 a British company, financed by the Imperial Bank of Persia, was started, to work the gold and other metalliferous mines, but the expectations then formed have not been fulfilled. Although rich ore-deposits were struck, the necessary fuel for smelting the ores could be obtained only at impracticable distances: the sea-coast is very far from the mines, and so too are the few coal-mines that exist in Persia. Gold occurs in the Bulmus Bash mountains, and at Meshed in the Turkebeh mountains: the placers are largely worked out. though in very primitive fashion. At Far Daod, in the neighbourhood of Bosmishk, are copper-mines, now in part flooded, which are said to have yielded 11 parts per million of gold.

In the Senshan district, veins of pyritiferous quartz are found in granite, yielding 46 parts per million of silver. Argentiferous-galena veins course through mica-schist in the Arghun mountains, and the ore has yielded as much as 675 parts of silver in a million. The Arghun mines are worked by seven shafts, about 325 feet deep; little has been done in the way of providing proper supports, and falls of rock are frequent, not to speak of other accidents. Every year there are about 3 fatalities among the 110 to 125 miners employed. The annual output is very small. Rich occurrences have been certified in many parts of Persia, of mercury, copper, tin, and antimony-ores, realgar, native sulphur, brown iron-ore,

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manganese and cobalt-ores., kaolin, borax, and alum. Workable coal is found in the Elburz mountains, in the Sharud river-basin, and along the banks of the Kevech, while brown coal occurs near Tabriz. Petroleum is characteristic of the Tertiary deposits on the south-western border of the Persian Highlands; it is found, moreover, on the shores of the Persian Gulf, in the neighbourhood of the Dalaki river, in the Darab mountains, etc. Rock-salt also occurs in large quantities.

L. L. B.

THE RAR-EL-MADEN MANGANIFEOUS IRON-MINE, ALGERIA.


The mine of Rar-el-Maden (hole of metal) is situated about 19 miles to the east of Nemours, 29 miles to the north-west of Tlemcen, and 5 miles (7 1/2 kilometres) from the little port of Honaine on the Mediterranean. On approaching the mine one encounters argillaceous shales, which form with the limestone rather high mountains, separated by valleys and deep gorges, in one of which latter occurs the Rar-el-Maden deposit.

The discovery of this mine was easy, because it is indicated by a fine cap of iron and a mass of old cinder, as rich as the ore itself, scattered over one of the sides of the gorge containing the deposit. Recent workings have revealed the place where the ancient Arabs worked a large quantity of the surface-ore; and the hole has since been filled up with sand and pebbles, washed down by the torrents. The ore projects from the abrupt slope of the gorge; and the very form of this deposit shows that a
considerable quantity of ore must have been removed by erosion, although that quantity is slight in comparison with what remains. The origin of the deposit may be explained in all its phases by following the outcrops in one direction or the other. On the surface, it is lost in the form of small veins, which have practically the same bearing; but in some places, and towards the bottom, these veins become thicker, forming here and there small nests of ore, without, however, the limestone being coloured by the ferrous or ferric solutions. The ends of these veins often indicate the direction in which pockets should be sought; and following them leads to a point where they become more numerous and interlaced, so as to form a kind of breccia (this term not being used in its ordinary sense, because all the elements were formed in situ); and it may easily be seen that in one direction one of the elements becomes thicker while another diminishes. In the present case, the particles of iron-ore increase and those of limestone diminish as the outcrop is followed from top to bottom; and the converse is naturally the case when the ore is followed from bottom to top, where the compact limestone is reached. Here the ore is found to be enclosed in the limestone; but the bicarbonate solutions have not rendered complete the substitution of limestone for iron-ore. The Rar-el-Maden deposit, occurring between the schist and the limestone, is a metamorphic contact-bed; and the iron is substituted for the limestone. The author found, near the deposit, pieces of diabase or diorite, which are probably not connected with the origin of the ferruginous sources of the ore; and he is inclined to believe that carbonate of iron will be found in depth.

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The upper layer of the deposit forms finely-divided ore, which is due to the shifting of the measures and also to atmospheric influence. The middle and lower portions are formed of partitioned ore (minerai cloisonne) and of masses in ribbon form, with concretions due to crystallization. These kidneys have a jet-black crust, probably very manganiferous, while the inside forms a crystallization sometimes fibrous and sometimes concentric. One third of the ore is in fine grains, while the remaining two-thirds occur in pieces and in larger or smaller granulations, no doubt very easy to reduce, owing to the porosity and composition of the ore. Working is effected opencast and in steps, and afterwards by drifts for obtaining a greater proportion of large ore. The composition is approximately:---Iron 50.5 per cent. and manganese 6.5 per cent. (making 57 per cent. of metal); phosphorous, 0.015 per cent.; sulphur, 0.025 per cent.; silica, 4 per cent.; lime and magnesia, 1 per cent.; and this excellent ore is, on account of its large proportion of manganese, suitable for producing spiegeleisen containing 12.5 per cent. of manganese. The quantity of ore directly workable is estimated at 500,000 tons; but it is considered, owing to the method of formation, that other lenticular masses or pockets of ore are likely to be found, both in depth and direction, in contact with the schist and the limestone, as well as in the limestone itself, so that the Rar-el-Maden must be regarded among the important mines of rich ironstone. The deposit is 170 feet wide, about 425 feet long, and about 200 feet deep. The iron-ore is conveyed from the mine to the shore by an aerial wire-ropeway, with a carrying capacity of about 20 tons per hour, loaded into lighters carrying from 10 to 14 tons, and then discharged into steamers lying off the shore.

J. W. P. and M. W. B.

THE DEVELOPMENT OF THE TRANSVAAL.
The author sketches briefly, from the Boer point of view, the political history of the Transvaal, upholding boldly the doctrine that the blacks were born to be slaves. Then, after a short description of the physiography and climate of the country, he turns to the oft-told tale of the gold-discoveries.

Previously to 1884, the only known auriferous deposits in the Transvaal were the alluvial placers of Lydenburg and De Kaap. In that year, however, true veins of auriferous quartz were struck in the nearly vertical Cambrian (?) metamorphic schists of the De Kaap Valley. The usual rush took place, the town of Barberton was founded, and for two years the district was the scene of abnormal mining activity, only to be deserted when over-speculation and downright fraud resulted in the inevitable "krach." Then in 1886, the Messrs. Struben discovered the famous Witwatersrand bankets, consisting of rolled quartz-pebbles cemented together by auriferous iron-pyrites and grit. About half of the gold in the cement occurs in the metallic state, and is therefore capable of amalgamation, while the other half, being combined with the sulphur of the pyrites, is refractory to amalgamation. The bankets, of which generally only two beds are workable, are interstratified with quartzites. At the outcrop, by reason of the oxidation of its pyrites, the hard banket is altered into a soft, ferruginous mass, with the whole of its contained gold capable of amalgamation.

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The author describes the necessarily primitive methods of transport and of mining which obtained when what is now Johannesburg was a mere medley of tents and corrugated iron huts known as Ferreira's Camp. As the workings got down to the hard, unweathered rock, mining was carried on at a loss, because the refractory gold (half of the whole) was sluiced away in the tailings. Ruin was, however, averted by the discovery of coal at Boksburg and elsewhere, by the building of railways, and by the introduction of the MacArthur-Forrest cyanide process—with the consequent putting-down of improved plant and machinery.

Very clearly and emphatically does the author set forth the grievances connected with the "monstrous dynamite-concession," the prohibitive freights charged on coal and other articles of necessity by the Transvaal State (Netherlands) railways, the amazing passenger tariff, the excessive import duties, the bribed connivance of the Pretoria Government in the illicit drink traffic, and the equally flagrant connivance of the precious Transvaal police in the thefts of gold by natives.

Despite the refusal of the Volksraad to sanction the reforms recommended by their own Commission of Inquiry, there were on December 31st, 1898, no less than 77 companies working gold-mines in the Transvaal, with a total output during that year of 8,979,428; tons of ore, producing 4,295,608 ozs. of gold, to the value of £15,141,376: this was equivalent to 28 per cent. of the total gold-production of the world during 1898.

L. L. B.

SILVER-MINES IN THE PROVINCES OF COQUIMBO AND ATACAMA, CHILE.


In this paper the author continues the study of the ore-deposits of the Atacama Desert commenced by him in 1897.*

East-north-east of La Serena, between latitudes 29 degrees and 30 degrees south, and within the area of Mesozoic rocks, but not very far from the boundary of the older coastal granite, lie the important mines of Arqueros, Rodaito, Condoriaco and Quitana.

Arqueros.—This deposit was discovered in 1825, and proved to be one of the richest in all Chile. It is said that $20,000,000 worth of silver was got from the Mercedes mine alone, but at the time of the author's visit mining operations had almost
completely ceased. In addition to its great mineral wealth, the deposit is remarkable for the peculiar mode of occurrence of the silver, which is nearly all in the form of a combination with mercury (Ag₆Hg), known as arquerite. The nearly vertical main leader strikes north-west and south-east, and is traversed by another striking east and west; the richest finds of ore were struck at the points of intersection of the two leaders. About 1 1/4 miles farther south is another leader (Cerro Blanco). The chief constituent of the gangue is a manganiferous calc spar, while heavy spar appears to be restricted to the lesser veins. The country-rock is a chocolate-brown brecciform or tufaceous porphyrite cropping out at the surface, and it is noted that the veins are metalliferous only so long as they course through that rock.


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About 200 feet down, another rock comes in, and though the veins go on through it they are quite barren. The Mercedes mine is the only one where the exploration has been carried to a considerable depth (910 feet), but practically no ore has been got below the chocolate-coloured porphyrite. The lowest rock reached is a compact grey limestone of Neo comian age, and here a little silver begins to come in again, but not in payable quantity.

Rodaito.—This mine is about 6 1/4 miles south-east of Arqueros. Here again the chief ore is a silver amalgam, but its constituents are not combined in the same proportions as in arquerite. Moreover, here, horn-silver occurs somewhat abundantly, and, in addition to the gangue-minerals noted at Arqueros, quartz and prehnite play an important part. Mining operations have been stopped here also: the shaft goes down to a depth of about 180 feet vertical, through a rock which in its reddish hue and general appearance recalls vividly the porphyritic tuff or manto pintador of Arqueros. It is, however, a massive melaphyre, the groundmass of which is chiefly made up of broad laths of plagioclase-felspar. Doubtless the Arqueros rock is in reality a tufaceous or brecciform derivative of the Rodaito melaphyre.

Condoriaco.—These mines, about 50 miles from La Serena and 12 1/2 miles from Arqueros, were opened up only about 20 years ago, and are still in full activity. There are no less than 40 of them, the most important being the Mercedes and San Jose mines. Up to the end of 1893, the output from these two mines alone had been 14,400 metric tons of ore, producing about 1,210,500 ounces Troy of fine silver. The percentage of silver is especially high in the San Jose ore, which moreover contains gold in the proportion of about 1-10th of the silver: the gold-content is even higher in some of the smaller mines, such as the Marcellina.

The veins are very various in character, and in some the gangue is chiefly calc spar, in others quartz. In the upper levels are found metales calidos, that is, native silver and horn-silver; while in the lower levels, silver-glance, poly-basite, argentiferous galena and silver-telluride are met with. The predominant rock, which is essentially the "country" of the richest veins, is a light-coloured, quartziferous, brecciform porphyry. A greenish, perhaps more basic variety crops out at the surface, and is generally barren. The latter observation applies to a pinkish variety of the same rock found in the neighbourhood of the Sol mine, and to the manto broceador (microscopically indistinguishable from it) found at the lowest depths, say 1,100 feet, of the Mercedes mine. Small crystals of pyrite are abundant in all these rocks.

Quitana.—About 4 1/4 miles to the west are the argentiferous deposits of Quitana. The only important mine that works them is La Veterana, opened up about 15 years ago. It is probably the richest mine in all the province of Coquimbo, and has been proved down to a depth of 900 feet or so. The deposits are dissimilar in character to those hitherto described: the dominant rock is a highly decomposed, compact "greenstone" or augite-porphyrite. The main leader strikes east and west, and
pitches steeply to the north; it is crossed by a system of minor fissure-veins running north-east or east-northeast, and is richest at the points of intersection with these, but not so at the points of intersection with other minor veins striking north and south. The whole complex is cut across by a great dyke of compact, light-coloured micro-granite. East of this dyke occur the richest masses of ore, while there is a notable "dying-off" of the ore west of it. At Condoriaco, the vein-mass consists largely of mylonized "country," but at Quitana the gangue is an angular breccia of "country" and quartziferous material. At the higher levels, the ores are native silver, horn-silver and iodide of silver; at the lower levels

the ores are silver-glance, polybasite, pyrite, chalcopyrite, arsenical pyrites, etc. The gangue-minerals are quartz, calcspat, and in places laumontite, but heavy spar does not occur.

Chimbero.—Leaving now the province of Coquimbo for that of Atacama, we come to the celebrated silver-mines of Chimbero, whereof the most considerable is the Buena Esperanza. The predominant rocks of this neighbourhood, 38 miles north-east of Copiapo, are Jurassic limestones and sandstones. These sedimentaries are not seen in the mine, however: here the chief rock is a quartz-porphyrite or dacite in an apparently bedded mass, while the metalliferous veins are intimately associated with a basic eruptive (andesitic) rock. But the richest ores do not occur so much in the main leader as at its points of intersection with the "bedding-planes" of the "country," and for some little distance along those planes, which dip on either side about 35 degrees towards the main leader. These planes are slickenside-faces or zones of crush, and in some cases regular friction-breccias have been formed along them. At the outcrop, the chief ore is horn-silver, but at the lower levels silver-glance, polybasite and pyrrargyrite come in. The main leader ceases to be metalliferous at a depth of about 500 feet vertical; to the northward the ore-bearing rocks are completely cut off by the Jurassic sedimentaries; while to the southward several eruptive dykes come in, beyond which the main leader continues (though devoid of silver), and pyrite is met with in abundance.

The author explains the origin of these Chimbero ore-deposits as follows: —In late Mesozoic times, in connexion with the eruption of the augite-porphyrrites, a great fissure was torn in the older porphyrites. On either side of this fissure there was a sagging of the rock-masses, with slipping along lines of weakness or planes of bedding, resulting in crush and brecciation. Thereafter, from solutions percolating upwards, were precipitated the metalliferous ores in the mass that was enclosed between the sedimentary rocks and the porphyrite-dykes, deposition taking place in the fissures and clefts as well as along the "bedding-planes" in their immediate vicinity. Thus originated the pseudo-stratified ore-deposits, dipping on either side towards the main leader, as seen in the Buena Esperanza mine.

Tres Puntas.—Barely 4 miles north of that mine is the silver-ore district of Tres Puntas, formerly very rich, but no longer worked nowadays. The metalliferous veins run in various directions, are often much faulted, and sometimes contorted: they generally become poorer in depth, although some of the mines have gone down very deep. It is proposed to start work again, as the very irregularity of the ore-occurrence induces prospectors to believe that careful search will reveal hitherto undiscovered deposits.

Chanarcillo.—The glory has departed, too, from the Chanarcillo silver-mines, at one time the most productive in all Chile, and perhaps the richest that have ever been discovered. Though the author admits that they have been fully described by previous observers, he thinks it advisable to describe them anew, adding some fresh details as to the microscopic characters of the rocks. One important feature which differentiates this district from the others dealt with in this paper, is that the ores are
richest where associated with the sedimentary rocks, and all but vanish where the eruptives come in. L. L. B.

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MINERAL INDUSTRY OF ECUADOR, SOUTH AMERICA.

At no time under the Spanish sovereignty did the mineral industry of Ecuador attain a development comparable with that of Peru, Bolivia, Colombia or Mexico. Since the declaration of independence, one of the principal checks to progress in mining has been the want of good roads. Moreover, much of the area where minerals could be found is covered by dense tropical forest.

The uninterrupted belt of porphyries which runs along the chain of the Andes is seamed with metalliferous veins, which mostly in the south of Ecuador are gold-bearing, while in the centre and north they are silver-bearing. All the streams which run down from the mountains to the Pacific seaboard, with a course from east to north, carry gold sands in their waters, while their banks are dotted with alluvial gold-deposits.

Mining was started in the Zaruma gold-field as long ago as 1549, and, after a long period of abandonment and various more or less unsuccessful fresh starts, the field is now being worked chiefly by an American company. Veins of auriferous quartz are crushed, containing about £3 6s. worth of gold per ton: of this only about a third can be extracted by amalgamation, the remainder being got out of the tailings by the cyanide-process. An Ecuadorian company is also at work in the field, restarting some old mines that date from the Spanish domination, and very rich samples of quartz have been got from this property. The average gold-content of the Zaruma ores is 3/4 to 1 ounce per ton. Going from the surface downwards, to a variable depth, the gold occurs in the metallic state, and it is found that the deeper down the workings go, the more do the sulphides increase, and gradually also the proportion of gold. Thus in the Bonanza mine, there is as much as 20 ounces of gold per ton, with a large percentage of silver. The thickness of the veins, of which there are 200 or more proved, varies considerably, but the normal thickness is about 36 or 40 inches. This gold-field is not far from the coast, water-power is abundantly available, good timber is to be got in the neighbouring forests, and the most urgent need at present is a tramway for the transport of machinery, etc.

Another American company has re-explored the vast gold-placers of the province of Esmeraldas in the north of Ecuador: these were in part worked when the country was under Spanish rule. Canals are now being dug to carry water for hydraulicking the alluvial deposits. These are 80 feet thick, and the first washings carried out on a great scale have yielded 15 to 20 centavos of gold per cubic metre [of gravel]: say, about 9d. per cubic yard. The placers and river-sands in the east of the country would prove highly remunerative and easy to work, but so far the necessary capital has not been forthcoming.

Abandoned silver-mines are to be found in the provinces of Canar and Aznay. One mine, near Azogues, was re-explored and started afresh in recent years (1891-1894), being worked by means of three shafts and several levels. The lessees exported to Germany 70 tons of ore, containing no less than 9 parts of silver in 1,000. Water-power, timber, and firewood were all available within a short distance of the mine. Argentiferous galena also has been proved in the province of Aznay, but here again the want of capital has stopped further operations, and the mining industry of Ecuador is still in its swaddling-clothes.

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The Mining Code, amended in 1892, and largely adapted from that of Chile, is very liberal.

L. L. B.

THE GOLD-DEPOSITS OF NEVADA COUNTY, CALIFORNIA.

Nevada County, the leading gold-mining county in California, is located about 100 miles east of San Francisco, in the Sierras. The county is 75 miles long, and from 25 to 75 miles wide. The deposits of auriferous gravel, often 200 feet deep, mark the ancient river-channels, but are, for the time being, out of reach, on account of the defects of the older methods. Some of this is now recovered in drift-mines, where from 2 to 5 feet of the gravel near the bed-rock is taken out and washed, paying from 8s. to £2 12s. (2 to 13 dollars) per ton. Quartz-mining properties, abandoned because they were thought to be exhausted, have been re-opened, and new levels driven, resulting in a number of cases in finding new and rich leads. In order to secure a permanent water-supply for the various mines, several companies have constructed in the mountains a series of artificial lakes, and leading from these 800 miles of canals, at a cost of many millions of dollars.

There are, at the present time, two centres in the district, viz:—Nevada City and Grass Valley, 6 miles apart. In the former, the rocks are diabase, granite and slate. The larger veins are near the contact of the granite and slate, and vary from 2 to 6 feet in width, though important mines are wholly in the granite, where the veins run from 6 inches to 3 feet. The ores are pyrite, chalcopyrite, galena with gold, the higher grades running as high as £60 (300 dollars) and the lower from £1 12s. to £8 (8 to 40 dollars) per ton. The leading mines are from 1,000 to 1,800 feet deep.

In the Grass Valley district, the veins average about 2 feet, and 4 inches veins have been worked with profit. The rocks are similar to those of the Nevada City district, with the addition of serpentine and diorite. The gold ore is associated with pyrite, chalcopyrite and zinc in quartz and a considerable amount of free gold is obtained.

A remarkable feature in the Grass Valley district is an enormous air-compressor, installed at the North Star mine on Massachusetts Hill. A 30 feet Pelton wheel, constructed of steel, with bronze cups, and making 65 revolutions per minute, is driven by a water-pressure of 335 pounds per square inch, controlled by a nozzle regulated by an automatic governor. A duplex air-compressor is attached directly to the axis of this wheel, with the low-pressure cylinders 30 inches in diameter and the high-pressure cylinders 18 inches. The output of the compressor is 300 horsepower, and the air, at 90 pounds pressure, is conveyed 800 feet to a Corliss pneumatic hoisting-engine of 100 horsepower, and to a 75 horsepower compound pump. The air also works the drills in the mine.

X. Y. Z.

NEWHOUSE TUNNEL, COLORADO.
This tunnel is 7,670 feet long, and is close to the veins of Seaton mountain. When completed it will be about 5 miles long, reaching the Eureka mine at

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Central City, 1,500 feet below the surface. In the distance to be driven there are 1,140 known veins, of which 200 are mines. The greatest depth of the tunnel will be 2,400 feet below the surface. The average depth of cutting all lodes will be almost 2,000 feet. The tunnel measures 16 feet by 12 feet, and power will be furnished to anyone desiring to work a property through the tunnel, the object being to have 500 men at work on the various lodes within 12 months.

X. Y. Z.

GRAVEL-MINING IN IDAHO.

The Twin Springs Placer Company own 3,500 acres of proven gold-bearing ground on Boise river in Elmore county. After recounting the careful operations by which the value of the ground has been conclusively proved, the author states that the principal workings, thus far, begin 1,500 feet up the river from Twin Springs. There is a flume, 9 miles long, conveying water from Brown Creek, Logging Gulch and Sheep Creek to the benches. The main flume is 6 feet 2 inches wide, 7 feet high, to carry 5 feet depth of water; the grade is 10.8 feet per mile, and its estimated capacity is 10,000 miner's inches. Along the line of the flume are several high trestles, one 127 feet above a deep gulch, also 2 tunnels. Sheep Creek, which furnishes the main water-supply, is on the south-eastern side of Boise river, whilst Twin Springs and the chief benches, where piping is now carried on, are on the opposite side. A distinctive feature is the inverted syphon which brings the Sheep Creek water across Boise river and discharges into the flume on the edge of the opposite bluff. The difference of elevation between intake and discharge of syphon is 35 feet, the total length of syphon is 1,780 feet and the bottom of syphon (supported on a bridge 110 feet above the stream) is 410 feet below the intake's horizon. The interior diameter of the intake is 6 feet, and the remainder of the pipe is 4 feet in diameter. The upper pipe-section on either side is 3/8 inch steel; middle, 1/2 inch; bottom section, 5/8 inch; and elbows, 7/8 inch thick. There are 4 expansion-joints, and air-valves are provided at each 50 feet in elevation. The pipe was hauled from Boise to Logging Gulch in 15 feet sections, there lowered by windlass on a truck, thence carried along the flume-grade to the syphon site, next lowered and hoisted into place, and finally rivetted. In the construction throughout there was no mishap of any sort, and from the first the syphon has never leaked nor occasioned a moment's trouble or uneasiness.

In character, the gold in large part is clean, bright, medium weight (distinctly so compared with Snake River gold), while the fine colours mostly have a much greater compactness than flour gold, so that a much larger proportion than usual (in Idaho) is recovered in the sluices. The gold is comparatively free from silver, the fineness varying from 0.840 to 0.912. Ordinarily, these gravel-beds are from 15 to 70 feet thick, with values quite generally well distributed from top to bottom. The gold-content varies from 7 1/2d. to 2s. 11d. (15 to 70 cents) per cubic yard. In the benches thus far opened, there are not many large boulders, and piping is conducted with fewer obstacles than usual.

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VERIFYING THE VERTICALITY OF BORE-HOLES.


The method consists in suspending at a sufficiently great height, exactly over the centre of the bore-hole at the level of the soil, a plumb-line carrying at its lower end a loaded cylinder nearly as large as the hole. For a hole 8.7 inches (22 centimetres) in diameter, the cylinder has a diameter of 8.3 inches (21 centimetres) and is formed of wooden laths nailed to two slight discs, being loaded with 15 pounds (7 kilogrammes) of lead-shearings, so that it can be easily destroyed by the boring-tool if it should fall to the bottom. On being let down into the hole, the cylinder slides along the inside, following its deviations. If the deviation, d, from the centre at the level of the surface, the height, h, of the point of suspension, and the depth, n, of the cylinder in the hole be measured, the deviation, D, at that level will be given with sufficiently near approximation by the formula \( D = d \times (h + n) / h \). The value of the method was tested by tracing on a plan, at the surface-level and also at a depth of 295 feet (90 metres), 20 bore-holes distributed over a circumference of 23 feet (7 metres) diameter for
freezing the ground, so as to permit of sinking a shaft 16 1/2 feet (5 metres) in
diameter and put down to the depth of 295 feet (90 metres). With two exceptions, the
holes were found to have been bored truly, not one of them having entered the
portion to be excavated, while the greatest deviation observed was 26 inches (0.656
metre).

J. W. P.

METHOD OF WORKING THIN SEAMS.
Note sur une Nouvelle Methode d'Exploitation appliquee aux Gites Minces. By —
No. 18 coal-seam, 31 inches (80 centimetres) thick, worked at the Lens colliery, is
tolerably regular, having only 25 per cent of disturbances; and the average dip is 15
degrees. Down to the end of 1896, this seam was generally worked by rising stalls, a
main rolleyway being driven, from which the stalls were turned off every 52 feet (16
metres) and, in the regular portions, carried to a distance along the rise of about 240
feet (75 to 80 metres). At this height, a fresh level was driven, from which a second
series of rising stalls were turned away, and so on until the stage was completely
worked out; but in the irregular portions the coal was taken out as best it might be. As
regards the actual getting of coal it would at first sight appear that this method has
many advantages; but this was not found to be the case as regards packing and
laying the rails, so that it was eventually superseded by a new method of long
forward stalls with complete packing.

This latter method consists in taking up from the rolleyway an incline which is carried
to the height of 400 feet (120 metres); and at its head a compressed-air winch draws
up the packing material. On each side of the incline, forward stalls are driven, one
above another, and served by passes. The roads, about 130 feet (40 metres) apart,
are driven for about 330 feet (100 metres) from the incline, at which distance an
incline is again passed, whereon are again established the three 130 feet (40 metres)
stalls, and so on; and, when the boundary of the district is reached, the

first incline is continued by pushing it forward 400 feet (120 metres) thus starting a
second intermediate stage. The packing material is drawn up the incline by the
winch, the tubs being led to the top of the stalls and tipped there, and it is afterwards
packed in the stall by the afternoon shift by means of plate-iron shoots.

This method has now been in operation for two years with a considerable reduction
in the cost of getting, the men being exclusively engaged in miner's work, i.e., getting
and timbering. Besides the lower cost of getting— almost 50 per cent. as compared
with the method by rising stalls—the expenses under other heads have been
reduced, especially the leading of packing material, the services of a night-loader
have been dispensed with; and in addition the suppression of the incline-heads in the
roof and the complete packing of the stalls afford conditions very favourable to
safety, while the tight packing of the stalls is excellent as regards ventilation and the
removal of fire-damp.

J. W. P.

EXPERIMENTAL EXPLOSIVES GALLERY AT THE MARIA COLLIERY, NEAR
HONGEN, IN THE DISTRICT OF AACHEN.
Die Versuchsstrecke auf der Steinkohlenlange Maria, bei Hongen, im Bergreviere
illustrations in the text and 1 plate.
The proposed order by the Bonn mining authorities as to rendering coal-dust non-
dangerous has induced the colliery-owners of the Wurm and Indemulde districts to
erect an explosives testing-station; and its erection, maintenance and management
have been entrusted to the authorities of the Bardenberg School of Mines.
The Maria colliery was selected for the erection of this experimental gallery, chiefly on account of the fact that natural pit-gas was there available. The experimental gallery is constructed along the southern edge of the waste-heap, and is built into a block of masonry. Close to this lies a building containing the fan and ball-mill; and 60 feet distant, and facing it, lies the house from which observations are made, this being so placed that the central line of the building intersects the axis of the experimental gallery at a distance of 50 feet from the block of masonry. Westward from this house there are two boilers, which act as reservoirs of pit-gas. A short distance away is the explosives magazine.

The gallery is elliptical in cross-section, 6.1 feet (1.85 metres) high and 4.6 feet (1.4 metres) wide, and consists of frames made of strong double T-iron which are spaced 17.7 inches (450 millimetres) apart for the first 32.8 feet (10 metres), and 22 inches (560 millimetres) apart throughout the rest of the length of the gallery. The frames are lined internally with three thicknesses (breaking joint) of pitch-pine 1.2 inches (30 millimetres) thick, grooved and tongued. The planks and supports are coated with tar mixed with a certain amount of cement. The gallery abuts against a block of masonry, which is bound together with rails, and is 13 feet (4 metres) in height and 11.9 feet (3.6 metres) square in plan. The masonry extends beyond the bottom end of the gallery for a thickness of 3.3 feet (1 metre) externally and 2.9 feet (90 centimetres) internally. The projecting length of the gallery amounts to 131 feet (40 metres). The gallery slopes towards the mouth with a dip of 1 in 100, and is connected with a ditch which passes in front of it. There are 22 sight-holes in the length of the gallery, situated three-quarter way up its side. They are spaced closer together near the closed end and farther apart.

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towards the open end. Each sight-hole consists of two cast-iron frames, bolted together, between which plates of glass 1 inch (25 millimetres) thick are secured and rendered air-tight by means of rings of asbestos and india-rubber. The available opening of these windows is 9.8 by 4.7 inches (250 by 120 millimetres). In the roof of the gallery, there are 4 safety openings, 9.8 inches (250 millimetres) in diameter, which are closed by means of wooden plugs attached to chains; and these are distributed through the first 33 feet (10 metres) of length of the gallery.

The gas-intake enters the lower part of the gallery 8.2 feet (2.5 metres) from the cannon. In the roof there is a charging-hole for the coal-dust to be tested. The latter falls upon the vanes of a fan, which can be rotated at a rapid speed by means of gearing in the proportion of 1 to 6, and which also serves for the uniform diffusion of gaseous mixtures.

In order to be able to form two explosion-chambers of 353 or 706 cubic feet (10 or 20 cubic metres) capacity, there are two fixed iron frames furnished with loose iron rings situated at distances respectively of 16.2 and 32.4 feet (4.93 and 9.86 metres) from the closed end. These can be covered with paper when experiments are being carried on, and thus form the explosion-chambers. Heating-pipes have been built in so as to enable the chambers to be warmed in case of need by means of steam.

In the block of masonry, there is only space for one cannon, situated close to the bottom of the gallery. Experiments having proved that shots starting from the bottom and pointing upwards produce the longest flame, the cannon is inclined upwards at an angle such that the prolongation of its axis cuts the roof of the gallery 32.8 feet (10 metres) from its end. The shots are fired electrically from the house destined for the observers. After a shot has been fired, the gallery can be freed from gas by means of a conical iron tube built into the block of masonry, the tube being so connected with the fan that communication can be closed or opened as required.

The building containing the engine is divided into two spaces: in the front one is a Pelzer fan, 19.7 inches (500 millimetres) in diameter and having a maximum capacity...
of 2,100 cubic feet (60 cubic metres) per minute. It is driven by means of belting from a 10 horsepower engine. This engine also drives a Krupp ball-mill, capable of grinding 33 pounds (15 kilogrammes) of dust per hour through a sieve of 8,064 meshes per square inch (1,250 meshes to the square centimetre). The ball-mill was erected, as it was not always possible to obtain natural coal-dust in sufficient quantity and in suitable form; and it was also thought well to institute systematic tests on the coal of all the seams, while a provision of artificial coal-dust was indispensable in the tests on explosives, etc., that it was intended to carry out.

The building for the observers has, on the side nearest the gallery, a slit at the height of the observer's eye. This slit, 7.8 inches (20 centimetres) wide, is closed by a sheet of glass, 0.8 inch (20 millimetres) in thickness. This building, next to which there is a small office, contains a gas-meter with a capacity of 530 cubic feet (15 cubic metres) per hour, used to measure the gases introduced into the explosion-chamber; an electrical shot-firing machine; scales, barometer, thermometer and hygrometer.

The pit-gas is forced into the reservoirs by means of a steam-jet; and the whole length of the experimental gallery is furnished with water-pipes and with tubes leading to the air-compressor of the mine. By this means compressed air can be conveyed into the gallery, and can be employed when it is required to produce flames of exceptional length. H. L. and J. W. P.

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THEORY OF SAFETY-EXPLOSIVES.*

This article consists of a reply by the author to criticisms upon his previous papers.† The labours of the French Commission have proved that safety-explosives must fulfil the two following conditions:—(1) That its temperature of detonation shall remain within definite limits, which must not pass 2,200° Cent.; (2) that it shall detonate and not deflagrate. According to French law, the use of black powder is absolutely forbidden in mines, and it is enacted that an explosive to be used in coal must have a temperature of detonation of less than 1,500° Cent., and in stone of less than 1,900° Cent. Since then, it had, however, been found that safety-explosives that fulfil the French conditions show remarkable differences in their safety when used in fire-damp. The author attempted to show that these differences could not be explained by the temperature of explosion within the limit of 2,200° Cent., but that the velocity of explosion had an important influence upon the question of safety. In making this statement he still adhered, however, to the French theory in this sense, that the conclusion which he had stated was only true for safety-explosives, namely, such explosives as fulfilled the above conditions; and it was, therefore, not correct to state that he had attempted to replace the French theory by one of his own.

H. L.

DETONATION OF FAVIER GRISOUNITES.

In consequence of a further accident occurring through the miss-fire of grisounite-carpets, the French Fire-damp Commission decided to carry out some experiments as to the manner in which the grisounites decompose, with the object of determining whether it were possible to realize experimentally the manner of exploding which appeared capable of accounting for the miss-fires to which the accidents were attributed. This explanation consists in supposing that (1) owing to defects of priming, or of the priming substance, a grisounite-charge may ignite and
fuse slowly into the shot-hole, and (2) owing to circumstances inducing an increase of pressure this fusing decomposition may suddenly be changed to detonating decomposition.

The experiments were carried out by the engineers of the Esquerdes powder-mill on (a) grisounite-couche (for coal), composed of 4.5 per cent. of tnnitronaphthaline and 95.5 per cent. of ammonium nitrate; and (b) grisounite-roche (for stone) composed of 8.5 per cent. of dinitronaphthaline with 91.5 per cent. of ammonium nitrate, the former explosive being merely pressed slightly into cases of thin cardboard, and about four-fifths of the latter being compressed into a hollow cylinder containing the rest of the charge in a pulverized state, for receiving the action of the detonator and transmitting it intensified to the compressed portion of the charge.


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Endeavouring to imitate the conditions that govern the explosion of charges in a shot-hole, the engineers placed in a brass tube a cartridge of grisounite-roche, of which one-fourth the pulverulent charge, or 0.1 ounce, had been replaced by the same weight of very fine gunpowder; they inserted in the latter the end of a safety-fuse, and surrounded the whole with sand that filled up the tube, which latter was closed at each end. On the charge being fired by the fuse, no report was heard; and, after 2 minutes had been allowed to elapse, the tube was dismounted, when the cartridge was found unaltered, the priming of gunpowder having been entirely consumed, while the surface of the Favier explosive in contact with it was scarcely blackened.

The engineers then endeavoured to ascertain whether the fusing decomposition could not be obtained by the use of detonators under conditions producing a miss-fire; and for this purpose they employed 4 detonators of increasing power. On the above-named experiment being repeated, but with one of the most powerful detonators placed at the end of the fuse, it was found that the portion of cartridge where the detonator had exploded was broken, but that there was no trace of detonation of the rest of the charge, not even of the pulverulent substance.

In order to decide the question whether, under the supposition that the pulverulent substance might explode without the explosion being propagated to the compressed matter, the latter could ignite so as to give the fusing decomposition, a special cartridge, in which the density of the compressed portion had been increased from 1.15 to 1.60, was placed at the bottom of the lower one of two cylindrical leaden blocks with concentric holes, 1.38 inches (35 millimetres) in diameter, on a plate of chrome-steel, 1.18 inches (3 centimetres) in thickness. On the pulverulent substance being fired by a detonator, it was always found that the fragments of the compressed portion remained absolutely unchanged.

It follows from the results of the numerous experiments made under the most varied conditions, without anything in the nature of delayed explosions having occurred, and without there having been any confirmation of the hypothesis put forward to account for them, that it must be concluded, with a probability verging on certainty, that the explosive action of the grisounites is attended by no circumstance that need prevent or restrict their use; but the workmen employing them should, when they notice any sign of an incomplete explosion, allow a few minutes to elapse before returning to the shot-hole, and in the meanwhile should remain in a place of safety.
INCANDESCENT IGNITER.
During the last two years, igniters, called spaltgluhzunder, taking a middle position between spark and incandescent igniters, have been used in the Dortmund district for firing single shots. They are essentially incandescent igniters; but the platinum-wire is replaced by finely-divided conducting substance, such as graphite or coal-dust, mixed with the igniting substance, and the resistance opposed to the current is far greater than that of a small platinum-wire, being generally about 5,000 ohms. The quantity of current required to ignite the few particles of dust between the ends of the poles is very slight, not exceeding a few thousandth parts, or at most one hundredth of an ampere; and such igniters combine the advantages of both spark and incandescent ignition without their disadvantages. Owing to the conducting capacity of the igniting substance, each detonator can be tested before being used, so that, with proper manufacture and treatment, miss-fires should not occur; and yet the resistance of the igniter is so great that, when iron wire is employed, the resistance of the conductor is a matter of no consequence, so that this cheap material may be used, and the insulation of the conductor need not be very perfect. These igniters have lately been made with a resistance of less than 100 ohms, so that they have been used in wet workings with uncovered iron wires for conductors. Some tests have been carried out at the testing-station of the Westphalian Miners’ Provident Fund, to ascertain the degree of reliance that can be placed on these igniters; and for the sake of simplicity in testing, the igniters were tested before they received their detonating cap, a double iron-wire cord, 330 feet (100 metres) long, being used for the conductor; and not a single miss-fire occurred with the 1,500 igniters tested. In some trials of low-tension igniters for separate shots, a conductor consisting of two naked iron wires, 0.04 inch (1 millimetre) in diameter, and 164 feet (50 metres) long, was used, and the conductors were immersed in water for a length of 10 feet (3 metres), while there was a distance of only 4 inches (10 centimetres) between the two; and yet, notwithstanding these very unfavourable conditions, not one of the 1,500 igniters missed fire. To ascertain whether the efficiency of these igniters would diminish in the course of time, 500 were stored for 8 weeks, and then fired without a single miss-shot.
When using the new igniters for series-firing, to make sure that they will not miss-fire, two conditions are necessary: —(1) Each igniter must have, as far as possible, the same resistance; and (2) a firing-machine must be used in which the quantity of current is not dependent upon the speed with which the handle is turned or upon the skill of the operator. In the first experiments at the above-named testing station, the second condition was not satisfied, as the shots did not ignite together, although each individual igniter was afterwards exploded by a strong current; but satisfactory results are now obtained with a firing machine, the efficiency of which does not depend upon the operator. J. W. P.

CONSUMPTION OF EXPLOSIVES IN THE DORTMTUND DISTRICT, GERMANY.
The explosives used may be divided into three main groups, the first of which is black powder of three different compositions, the difference chiefly consisting in the saltpeter content, which is 65, 70 or 75 per cent.; the second group consists of
dynamite, almost exclusively used in the form of gelatine-dynamite; and the third comprises nitrate-of-ammonium explosives and carbonit, including ammonium-carbonit C, dahmenit A (Victoria powder), Koln-Rottweiler safety blasting-powder, roburite I, westfalit, carbonit (Wittenberger wetterdynamit) and kohlencarbonit I. and II.
The total quantity of explosives used during 1898 was 4,033.257 tons, in the proportion, for the three groups above-named, of 332.292 tons, 2,247.799 tons and 1,453.166 tons respectively, for a total coal-production of 51,001,551 tons, showing a proportion of 176 pounds (79.1 kilogrammes) per 1,000 tons of coal drawn. In that year, 14 pounds (6.5 kilogrammes) of black powder was used against 17 pounds (7.8 kilogrammes) in 1897; and the dynamite-consumption had diminished, while that of safety-explosives had increased.

J. W. P.

UNDERGROUND EXPLOSIVES Magazines.


This series of experiments was made in order to determine the conditions under which small dynamite-magazines may be allowed underground, in which the daily consumption of explosives in the mine may be stored. The quantity of dynamite that is stored at one time varies, in general, between 1 and 5 boxes (44 to 220 pounds or 20 to 100 kilogrammes).

Two questions had to be determined: (1) what was the amount of destruction that the explosion of isolated cases of dynamite would cause to the essential elements of the ventilation, viz., doors and fans; and (2) was it possible by suitably arranging the cases to prevent the communication of the explosion from a case to its neighbours.

The first experiment was made with the object of determining the damage caused by the explosion of a case of dynamite to the doors and fans placed at different distances from the explosive. An old disused drift was employed for this experiment; a stopping was put into the drift 492 feet (150 metres) from its mouth. It was formed by a brick wall which was close stowed at the back for a length of 32.8 feet (10 metres). At the base of this wall, the case containing 44 pounds (20 kilogrammes) of No. 1 dynamite was placed; in front of it, a first door was erected 32.8 feet (10 metres) from the dynamite; a second door, 164 feet (50 metres) from it; and finally a wooden framework representing a fan was erected at a distance of 459 feet (140 metres). The gallery was 43 square feet (4 square metres) in cross-section. It was timbered, but the timber was in pretty bad order, and for a certain distance from the dynamite was repaired by means of middle props supporting the caps. The doors were built in brick walls 1 foot (0.3 metre) thick, the section of the doorway being half of the total section of the drift. The door itself was made of planks 4 inches (10 millimetres) thick, fastened to a wooden frame and fixed to two long iron straps carrying the hinges. The first door opened inwards, and the second door outwards. A light six-armed wooden frame was built to represent the skeleton of a fan; it occupied about two-thirds of the section of the gallery, and could be worked from the outside by means of a rope passing over a pulley.

The explosion of the dynamite produced an air-blast at the open end of the drift, and carried a cloud of smoke outward for a distance of about 16 feet (5 metres), followed by two smaller blasts, with intervals of about 1 second, and successively weaker. On entering the drift, it was found that one of the light wooden planks which formed the wings of the fan had been loosened, but nothing had been broken. A real fan,
therefore, which would have been much stronger, would have suffered no damage. The second door, 164 feet (50 metres) distant, had been blown away bodily, and flung a distance of 69 feet (21 metres), the ironwork having been torn off and twisted. The frame of the door was shaken, but the brickwork was intact. Beyond this, the roof of the drift had broken down; a strip of rock had fallen from the roof along the course of the drift for a length of 49 feet (15 metres) from the stopping, which barred the gallery. In all other places the woodwork was uninjured, but some of the middle props were thrown down. Four lamps, which had been placed on the floor of the drift at 66 feet (20 metres) from each other, beyond the second door, were all overthrown, and, therefore, extinguished. A lamp, which had been hung up beside the last one, was not extinguished. Upon the whole, it may be said that the conditions of the experiment were, as should always be the case, more severe than in actual practice. As regards fans, the experiment proved conclusively that at a distance of 492 feet (150 metres) they would not have been damaged by the explosion of one isolated case of dynamite. This condition might always be realized, having regard to the depth at which coal-mines are now working, and this question may therefore be disregarded. As regards the doors, the results obtained deserved closer discussion. The doors closing the magazines were completely swept away up to a distance of 164 feet (50 metres). The same result would probably have been the case at a distance of 492 feet (150 metres) or perhaps even of 656 feet (200 metres). There is therefore no hope that the underground magazines could be so built that in case of explosion the doors closing them should remain undamaged. In no case, however, should the magazines open into two different roadways, free communication between which might short-circuit the ventilating current in a section of the mine. If there are two entrances to the magazine, it must be placed parallel to one roadway and away from it, so that if completely destroyed the general scheme of ventilation will not be affected.

In addition to the doors of the magazine, attention must be directed to the much more important question of the doors that may exist in the neighbouring roadways where they are used for directing the air-current into the workings. These doors will be much less exposed, because they will only be reached by the explosive wave after this had been split up into several directions on leaving the magazine. On condition that the dynamite shall be stored at a distance of at least 656 feet (200 metres) from doors used for ventilation, no serious risk will be run. As an additional precaution, this distance may perhaps be doubled in certain exceptional circumstances, as, for instance, in the case of a pair of pits where the entire ventilation of the mine depends upon the doors that separate these pits from each other; and if so great a distance cannot be obtained, very strong iron doors should be used.

The second series of experiments was made with the object of finding a means of preventing the accidental detonation of a case of dynamite in an underground magazine from being transmitted to the neighbouring cases. The experiment was performed by enclosing each case of dynamite in a brick recess closed by an iron door, and separated from its neighbours by greater or lesser distances. By this means it was hoped that the case could be protected against the shock of explosion and the penetration of the heated gases. A drift was selected 95 feet (29 metres) long and 43 square feet (4 square metres) in area. It was walled with brickwork 14 inches (0.36 metre) thick for a length of 36 feet (11 metres) from the closed end, the remaining 52 feet (16 metres) being timbered. The brickwork was built with lime-mortar, had only been finished a fortnight, and

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was therefore no stronger than dry-stone walling would have been. In this brickwork three recesses were left for the boxes of dynamite. They were placed at a mean height of 20 inches (0.5 metre) above the floor of the drift. Their brick walls were 12 inches (0.3 metre) thick. They were closed by doors of sheet-iron 0.4 inch (10 millimetres) thick, hanging by hinges at their upper edge and closed by a bolt at the bottom. The first recess was 3 feet (0.9 metre) from the end of the drift, the second was 10 feet (3 metres) from the first, and the third 20 feet (6 metres) from the second. The middle case of dynamite was fired, the door of the central recess being left open. The doors of the two side recesses were dropped, but the bolts were not shot home, as might in practice occur as the result of negligence. The detonation was not transmitted to either of the neighbouring cases, and their doors appeared not to have suffered in the least from the effect of the explosion. The case 10 feet (3 metres) away was only a little shifted in its recess, but without showing any indication of the planks being broken. The bad condition of the ground and the imperfect setting of the mortar had allowed sufficient lateral pressure to be transmitted to push in a little the brick chamber and at the same time to crack the cast-iron frame, which was carrying the door. The timbered portion of the gallery which was beyond the mouth of the brick portion was uninjured, and there were no falls, as might have been expected from the previous experiments; in this case, however, the timbering was new, whilst in the previous one it was old and in bad order.

The conclusion which might be drawn very definitely from these experiments was that even in exceptionally bad ground there was no danger of the transmission of explosion between cases of dynamite placed in separate recesses 10 feet (3 metres) apart. These experiments allow of a certain number of rules being formulated, the application of which would appear to prevent the possibility of any serious danger to a mine in the case of an explosion in an underground dynamite-magazine.

Each case should be enclosed in a brick recess closed by an iron door at least 0.4 inch (10 millimetres) thick, hung by hinges above so as to be self-closing, and so arranged that the weight of the door must close it thoroughly. It must be kept shut by means of a bolt at the lower edge.

These recesses must be 13 feet (4 metres) apart in soft ground, like coal and schist, and 10 feet (3 metres) in hard ground, such as grit. The recesses shall be placed along the same side of the magazine, and never along its two opposite walls.

The magazine must be prolonged at each end into closed ends, at least 10 feet (5 metres) long, as shown by Fig. 1.

[Fig. 1. Plan of magazine layout.]

The closed ends may be utilized as chambers for opening the cases of dynamite and distributing explosives. Each magazine shall communicate only with one roadway in the mine, and the communication from magazines to take more than 5 boxes shall be by means of two separate roadways closed only by light lattice-doors, so as to secure sufficient ventilation.

Every magazine shall be at least 656 feet (200 metres) distant from any ventilating-door and, as far as possible 1,312 feet (400 metres) from any main ventilating-door, the destruction of which might cut off the ventilating-current from either the whole mine or an important section thereof. H. L.

SINKING SHAFTS THROUGH QUICKSAND.
Whatever be the depth at which water-bearing sands may occur, precautions should never be neglected; and in sinking shafts through such measures the leading principle that should guide an engineer is the necessity of succeeding at any cost, although there is a limit of cost beyond which the work should not be undertaken. It is not always, however, the method that appears at first sight to be the most economical that is so in reality; and, although it is important to acquire a previous knowledge of the measures to be passed through, too much reliance must not be placed in the information afforded by bore-holes, especially as regards the shifting nature of the strata.

The No. 6 plant of the Bascoup colliery was to consist of two shafts of 14 feet (4.25 metres) in diameter; and their tubbing was to be carried up to within a few feet of the surface. Instead of using the definite tubbing for keeping back the water, the late Mr. Alphonse Briart decided to employ for this purpose an additional tubbing, of larger diameter, that should serve as a coffer-dam; and this outside tubbing need not be of great strength, or very carefully fitted, because it would not have to stand any great pressure of water, and would be removed on the completion of the sinking. It consisted of cast-iron rings 1 inch (25 millimetres) thick, 3 1/4 feet (1 metre) high and 18 feet (5.5 metres) in outside diameter, divided into 10 segments, cast with 4 inches (10 centimetres) flanges, drilled with holes 9 inches (23 centimetres) apart. The first beds of sand were passed through by means of sheet-piling, but, on the quantity of water attaining 660,000 gallons (3,000 cubic metres) per 24 hours, a cutting crib was lowered carrying the ten lower rings. Pressure was given by 4 screws passing through strong oaken beams under a bed of pebbles, and exerting their effect on other beams fitted with wrought-iron plates laid on the top of the tubbing; and the passage of the cutting-shoe was facilitated by grabs, trepans, etc.

When the temporary tubbing was finished to within 33 feet (10 metres) from the surface, the water was still raised by three pulsometer-pumps, placed in the free space intervening between the tubbing and the inside of the shaft; and both shafts were cleared of sand down to the limestone, after which the sinking was continued by the ordinary method of pumping the water. Inside the temporary tubbing, a ledge was left 2 feet (60 centimetres) wide by 8·20 feet (2·5 metres) high, for forming the joint; and under this ledge the sinking was continued, while the diameter was increased progressively until the required dimension was attained.

The sinking was continued to a depth of 8·2 feet (2·5 metres) into the top of the Coal-measures in No. 1 shaft, and 15·7 feet (4·8 metres) in No. 2 shaft,

at which points the wedging-cribs were laid for carrying the tubbing, which consisted of rings 14.6 feet (4.45 metres) in diameter, having 4 inches (10 centimetres) flanges, and a thickness of metal decreasing from 1.18 inches (30 millimetres) for the 15 lower rings to 1.08 inches (27 1/2 millimetres) for the succeeding 15 rings, and to 0.79 inch (20 millimetres) for the upper 10 rings. The part left for the ledge was then widened out to the full diameter; and the definite tubbing soon entered the temporary tubbing, the upper rings of which were then taken out, only 2 rings, in addition to the cutting-crib, being left in No. 1 shaft, and 1 ring only in No. 2 shaft, the space between the definite tubbing and the rock being run in with cement-concrete.

The single shaft of the No. 7 plant was sunk in the same manner as the shafts of No. 6 plant; but no bore-holes were put down, because it was known that there were at least two water-bearing strata to pass through. The upper water-bearing stratum was passed through without any great difficulty, by means of sheet-piling; and on the
cutting-crib entering the clay at the depth of 87 feet (26.4 metres) the temporary tubbing was inserted up to 37 feet (11.4 metres) from the surface, the water being raised by a single pulsometer-pump. Sinking was then resumed, a 19.7 inches (50 centimetres) ledge being left as before; and the green-sand was reached at the depth of 118 feet (36 metres), when a feeder of at least 110,000 gallons (500 cubic metres) per hour was encountered. The difficulty became very serious on the lower bed of very fine and shifting sand being entered at the depth of 133 feet (40.5 metres). When, at the depth of 139 feet (42.4 metres), the first sheeting-pile was driven of what was thought to be the last series, a large quantity of sand burst in, and the work was stopped, because it was noticed that the shaft had shifted laterally while the lower tubbing-rings were canted.

Rather than run the risk of compromising the shaft, the engineers decided to employ a false or supplementary tube, provided with a cutting-shoe, and consisting of 2 steel-plate rings 1 inch (25 millimetres) thick, 15.2 feet (4.65 metres) in diameter, and about 5.1 feet (1.57 metres) high, divided into 5 segments, fitted with 3.9 inches (10 centimetres) angle-irons, forming flanges to receive the bolts, while the lower ring was cut out to the shape of the Coal-measure bed, as ascertained by boring. This false tubbing was sunk in the ordinary manner for 16.6 inches (42 centimetres) into the top of the Coal-measures. The operation caused great difficulty, owing to the sheeting-piles that had been used previously and had to be drawn out by grabs, pincers, etc. Sinking was then resumed, a ledge being left as before, until at the depth of 147 feet (45 metres) the wedging-crib was laid, 9.1 feet (2.8 metres) in the Coal-measures. The definite tubbing was then connected as quickly as possible, because the false tube had become oval in section owing to pressure, and there was only 0.1 inch (2 1/2 millimetres) between the tube and the tubbing on the north side. When the definite tubbing was completed, the false tube was withdrawn, except the cutting-crib and the first ring; and cement-concrete was run between the tubbing and the rock.

J. W. P.

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EXTENDING AN AIR-SHAFT.

Between the surface and the level of 853 feet (260 metres), the air-shaft of the Perron pit is vertical and masonry-lined to a diameter of 9.8 feet (3 metres); but from that level to 1,411 feet (430 metres) it followed the inclination of a thin coal-seam, dipping about 80 degrees. When it was decided to carry the vertical portion deeper, the presence of the inclined portion through which the return air of the lower levels must continue to pass, rendered very difficult the sinking of the first length or section, between 853 feet (260 metres) and 1,007 feet (307 metres). The inclined shaft had a rectangular section of 6.5 feet (2 metres) by 11.4 feet (3.5 metres), and only diverged from the line of the new air-shaft about 36 feet (11 metres) below the level of 853 feet (260 metres); and as the masonry of this new shaft could take a bearing on the roof of the thin coal-seam, at the depth of 900 feet (274.5 metres), the sinking was effected in two sections, namely, from 853 feet (260 metres) to 900 feet (274.5 metres), and from that level to 1,007 feet (307 metres) The excavation of the first of these sections was effected in an upward direction, and in short lengths—masonry-lined as soon as driven. Some timbers of the inclined shaft, which interfered with the work, were replaced by others; but the overhanging lining of the old shaft could be left in place. The long members of this lining rested on vertical timbers, distributing the pressure on the solid rock above and below the excavation; and the brattice-timbers were replaced by others arranged obliquely. The thickness of masonry is 3.3 feet (1 metre) on the side next the old shaft, and half that
thickness on the other. The execution of the first section took up 4 months and cost £2 19s. per foot (245 francs per metre) for labour, because it was necessary to take great precautions in arranging the timbering, while the masonry had to set before the timbering could be allowed to bear against it.  

J. W. P.

REPAIRING OF TUBBING IN A SHAFT.


No. 1 shaft of the Gneisenau colliery, Westphalia, is tubbed from the depth of 484 feet (147.5 metres) to that of 800 feet (243.5 metres) with 61 cast-iron rings, 12 feet (3.65 metres) in diameter and 4.9 feet (1.5 metres) high, the thickness varying from 1.18 inches (30 millimetres) to 2.76 inches (70 millimetres). About 1890, it became evident, at the depth of 656 feet (200 metres), owing to the great pressure, that Nos. 35 and 36 rings were being forced apart in a horizontal direction; and, with a gradual increase of the pressure, the bolts of the horizontal joint were sheared, and the ring-flanges torn out, so that the tubbing no longer remained tight. On the flow of water increasing, it was decided to insert an additional ring for making the tubbing tight, and accordingly exact measurements were taken in the shaft for the construction of this ring of the largest possible diameter, with the object of retaining the existing large winding-cages and keeping the pumping-engine at work with a minimum of alterations.

This ring consisted of 8 segments, for the most part of cast-iron, but of cast-steel where there was only room for a slight thickness. While the ring was being inserted, however, it was soon seen that a further displacement of the tubbing had taken place, and the flow of water increased to about 770 gallons (from 3 to 4 cubic metres) per minute. It was especially difficult to insert the last segment, as it had to be fitted to a template. Ultimately the breach was tightly closed, the work being regarded as well performed.

Five years afterwards, however, a further displacement made itself manifest, as the closing ring was no longer tight, and it now appeared necessary to insert a column of cast-iron tubbing rings, 49 feet (15 metres) high, at the place where the breach occurred, a measure that had not been adopted before because it was feared that such supplementary tubbing would also give way on the thrust continuing and increasing. This new inside tubbing, 2.76 inches (7 centimetres) thick, was made to an inside diameter of 9.2 feet (2.8 metres), determined by the space inside the old closing ring, which it was not desirable to remove, because in that case the inburst of water would render the work very difficult, if not impossible. The column consists of 9 rings each, divided into 6 segments 4.9 feet (1.508 metres) high, and 2 wedging-cribs 11 inches (28 centimetres) high. The reduction that would thus be made in the cross-section of the shaft rendered it necessary to substitute a 4-decked cage with 1 tub on a deck for the previous 2-decked cage with 2 tubs on each deck.

For putting in the timber bed to carry the new tubbing, a working platform was erected, and perforated with holes because the shaft was a down-cast. The timber bed, of inverted internal conical form, was built between 6 horizontal feathers and flanges of the original tubbing, in order to give a sufficient bearing to the wedging-crib and to well distribute the weight of the new lining. The inside diameter of the lower wedging-crib is 3.1 inches (8 centimetres) less than that of the new tubbing; and the holes in the former were drilled while it was being erected in the shaft, after the first ring had been secured, the excess of metal being chipped off. In order to afford a better hold to the cement-concrete run in between the two tubbings, each of the four lower rings of the inside tubbing had 4 slightly projecting feathers cast on the outside. The joints were made with sheet-lead; and the water running from the breach,
intercepted by a water-ring, was led down in pipes. Each segment of the fourth ring was cast with a hole, at first left open, but afterwards closed by a screw-plug. The fourth ring was surrounded with cement-concrete and covered with sand, when the water-ring was removed, to permit of the erection of the fifth ring, which came opposite the middle of the breach. There were 12 holes in this ring, so that the water might flow away by 18 holes altogether, and therefore not rise behind the inside tubbing. The sixth ring, which also had 6 water-holes near the bottom, was then erected and cement-concreted, after which the remaining rings were added successively and backed with cement-concrete. The upper crib, consisting of 6 segments, was inserted, screwed up, wedged and backed with cement-concrete, being also tightly wedged against the upper strengthening ring of the old tubbing. For safety's sake, a tightly-fitting timber ring was laid over the wedging-crib and secured by 80 cleats, bevelled off upwards, against two feathers of the old tubbing, so that in this case also further wedging might be effected in case the cement-concrete should allow water to pass. After the cement-concrete had set sufficiently, the 24 water-holes were gradually closed by screwing in plugs, and the water-pressure came upon the whole tubbing, high-pressure valves being inserted in the last 3 holes to be closed, so as to permit of the closing being effected easily and thoroughly.

INTERCEPTION OF WATER FALLING DOWN SHAFT.

When communication was effected between the Milmort pit and the Collard shaft, the latter (formerly used for winding) had been divided into two compartments, one for a ladder-way and the other as an upcast pit; and for that purpose the shaft was surmounted by an air-lock, connected by a drift with the Guibal fan. The engine for driving this fan, and also a pumping-engine, were erected in the old winding-engine house, while the boilers were put in order and tested. For feeding the latter, as there was no water near the shaft, a reservoir was formed in the foundations of the old winding-engine; and at the bottom of the shaft, 213 feet (65 metres) deep, a pump was erected for forcing the mine-water to the surface, thus ensuring in a few hours the boiler-feed for a whole week. Winding could now be effected in the new shaft, which is circular, and 12.8 feet (3.9 metres) in diameter, were it not for torrents of water falling to the underground landing, which not only rendered all work difficult, and would have wetted the coal to such an extent that it could not be screened but also interfered with the workmen travelling. Inasmuch as tubbing would have been costly and would have involved too much delay, the following course was adopted: — It was necessary, for a vertical height of 266 feet (81 metres), to prevent the water escaping from the sides of the shaft from falling in the form of spray over the whole cross-section; and this was effected by sheet-iron lining, behind which the water is collected in a channel (made water-tight like a wedging-crib), whence it is led by a pipe to the water-lodge. On three rolled joists was laid a circular frame, made of H-steel bars, over which were placed between the frame and the sides of the shaft, rail-ends almost close together, one end of which was bedded in the shaft sides and the other resting on the frame. Brick-work, laid on these rail-ends, was carried up to a height of 10 inches (25 centimetres) for receiving a second and similar frame, and again 3.9 feet (1.2 metres) above a third frame bearing on the second by means of four steel stanchions. Behind these two last-named frames were placed galvanized mild-steel plates 0.08 inch (2 millimetres) thick, bent to the circumference of the shaft, bolted together longitudinally, and hung to the frames by flat hooks rivetted to
the plates. Cement-concrete was run in behind the plates up to half their height; but, as the mortar of the brick-work had been largely washed away, the cement of the concrete ran off; and in order to form a watertight bed, cloths coated with tallow were laid on the brick-work, a pipe being inserted in the cement-concrete for taking off the excess of water. The rest of the lining was made with similar plates, not bolted together but overlapping horizontally and vertically, the vertical laps breaking joint and being attached by hooks to frames as already described, while at intervals, or supporting a certain number of frames, fresh seatings were put in.

J. W. P.

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CANALIZING WATER-COURSES FOR PREVENTING INFILTRATION INTO UNDERGROUND WORKINGS.


The Roche-la-Moliere et Firminy royalty is traversed by numerous watercourses, most of which flow over the outcrops of coal-seams, in which there are many old workings; and the gauging of several have shown that the infiltrations through the fissures are considerable, the water sometimes disappearing totally in summer after passing over certain outcrops. In order to reduce these infiltrations as far as possible, and therefore the quantity of water to be pumped, numerous and important canalization-works have been carried out since 1884, their total length amounting to 19,200 feet (5,843 metres), and the works being of two different types:—(1) Canalization with a watertight bed over the whole surface, and (2) the same with watertight banks for preventing lateral infiltration. The former consists in principle of forming an artificial bed of cement-concrete lined with cement, resting on a bed of puddled clay, for preventing infiltration, if the concrete should crack; and the latter consists in forming two banks of earth, faced with rubble masonry and backed with clay.

An example of each of these types is given, together with a table giving, year by year, from 1881 to 1898, the rainfall, the quantity of water pumped in the three divisions of the concession, and the works executed. An examination of the table shows clearly the advantage of the canalization-works. In the Malafolie division, the quantity of water pumped diminished considerably from 1886, owing to the deviation of the Ondaime stream, although the gauge showed a greatly increased rainfall; and the improvement was far more marked after the canalization of the Echapre in 1888. A comparison of the two rainy years 1891 and 1892 with two similar years before the works were carried out, namely, 1881 and 1882, shows that 35 per cent. less water had to be pumped for the two years together. On the other hand, a considerable increase in the water pumped from 1897 is due to the fact that two new feeders then showed themselves; and, if the quantity of water given by them be deducted from the above figures, the normal quantities of previous years will be obtained.

J. W. P.

WINDING-ROPES IN THE DORTMUND DISTRICT IN 1898.


Statistics published yearly since 1872 by the chief inspector of mines for the Dortmund inspection-district, with the object of increasing the degree of safety in shafts generally, and as regards travelling therein especially, show that the originally prevailing iron-wire rope has completely disappeared during the last three years. Table A shows the satisfactory result that the number of breakages of ropes had diminished in 1898 as compared with previous years. Both the
ropes that broke last year were flat ropes made of mild steel, one of them close to the drum, after 187 days' use and having raised 35,510,000,000 kilogrammetres; and the other 820 feet (250 metres) below the pulley, after 246 days' use and raising 13,280,000,000 kilogrammetres.

TABLE A.—Number of Breakages and Disused Winding Ropes.

[Table omitted]

The best results were shown by two ropes at No. III. shaft of the Bismark colliery, which were in use for 1,386 days and raised 1,179,200,000,000 kilogrammetres. These and other favourable results recorded are due partly to the excellent material from which the ropes are made and the method of manufacture, but chiefly to the well-designed construction of the winding-plant.

The length of service and performance of the locked-coil ropes taken out last year tell more in their favour than do the figures of the previous year; and the flat-strand ropes lately introduced for winding appear to constitute a noteworthy improvement. The latter type of rope has been used since the end of 1897 in the inclined shaft of the Langenbrahm colliery, where, owing to the changing inclination (between 44 and 31 degrees) a rubbing of the rope against the timbering cannot be prevented. Whereas locked-coil ropes, previously used in that shaft, never lasted so long as 150 days, while no rope raised so much as 250,000,000,000 kilogrammetres, the two flat-strand ropes taken out at the end of 1898 had been in use 350 days, while one had raised 553,000,000,000 kilogrammetres and the other 590,000,000,000 kilogrammetres. Owing to the construction of the flat-strand ropes several wires of each strand come together outside, so that they wear equally; but in ordinary ropes it is only one wire of each strand that receives all the wear. The former also have the advantage that each wire remains for a comparatively considerable length on the outside of the rope; and therefore when it passes over the pulley, or is being wound round the drum, a long bearing surface is afforded for each separate wire.

TABLE B.—Life of Disused Winding-ropes.

[Table omitted]

TABLE C. — Effective Work of Disused Winding-ropes.

[Table omitted]

TABLE D. — Reasons for Disuse of Winding-ropes in 1898.

[Table omitted]

Tables B and C show the time that the ropes have lasted which were disused during 1898, and the work performed by them. The reasons for the removal of particular ropes are shown in Table D. H. L. and J. W. P.
BENNINGHAUS REVERSING LEVER FOR WINDING-ENGINES.
In the Benninghaus arrangement, power is first exerted by the reversing lever acting on a very short lever-arm; and then, when pressure is taken off the valves, the lever-arm is increased automatically for giving the valves the necessary travel. For bringing this about the reversing-lever is made with two slots, and the sector with two curved paths, so that in its ordinary movement the lever, to which studs are fixed (travelling in the curved paths), draws up by links the reversing-rod, thus altering the length of the lever-arm. J. W. P.

AUTOMATIC SHAFT-FENCES.
The sliding fence that is often used at pit-banks—taken up by the rising cage and again left in place on its descending—has been modified so as to serve for underground landings. The brackets fitted to the bottom-rail of the fence, that are caught by the roof of the cage, are suppressed; and one of the round vertical rods on which the fence slides is made removable, so that the fence can turn like a door round the other left in place. Two straps are attached by bolts to the upper rail of the fence for receiving the ends of ropes that pass over sheaves, and the other ends are attached to a flat horizontal bar, hung at such a distance above the fence that the floor of the descending cage will draw it down, and thus raise the fence sufficiently to allow of tubs passing, the parts returning to their original position on the cage again rising. When it is required to let down timber, the bolts of the straps are taken out and also the removable guide-rods, allowing the fence to swing vertically out of the way. J. W. P.

PREVENTION OF SHAFT ACCIDENTS.
For the purposes of this paper, accidents connected with shafts, which in Belgium (with a total number of 87,580 underground workpeople) amounted to 47, causing 28 deaths and 24 cases of serious injury, during the years 1896 and 1897, are divided into 10 categories, due to the following causes, to which the number of accidents is appended, followed by that of fatalities in parentheses: —Insufficient closing-in of cages, 8 (4); untimely or unexpected movement of cage, kibble, etc., 17 (5); insufficient fencing of landings, 5 (6); falls during inspection of and repairs to shaft, 6 (5); fall of hard substances down the shaft, 1 (0); breakage of ropes or connexions, 2 (2); drawing-up of the cage to the pulleys, 2 (2); use of the man-engine, 1 (1); underground steam-engines, 1 (3); and miscellaneous, 4 (0). Attention is, however, chiefly bestowed on accidents caused by insufficient closing-in of the cage, and those due to men getting on the cage-cover; and it is hoped that, at any rate, the direction is indicated in which reform should be effected for diminishing accidents.
In connexion with the first category of accidents, many arrangements for enclosing the cage are described—all of them susceptible of modification in detail to suit special cases—abundantly proving that the problem of effectually shutting in cages on all their sides is not insoluble, so as to place the workmen entirely out of danger in this respect; and it is claimed that these arrangements in no way interfere with any of
the purposes to which the cage may be applied in addition to winding workmen under normal conditions. To sum up the principal characteristics of these cage-closing arrangements, the lateral faces of the cage must be closed by perforated plate or wire-gauze, having some of the panels left free for giving access to the signal-cord, and others that can easily be taken out for inspections and repairs, allowing the workmen to escape if the cage should stop elsewhere than at a landing, etc.; and the ends, or charging-faces, should be fitted with light doors easily moved, sliding vertically or rolling up like a window-shutter, or, again, folding back against partitions permanently fixed to the cage, so as to close the compartment, at any rate, up to the height of 2 1/2 feet (70 centimetres), the closure being completed if the cage is high by a fixed bar placed 1 1/2 feet (50 centimetres) higher. Inasmuch as the doors may be opened at any time, from the outside as well as from the inside, the exit, if necessary, of the workmen in the cage is thus permitted by the ends as well as by the sides.

Many of the accidents that come under the second category are due to imprudence or clumsiness on the part of the victims or their fellow-workmen, or, again, to too great precipitation in moving the cage, which is the almost inevitable consequence of continually increasing the output by the same shafts, requiring very rapid working of the cage. It is, therefore, desirable that no action in connexion with loading or unloading be effected, and that no one be permitted to enter or leave the cage before the latter is down upon the keps.

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or has come to rest, because there are collieries where the caging is performed without keps, which are, moreover, taken out from landings no longer used. Two of the accidents recorded in the third category would not have been prevented by most of the arrangements proposed, and, indeed, recommended by the French Ministerial circular of May 2, 1892, although they might, on the contrary, have been prevented by the Mauerhofer lattice-work doors, which are double for each shaft-compartment and slide forward one towards the other on rails inclined so as to form a letter V in plan, so that, when left free, they completely close the compartment; but on the cage passing (which is fitted with a special frame terminating above and below in projecting elongated wedges) they are separated and kept apart until the cage has passed. Several shaft-closing arrangements used in Westphalia are described, which not only keep the landings closed when the cage is not there, but also prevent any inopportune movement of the cage while the tubs are being run on or pushed off.

As to inspecting and repairing the shaft, one of the accidents recorded under this head gave rise to an official inquiry in Belgium for ascertaining whether the practice of workmen getting on the cage-cover is necessary, or whether some less dangerous manner of inspecting the shaft cannot be adopted; and the following are some of the recommendations made in consequence:—The men should not get upon the cage-cover except in cases of absolute necessity, and should be provided with a safety-belt and a movable shield attached to the winding-rope for protection against falling stones. The cage-cover should not have a dangerous slope, and it should also be surrounded by a sufficiently high rail; and, when the signal cord cannot be worked easily, the banksman should keep his hand on it, so as to feel the slightest pull. The safety-belt, although generally recommended, has the disadvantage that it necessarily connects the man wearing it with the rope, etc., to which he may be attached, thus depriving him of all chance of escape in the event of an accident happening to the object to which he is attached, while it interferes with his movements and prevents him from escaping in the event of unforeseen danger. The author would not, however, prescribe safety-belts altogether, but only limit their use to cases where other means cannot be substituted.
A large proportion of the accidents coming under the fifth head, namely, the fall of hard bodies down the shaft, were attributed to the use of flying scaffolds of rough and insecure construction, while there are several of good design that may be employed. Accidents due to breakage of rope are left for special consideration in a separate paper; and as to overwinding, the author recalls a former remark of his, that in any case, well-designed head-gear of great height, and fitted with guides gradually brought nearer together above the bank, afford a safeguard against accidents due to this cause, although it is evident that the construction must be sufficiently strong to effectually retain the cages. J. W. p.

LOCOMOTIVE HAULAGE IN AMERICAN MINES.
The steam locomotive continues in use in some of the larger collieries in Pennsylvania and elsewhere, but the objections to its use are obvious.

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The electric locomotive is built in very compact form, and adapted to all mine-galleries except the very smallest. The usual custom is to use a bare copper wire to carry the current, and, in practice, the danger involved in this is less than might be expected. There are several types of electric locomotive for use in mines. One of the Baldwin-Westinghouse type was built for the Berwind-White Coal-mining Company. The motive power is furnished by two 50 horsepower single-reduction motors (of slow-speed tramcar type), one geared to each axle. The driving-wheels are 30 inches in diameter, and the axles spaced 4 feet apart between centres. The total weight, ready for service, is 25,800 pounds, all of which is carried by the driving-wheels. The journals are unusually large, being 4 and 6 inches in diameter, and carefully protected against dust. There is a rheostatic controller. The extreme height of the locomotive is 41 inches; width, 55 1/2 inches; and length, 164 inches. The drawbar-pull is 4,300 pounds at 8 miles an hour on the level, and this has been exceeded in practice. The electric current is taken through a trolley-wheel from an overhead conducting-wire. The gauge of the track is 3 feet, with an extreme width of 3 feet over all.

At present, the most formidable rival of the electric mine locomotive is the compressed-air locomotive, which has proved its efficiency in many places, and is worth careful attention from mine-managers. In a four-cylindered compound engine of the Vauclain type, the air is carried in the storage-tanks (which take the place of the boiler on a steam-lococotive) at a pressure of 600 pounds per square inch, and is supplied to the cylinders at a working-pressure of 200 pounds per square inch. There are three air-tanks, two storage-tanks, 31 inches diameter, one being 13 feet 7 1/2 inches long, and the other 11 feet 4 1/2 inches long; and the third tank is 7 feet 4 inches long and 8 inches in diameter. The high-pressure cylinders are 5 inches and the low-pressure 8 inches in diameter, both being of 12 inches stroke. The valves are of balanced-piston type. The cylinder-covers are corrugated, in order to accelerate the dissipation of heat. On each side the piston-rods of the high-pressure cylinders and low-pressure cylinders are connected to a single cross-head. The driving-wheels are 24 inches in diameter and spaced 4 feet apart between centres, the short wheel-base enabling the engine to take sharp curves. The limits of size in this engine are:—

Height, 6 1/2 feet; length, 14 feet; and width, 6 feet 4 inches. The total weight, ready for service, is 22,000 pounds, all of which is carried on the driving-wheels. Since it is necessary to have sufficient storage to charge the locomotive almost instantaneously, it is customary to extend the pipe-line sufficiently far into the mine, so that it may act as a reservoir, and, at the same time, afford charging-stations at convenient points. This engine has hauled 32 cars, each weighing 1 ton, up a grade
of 1.66 per 100. The first locomotive of this type proved so satisfactory that several others have since been built. The author quotes cases, and affirms that, in practice, the compressed-air locomotive has given efficiencies of over 50 per cent for the entire system.

AN IMPROVED ORE-SKIP.

The author, having had an average amount of experience with the old-fashioned and other ore-skips, and never having been satisfied with them, decided that, in the equipment of the Golden Group mine at Montague, he would build one on entirely new lines. The construction and operation of this skip is somewhat of a new dejoarture. The box is constructed of 3/16 inch steel built on 3 inches by 3 inches angle-iron, riveted with 1/2 inch rivets, the size being 30 inches by 36 inches by 60 inches, and a capacity of about 37 cubic feet. On the inside, at both top and bottom, there is a band of 1/2 inch by 4 inches iron, securely rivetted to the sides of the skip, and to the angle-iron in the corners. This serves to keep the body of the skip square, and also takes up the wear occasioned by receiving and discharging the load. On the bottom there are two steel doors 15 inches by 36 inches by 1/2 inch. These doors are strengthened by strips of steel 7/8 inch by 6 inches, and are securely fastened to the bottom of the skip on each side by three hinges on each door. As the doors have to withstand the entire shock due to the dumping in of the rock, both doors and hinges are made very strong. The hinges are made of 1 inch by 5 inches Swedish iron, and run entirely across the doors, to which they are fastened with 7/8 inch rivets. Across the doors, running lengthwise, are two axles, each 2 inches by 2 inches, and extending 2 inches on each end over the ends of the door. These ends are turned down to 1 1/2 inches, so as to receive the ends of the connecting-rods. These rods, four in number, two on each door, or one at each end, are made of 2 1/2 inches by 1/2 inch iron, and are about 2 feet long. These rods on the other end are connected with the side-rod, or bail, which passes up on two sides of the skip, and is held loosely in position by two clips on each side. These clips are made of 1/2 inch by 4 inches iron, and are bolted to the body of the skip by ten 1/2 inch bolts—bolts being used so that the clips may be removed at any time when it is desired to remove the bail. This bail, or side-rod, is made of 1/2 inch by 5 inches iron, and extends about 2 feet above the skip. The two bails, or strips, are connected across the top by a 5/8 inch by 6 inches piece, which is morticed into the side-rods. The top ends of the side-rods are connected to a ring in the centre, to which the hoisting-rope is attached. On the sides there are two sets of guide-shoes, made of 3 inches by 3 inches angle-iron, and faced with 3/16 inch by 6 inches plate. Inside of the guide-shoes, and fastened to the side of the skip, are pieces of hard tvood 2 inches thick, 2 feet long, and 61/2 inches wide, forming a rubbing-board, to take up the wear of the guides, these guides being made of 4 inches by 6 inches spruce.

It will be seen that the load and skip are raised by a direct pull on the doors, and that it is impossible for the doors to open while the skip remains suspended. When the skip is hoisted to the surface, and sufficiently high to admit of a car being run underneath, a set of clutches engage the sides of the skip, holding it securely; the engineman then slacks back the cable, and the weight of the load forces down the doors, pulling down the side-rods at the same time. The material being discharged, the engineman hoists, the side-rods move up, the connecting-rods close the doors, and the skip is ready for another descent. The entire arrangement is nearly automatic, and has given every satisfaction.
SELF-LIGHTING MARSAUT LAMP.

Inasmuch as trials, continued for more than a year, have shown that lamps burning benzine possess great advantages over those burning oil, while also being appreciated by the workmen, the author set about designing a safety-lamp to burn benzine, the use of which might be permitted by the French Mine Administration.

As it was desired to preserve the Seippel self-lighter, which is placed above the reservoir, the latter has nearly the same arrangement as in the lamps used at Westphalian collieries; but it is made of sheet-iron instead of malleable cast-iron, and lower and of larger diameter, for receiving the rack that forms part of the locking arrangement. The bottom is of brass; and in the middle of the cup there is a small cylindrical brass cage containing the wick-carrier and screw for working it. The screw-shank, contained in a small brass tube, terminates, underneath the bottom, in a milled head, which permits of working it from the outside. The oil-vessel is filled with cottonwool, and is traversed by a small tube carrying the rod for working the self-lighter by a key at the bottom. The round wick, of plaited cotton, is drawn rather tightly through the wick-holder; and the end is unravelled for affording better contact with the layer of cotton-wool at the bottom of the oil-vessel. The lamp may be used for 12 months without the wool being renewed, except the small layer at the bottom of the oil-vessel, which should be changed every 3 months. The wicks would last indefinitely if they did not become dirty; but for that reason it is better to renew them every year. A good benzine or petroleum-spirit should be chosen for ensuring proper working; and one of about 0.7 density, boiling at a temperature of 136° to 248° Fahr. (between 58° and 120° Cent.), gives good results. The spirit is introduced by a small funnel, and the excess must be poured off, 1/2 ounce (15 grammes) of wool absorbing 4 1/2 ounces (135 grammes). The consumption per hour is under 0.16 ounce (5.58 grammes), while the lamp can burn for 28 hours with an inch (25 millimetres) flame. No smoke is produced; the gauze does not become fouled, and the glass is almost as clean at the end of a shift as at the beginning, so that the lighting-power is almost constant. The complete lamp weighs 3 pounds 7 1/2 ounces (1,575 grammes), or filled ready for use 3 pounds 12 ounces (1,710 grammes).

With petroleum-spirit, this lamp is far more sensitive to fire-damp than one burning oil; and on turning down the flame it is possible to detect 1/2 per cent. of fire-damp, while a 1 per cent. gas-content gives a cap about 0.16 inch (4 millimetres) high, which is perfectly visible. It is found that the addition of a shield to a lamp having a single gauze improves the illuminating-power, but that the addition of a second gauze to a lamp already having one and also a shield reduces the illuminating power by about 18 per cent.

An hour's lighting by the Marsaut lamp burning benzine costs 0.0347d. (0.00347 franc) against 0.0374d. (0.00374 franc) by one burning oil, thus showing a saving of 7 per cent. in addition to the improved lighting. At the Lens colliery, the oil-vessels are filled in an isolated lamp-room, as certain precautions must be taken; but there is no danger after the cottonwool is drained and the plug screwed up. On account of the intensity and especially the uniformity of the light, with the facility of re-lighting, this lamp is asked for by the workmen; and it appears to afford as high a degree of safety as an oil-fed lamp.

J. W. P.
SUSSMANN ELECTRIC-LAMP FOR MINES.

Some important modifications suggested by practical experience have been made in the Sussmann electric lamp. The first change consisted in introducing the accumulator at the top instead of at the bottom of the box; and for this purpose the box, made of tin-plate, is cut near the top into two parts, which are connected by soldering over the joint a strip of tin-plate after the accumulator is put in place, the opening being effected by simply tearing off the strip. It was, moreover, soon perceived that the lamp was far from standing the rough usage of collieries, and in the new form all the rigid parts of the accumulator are replaced by flexible substances, an indiarubber receptacle being substituted for that of ebonite, and a specially-shaped indiarubber cover for the wax-cement joint, the connexion between the cells and between the latter and the lamp-terminals being quite flexible, and only the parts connected with the switching on and off of the light remaining rigid. While the mounting of the incandescent lamp itself has been modified, a special arrangement of interrupter permits of handing the lamp, closed but not lighted, to a workman, thus saving nearly 3/4 hour in the period of lighting. The Belgian Mine Regulations prohibit the use of an external switch, so that the workman cannot switch the light off and on underground; and, again, present methods of locking are not sufficiently rapid to obviate the necessity of preparing and therefore lighting in advance a large number of lamps, thus uselessly increasing the period of lighting. The new arrangement permits of only switching on the light when the lamp is handed to each workman, or, if it be preferred, to let each man switch on the light, at the moment of going down, by simply giving a last turn to the screw which completes the closure, while at the same time affording a simple connexion between the two parts, turning one upon the other for opening or closing. The improvements made appear to have met the requirements of practice; and even some lamps crushed between tubs have continued to give light. The arrangement for charging the accumulators have also been improved, in order to save time; and arrangements are being adopted so as to permit of charging the lamp so soon as handed in, without the necessity of waiting until each series of 20 lamps to be charged is completed.

J. W. P.

ELECTRICALLY-DRIVEN CAPELL AND MORTIER FANS AT THE UNITED BONIFACIUS COLLIERY.

The rather rare opportunity of being able to work two fans under the same conditions, and thus to compare their efficiency, is afforded by the electrically driven ventilating appliances of the Bonifacius pits, at Kray, where a Capell fan (1893) and a Mortier fan (1896) have been erected side by side. The plant consists of three separate parts:—(1) The generating-station, with steam engine and dynamos; (2) the conducting-cable; and (3) the secondary station, with three motors and the two fans.

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[Table omitted, shewing results of experiments with Capell and mortier fans.]

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(1) The steam-engine has a single cylinder 20.47 inches (520 millimetres) in diameter and 31.50 inches (800 millimetres) stroke, working without condensation, at a
pressure of 65 pounds per square inch, with a normal velocity of 45 revolutions and a maximum velocity of 60 revolutions per minute. The engine developed 64.4 horsepower at 60 revolutions. The fly-wheel, 13.12 feet (4 metres) in diameter and 19.68 inches (1/2 metre) broad, transmits the power by means of 5 hempen ropes to a lay-shaft, in the ratio of 1 to 4. The power is taken off the latter by means of belting in the ratio of 1 to 1.67, so that the generating-dynamos can thus be driven independently, accordingly, when the engine is working at 60 revolutions the dynamos make about 400 revolutions per minute. The continuous-current dynamos are capable of producing, at 430 revolutions per minute, a current of 42.5 amperes and 1,200 volts. The conductor to the secondary station, 3,937 feet (1,200 metres) distant, consists of 8 bare copper wires, having an area of 0.0527 square inch (34 square millimetres), coupled in pairs.

The motors and fans are erected close to the No. 3 shaft. The motors, at 200 revolutions per minute, yield 43 horsepower; and are so arranged that the two external ones can drive only the fan next to them, but the middle motor can drive either fan.

The Capell fan has a diameter of 9.84 feet (3 metres) and a breadth of 6.56 feet (2 metres). The Mortier fan has an external diameter of 9.18 feet (2.8 metres) and 18 vanes 4.07 feet (1.24 metres) broad. The observations were made in December and January, 1898-99, during favourable weather, in which the barometer showed no considerable fluctuations. They were made on Sundays, holidays or at night, whilst no coal was being drawn and no workmen were in the pit.

The calculation of the motor-efficiency of the ventilators could not be performed with the accuracy that might be desired, as the work transmitted from the motor to the fan could not be directly measured, there being no suitable instruments for electrical measurements at the secondary station. Accordingly, the current-quantity and tension were measured at the generating-station. The motor-efficiency (Ne ÷ Nth) refers accordingly to the ratio of the effective work rendered available by the fan to the work performed by the generating dynamo; so that the loss of tension in the conductors and the resistance in the secondary motor are not separately taken into account. As, however, the same primary dynamo and secondary motors were used throughout, the calculated values may serve for a comparison of the two fans.

Three series of experiments were undertaken: (1) Both fans were made to work so as to produce the same water-gauge; (2) both fans were run with the same number of revolutions of the steam-engine; and (3) the fans were so driven that the generating dynamos supplied both fans with an equal number of watts. The main results of these three series of experiments are shown in the annexed table. [Page 166, omitted.]

The general result of the various experiments may be summarized in the statement that, under the conditions existing at the Bonfacius pit, the Capell fan gave the same quantity of air as the Mortier fan with a lesser water-gauge and required somewhat less power at a normal mean velocity. The Mortier fan, on the other hand, showed a considerably higher manometric efficiency, while the efficiency of both fans was about the same. The equivalent orifice of the Bornfacius pit was 20.88 square feet (1.94 square metres) when worked with a Capell fan, and 20.24 square feet (1.88 square metres) with the Mortier fan.

H. L.

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FORCING VENTILATORS AT THE CONSOLIDATED SILESIA PIT, NEAR CHROPACZOW, AND THE CONSOLIDATED DEUTSCHLAND PIT, NEAR SCHWIENTOCHLOWITZ, IN UPPER SILESIA.

(1) Die blasende Ventilation auf den Steinkohlenruben Cons. Schlesien bei Chropaczow und Cons. Deutschland bei Schwientochlowitz in Oberschlesien. By
The authors summarize the information up to the present available on the subject of fans employed for forcing air into the mine instead of exhausting it. The French Commission came to the conclusion that theoretically forcing ventilation had many advantages over ventilation by exhaustion, because the former required a little less power and produced a plenum of pressure which tended to keep back blowers of gas and choke-damp, and moreover, with a falling barometer, any more rapid evolution of such gases could be more effectually met by increasing the compression of the air in the mine, yet in practice, such forcing fans are seldom found, because in order to maintain the natural principle of ascensional ventilation such a fan would have to be situated at the deepest shaft, which would generally be the winding-shaft: this causes difficulties, whilst a ventilator acting by exhaustion may be placed at any shaft whatever, and need not take up space in the winding-shaft. Further, on any sudden stoppage of a fan working by exhaustion, atmospheric pressure in the mine would naturally increase and thus offer greater difficulties to the escape of the mine-gases, whereas with a forcing ventilation the opposite is the case, which is all the more serious because the stoppage of a ventilator is always a critical moment for a mine. Nothing is said as to forcing ventilation favouring the production of gob-fires.

At this time, the possibility of placing a fan at the bottom of the shaft, and thus not disturbing the drawing of the coals in the shaft, seems not to have been considered. Since 1882, a large forcing Guibal fan, 22.96 feet (7 metres) in diameter has been in operation underground, upon which a full report by Mr. B. Otto has been published.* Mr. Richter, who put in this fan, had already obtained good results with a 9.84 feet (3 metres) Ritter fan, used in the same way, at the Johannes shaft, near Lugau, and selected it because large quantities of choke-damp were given off from the workings, and it was hoped that this might be kept back by the employment of forcing ventilation. According to Mr. Otto, the results of a forcing ventilation were favourable, but detailed proofs are wanting. Nevertheless, despite of his favourable opinion, such ventilators were subsequently but little used, although at No. 3 shaft of the Danube Shipping Company, at Funfkirchen, in Hungary, an underground forcing Guibal fan, blowing 34,000 cubic feet (960 cubic metres) per minute, was put in operation in the year 1889.

At the Silesia colliery, a fan was erected in 1892 at the 541 feet (165 metres) level, another in 1893 at the bottom or 754 feet (230 metres) level, whilst at the Deutschland colliery both fans are situated at the 738 feet (225 metres) level, and not on the lowest or 984 feet (300 metres) level, one of these having been set to work in 1895 and the other in 1897. The results obtained by these different fans are indicated in the annexed table.


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[Table showing efficiency of forcing fans, etc, omitted.]

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With the exception of one Mortier fan, the three others are all centrifugal fans with 24 or 25 blades. The Mortier fan is 6.88 feet (2.100 metres) in diameter, that of the other fan at the Deutschland colliery 11.16 feet (3.400 metres), whilst the two fans at the Silesia colliery are respectively 8.20 and 9.18 feet (2.500 and 2.800 metres) in diameter.
It is seen from the table that the compression effected, especially on the Silesia colliery, is not very considerable, so that even now the natural ventilation of the mine plays a very important part. The result of the experiments with this fan seems to be that when the mine is connected to the surface through open workings or fissures, a portion of the air forced in by compressive ventilation makes its way through the old workings and ventilates them, so that any gases given off can no longer enter the mine, but are forced up to day through these fissures. Under similar conditions, ventilation by exhaustion would draw the foul air from the old workings into the mine, whilst fresh air would find its way down from the surface and be drawn up by means of the fan. In such cases, there seems no doubt that the method of compression is preferable. In the absence of any such communication with the surface, the plenum of pressure produced by a forcing fan will extend to all mine-workings, as also to the goaf and any fissures that may exist. The foul air will only be kept back in these until the plenum of pressure, which naturally diminishes as the distance from the fan is increased, is everywhere uniform. With ventilation by exhaustion, the diminution of pressure produced by the fan will also extend to the goaf as soon as equilibrium exists. In either case, the foul gases can only escape by diffusion. Variations of barometric pressure will have an equal effect in either case, but as the barometric pressure is apt to change abruptly and to a very considerable extent, it is obvious that with fans of only moderate power, such as all the fans that have been used up to the present, it is impossible to compensate for this.

Another forcing-fan was erected in the year 1897 in Westphalia, at the Gluckswinkelburg colliery, near Bochum, where a forcing Capell fan of 5.74 feet (1.75 metres) diameter has been erected at the surface, forcing about 14,000 cubic feet (400 cubic metres) of air into the mine per minute, with an average of 60 revolutions and a plenum of pressure equal to about 1 inch (25 millimetres) of water. The object of erecting a forcing-fan in this case was that there are workings at various levels, and by putting a forcing-fan over the main entrance it was possible to use four air-drifts as return airways. In order to keep the air-current moving in the same direction, and to gain the benefit of ascensional ventilation, it would accordingly have been necessary in this case to have erected four separate smaller fans at the mouth of each of these smaller airways.

Exhausting fans have frequently been erected remote from the winding-shafts, at special air shafts, and therefore cannot be so readily got at. It may also be pointed out as an advantage of the forcing-fan that in the case of an underground fire the rescue-parties can work with a greater feeling of safety on account of the knowledge that they have the fan behind them, and therefore the road to the fresh air is always open.

It is suggested that in shallow pits which are connected with the surface by means of numerous cracks and fissures, forcing ventilation is preferable to ventilation by suction, and that a forcing-fan will produce a better effect upon the ventilation of the pit the greater the water-gauge due to it.

H. L.
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MECHANICAL VENTILATORS.*

Report of the Committee of the North of England Institute of Mining and Mechanical Engineers, and the Midland Institute of Mining, Civil and Mechanical Engineers.†

By M. WALTON BROWN.

I.—Introduction.

At a meeting of the Committee held in London, on June 6th, 1888, Mr. John Daglish was elected chairman, and Mr. M. Walton Brown as reporter and secretary. The Committee agreed that the experiments should be restricted, at first, to those collieries where two fans of different types were erected upon the same shaft, and where experiments could be made upon both fans, when working under precisely the same conditions.

At the same meeting, the instructions to the engineers compiled by the writer were approved (Appendix A), under which the experiments were to be conducted. The Committee communicated with H.M. Inspectors of Mines and others so as to ascertain the collieries where two fans of different constructions were erected at the same mine, in order that arrangements might be made for experiments upon a number of typical fans, when working under exactly the same conditions.

This information was readily furnished to the Committee, and introductions were obtained to the owners and managers of these collieries.

II.—Object, Description and Programme of the Experiments. The Committee considered it desirable that all the experiments should be carried out under exactly similar conditions, by the same engineers, with every care and system, in order that the results should afford exact and useful information as to the relative efficiencies and deficiencies of the various ventilators tested.

* The labours of the Committee were considerably lightened by their being able to use the valuable Report on Mechanical Ventilators made by a Committee of the Societe de l'Industrie Minerale, Bulletin, 1878, series 2, vol. vii., pages 477 and 713.


(a) Selection of Ventilators.

The experiments were solely confined to the merits of the ventilators, irrespective of the ventilation produced in the mine being sufficient for its requirements.
The Committee had a somewhat large list of ventilators in use from which to make a selection, and Table A contains particulars of the fans which were chosen as most suitable for the experiments.

Table A.—Dimensions of Ventilators Tested.

[Table omitted]

The selected ventilators are all centrifugal fans, and may be divided into two classes—(a) Ventilators of small diameter running at a high angular velocity; and (b) Ventilators of large diameter running at a much lower angular velocity. The first class will comprise the Schiele fans, 12 feet and 15 feet 3 inches in diameter; and the second class, the Guibal fans, 30, 36 and 40 feet in diameter, and the Waddle type of fans, 30, 31.6, 40 and 45 feet in diameter.

(b) Programme of the Experiments.
The programme of the experiments was drafted so as to afford comparative results for the several ventilators, irrespective of the relative resistances of the mines ventilated by them. The volume of air produced by a ventilator in the unit of time, through the mine upon which it is erected, is the chief element to be considered in the selection of a ventilator.

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The volume exhausted is, however, a variable quantity, dependent upon the velocity of the fan and the resistance of the mine. These elementary ideas are often overlooked in experimental tests made upon ventilators, and it is sometimes difficult to make use of the results in a satisfactory manner. The results produced by different fans can, however, be compared with accuracy if they are tested at similar circumferential velocities, and the comparison should be extended by a series of experiments made under the various conditions which may be presented by the workings of the mine, by varying the resistances of the mine to the passage of the air.

(c) Velocity of the Ventilator.
The variations of the velocity of the ventilator are eliminated in the comparison of experiments by the application of the principle that for a mine of any degree of resistance the volume of air exhausted by a ventilator is proportional to its velocity. The volume produced by a ventilator overcoming any resistance to the circulation of the air at the speed at which the experiment is made, is transformed by a simple calculation into the volume that might have been produced if the ventilator had been running at any other required velocity. The point was considered, as to the velocity at which the results given by the various ventilators should be compared. There are known practical limits within which ventilators yield satisfactory results, and it was not difficult to conceive that there was a mean or normal velocity at which all fans might be run for purposes of comparison. In the case of centrifugal fans, the normal velocity may be determined with some precision. It happens, from their mode of action, that their angular velocity varies inversely with their diameters, and there is no difficulty in producing comparative equality in the lineal velocity of the tip of the vanes of the two classes of fans. After careful consideration of numerous observations upon the fans proposed to be tested and of other centrifugal fans, it was decided that the normal velocity of the
fans to be tested should be taken at 6,000 feet per minute, measured at the tips of the vanes.  
The comparison of the volumes and water-gauges produced by the several fans, under various degrees of resistance of the mine, was therefore made under these conditions.

(d) Resistance of the Mine.  
As regards the variable resistances of the different mines to the circulation of the air, it appeared to the Committee that the idea of the equivalent orifice of the mine was capable of yielding useful and practical results when applied to experiments of the number and nature undertaken by them.  
Mr. Daniel Murgue was led to consider that the resistance of any mine could be compared to an orifice in a thin plate, or, in other words, that any mine which was ventilated by a known volume of air under a certain depression or water-gauge was the exact equivalent to an orifice made in a thin plate, which allowed the passage of the same volume of air under the same depression.  
This imaginary orifice forms, so far as the resistances are concerned, the exact mechanical equivalent of the mine under consideration and the area of the orifice may be taken as a measure of the resistance of that mine in comparison with the resistance of any other mine. Consequently, by the idea of the equivalent orifice of the mine, the resistances of all mines can be represented by orifices, from complete closure to the large orifices of 200 square feet found in railway-tunnels.  
If the volumes produced by each ventilator through any mine, or through any equivalent orifice (as every mine may be represented by its equivalent orifice) are known, then a curve may be drawn for any fan running at the normal velocity, whose abscissae are the equivalent orifices or inverse measures of the comparative resistances of the mines, and whose ordinates represent the volumes of air produced.  
Such a curve is the characteristic curve of the ventilator, and a comparison of a series of these curves for different types and sizes of ventilators will determine the most suitable ventilator for any mine whose resistance as measured by its equivalent orifice is known.

(e) Experiments.  
A characteristic curve can be constructed, if for any determined useful length, a number of points have been determined by experiments.  
A curve can be determined with some accuracy for a limited length by means of at least five points, one corresponding to a mine under ordinary working conditions; two degrees of mines of greater resistances, produced by appropriate obstructions placed in the mine; and two degrees of mines of less resistances than under ordinary working conditions, produced by the opening of separation-doors and drift-doors, by which the entrance of the air to the fan is greatly facilitated.  
By these artifices, observations were made upon each fan running at the normal velocity, upon the mine, and upon four other conditions of

the mine offering different resistances to the ventilation; or, in other words, the volume of air produced by each fan was determined for at least five different conditions of the mine whose resistances varied to a very considerable extent. Two observations were also made with the fans running upon the mine under ordinary working conditions at velocities other than the normal, where possible, one at a higher and the second at a lower speed. In other cases, two speeds were selected lower than the normal velocity, where the boiler-power or heating of the fan-shaft bearings, etc., prevented the ventilator being run at the higher speed. In most cases, tests were made to ascertain the power absorbed in the engine and fan when running at a low speed, and of the amount of ventilation produced by natural means, with the mine under ordinary working conditions, and the fans at rest. In a few instances, with the mine under ordinary working conditions, observations were made as to the volumes of air exhausted by each fan at the same depression. These numerous experiments furnish all the information necessary for a careful study of the various ventilators, not only as to the limits of the practical velocity, but also in respect to their dimensions. In every instance the experiments were made at a time when the working of the mine was entirely suspended.

(f) Mechanical Efficiency.
The useful effect of a ventilator expressed in horsepower is the product of the volume of air in cubic feet per minute, the depression in inches of water, and the weight of 144 cubic inches of water in pounds, divided by 33,000 foot-pounds. The horsepower of the engine was determined from diagrams taken with a Richards indicator in the ordinary manner. This method is, of course, subject to criticism, as being incorrect, as the indicated horsepower is diminished by the inherent resistances of the steam-engine before being applied to the ventilator. Various means were considered for measuring the power applied in turning a ventilator, but they were all in turn reluctantly discarded, as none of them could be applied to all of the ventilators, the subjects of the experiments. The fan and the engine have been considered as a single machine, and the mechanical efficiency of the system is the ratio of the useful effect to the indicated horsepower, and is therefore somewhat dependent upon the degree of perfection of the engine.

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It is evident in ventilators of the same type that the mechanical efficiency falls as the volume decreases. In a theoretically perfect centrifugal fan the velocity of the circumference produces the theoretical depression \( H_0 = \frac{u^2}{g^*} \), and the maximum theoretical volume, \( V_0 = 0.65au \sqrt{2} \).† If there were no resistances, or losses of kinetic energy owing to the various imperfections inherent to all classes of ventilators, the mechanical efficiency of the perfect centrifugal fan would be unity. In the case of an ordinary fan in practice running at the same circumferential velocity, various causes co-operate in reducing the depression and the volume of air, and the more the actual volume of air falls below the theoretical volume of air, the efficiency of the ventilator will be similarly varied, and the mechanical efficiency will decrease with the variation of the volume.

(g) Costs.
The costs, as kindly supplied by the various colliery companies are given, and allow a comparison of economic values, but this can only be of limited extent, as the cost chiefly depends upon factors independent of the ventilator, such as foundations, boilers, fuel, cost of materials, and labour, which varied largely at the time the various ventilators were erected.
(h) Conclusion.
It will be seen that a considerable amount of work has been entailed in each
experiment upon a single fan, at least nine observers being required, without
counting several workmen employed to open or close separation-doors, etc.

In many instances serious expenditure was incurred by the colliery companies in
alterations required for the exact carrying out of the programme of experiments.
Without ample voluntary assistance the engineers would have failed to carry out the
experiments: aid was freely and voluntarily accorded by all the colliery companies,
who rendered every possible assistance through their own members and agents, and
by the services of such workmen as were required.
The Committee feel their indebtedness, and would here convey their most hearty
thanks to the colliery companies and others, who so willingly afforded them every
assistance in the experiments.
The thanks of the members are also accorded to the engineers, Messrs. W. J. Bird
and T. W. H. Mitchell, for the very able manner in which they conducted the
experiments.

* Page 203. † Page 197.

The thanks of the Committee are also accorded to Messrs. A. A. Atkinson, A. Nagel,
R. A. S. Redmayne and F. C. Swallow, who are responsible for the correctness of the
numerous calculations and illustrations contained in this report.

III.—Experiments.
(a) Description of the Ventilators.
The six collieries chosen for the experiments were all ventilated by exhausting fans;
no colliery, brought under the notice of the Committee, was provided with duplicate
compressing ventilating machinery.

All the ventilators tested were well-known types of centrifugal fans, and do not
require to be particularly described, beyond the short summarized details of the
arrangements of the duplicate fans at each colliery.

(1) Cwmaman Colliery.—This colliery is alternately ventilated by a Guibal and a
Waddle fan.
The Guibal fan was built by the Grange Iron Company, Limited, of Durham, and
erected in 1873. It commenced to work on August 10th, 1874. The only accident
had been a broken shaft in July, 1876, causing a stoppage of about three weeks. The fan
is 30 feet in diameter and 10 feet wide, the inlet being 10 feet 2 inches in diameter. It
has ten blades. The shutter is fixed immovably, the opening being 10 feet 1 inch by 3
feet 6 inches, or an area of 35.29 square feet. At the top, the chimney was 9 feet 9
inches by 7 feet 1 1/2 inches, the area being 69.46 square feet. The engine was
originally in duplicate, but now there is one cylinder, 24 inches in diameter and 2 feet
stroke. The exhaust steam, when required, can be condensed by means of a Morton
ejector-condenser, producing a vacuum of from 10 to 12 lbs. per square inch. A large
fan-drift (arched with stone) but somewhat irregular in section connects the fan-
chamber with the upcast-shaft, a few feet below the surface (Fig. 1, Plate XV.). At the
point where the air was measured, the section was divided into 16 approximately
equal areas with a total surface of 112.26 square feet (Fig. 2, Plate XV.).

The Waddle fan was built by Mr. J. E. Waddle, of Llanelly, and erected and
commenced working in 1887. It is 30 feet in diameter, 16 inches wide at the
periphery and 42 inches at the inlet. The inlet being 12 feet in diameter. It has twenty
alternating long and short curved blades. An inverted vertical marine engine, bought
second-hand, in 1873, for another purpose, drives this fan by means of helical-
teethed gearing. The two cylinders are 40 inches in diameter and 30 inches stroke, and the piston

rods 4 3/16 and 4 1/8 inches in diameter respectively. The engine is geared to the fan in the proportion of 70 to 29, and is fitted with ordinary air-pump condensers worked by levers from the cross-heads. There is no fan-drift, as the upcast-shaft discharges the air direct into the fan-chamber (Fig. 1, Plate XV.). The air was measured at the top of the upcast-shaft, at a rectangular frame 10 feet 6 1/2 inches by 8 feet 7 inches (with a transverse bar, 6 1/16 inches wide), divided into 16 equal parts by strings, with a total area of 86.15 square feet. There have been no accidents to this fan. The cost of maintenance is about £18 per annum.

There are two shafts, 66 feet apart. The downcast shaft is elliptical in shape, 15 feet by 9 feet 6 inches, sunk to a depth of 792 feet, cutting the following seams:—The Two-feet-nine-inches coal-seam at 654 feet; the Four-feet-coal-seam at 675 feet; and the Six-feet coal-seam at 759 feet. The downcast (winding) shaft is fitted with buntons and rail-guides. It also contains a 9 inches steam-pipe and a 4 inches rising main water-pipe, both of which are carried from the surface to the Four-feet-coal seam. The heating-effect of the steam is shown by the recorded temperatures of the air. A third pipe, 4 inches in diameter, is used for conveying, a blower of gas to the surface from a depth of 213 feet (Fig. 3, Plate XV.).

The upcast-shaft is circular and 9 1/2 feet in diameter, and is sunk to the Six-feet coal-seam, at a depth of 792 feet. The portion between the Four-feet and Six-feet coal-seams is dumb, a scaffold closes the shaft just above the level of the Four-feet coal-seam, and all the return-airways enter at the Two-feet-nine-inches coal-seam level at a depth of 675 feet. There are no obstructions whatever in this shaft (Fig. 4, Plate XV.).

The pits are sunk at the rise side of the royalty, most of the coal laying to the dip. The workings are on the longwall system. The position of the water-gauges during the experiments is shown in Fig 1, (Plate XV.), Guibal fan:—No. I, at the inlet of the fan; II, in the fan-drift at the place of air-measurement; III, at the separation-doors at the pit-bottom; IV, at side of fan; and V, in upcast-shaft, 16 feet below the drift to the Guibal fan. Waddle fan:—I, at the inlet of the fan; II, at the top of the upcast-shaft at the place of air-measurement; III, at the separation-doors at pit-bottom; and V, in the upcast-shaft, 16 feet below the drift to the Guibal fan.

The restricted orifices were formed upon the top of the upcast pit.

(2.) Great Western Colliery.—The two ventilators in use at this colliery are a Guibal and a Schiele fan (Fig. 5, Plate XV.).

The Guibal fan was built by Messrs. Black, Hawthorn & Co., of Gateshead-upon-
Tyne, in the year 1876. It is 40 feet in diameter and 12 feet wide. It is driven by a
direct-acting horizontal engine, having a cylinder 36 inches in diameter and 8 feet stroke. The cost, including buildings, was £4,186 5s. 0d. The average annual cost of repairs is £96 8s. 0d., and of stores £192 16s. 9d.

The Schiele fan was constructed by the Union Engineering Company (Messrs. C.
Schiele & Co.), of Manchester, in the year 1885. It is 15 feet 8 inches in diameter, and is driven by a horizontal engine, with one cylinder 32 inches in diameter and 3 feet stroke, by belting in the ratio of about 3.2 to 1. The cost, including buildings, was £4,941 15s. 4d. The average annual cost of repairs is £18 12s. 0d., and of stores £140 19s. 1d.
At the Hetty (downcast) shaft, the Four-feet coal-seam, 6 feet thick, is worked at a depth of 1,095 feet, and the Six-feet coal-seam, 6 5/6 feet thick, at 1,174 1/2 feet. The No. 2 or upcast-shaft passes through the Four-feet coal-seam at 1,125 feet; the Red coal-seam at 1,229 feet; the Nine-feet coal-seam, 5 feet thick, at 1,264 1/2 feet; and the Five-feet or Lower coal-seam, 4 feet thick, at 1,420 1/2 feet. The position of the shafts and fans and the relative positions of the water-gauges are shown in Fig. 5 (Plate XV.). Figs. 6 and 7 (Plate XV.) are plans of the Hetty or downcast-shaft, and the No. 2 or upcast-shaft.

There being no convenient places for the measurement of the air in the fan-drifts, the air was measured at a section 3 feet from the top of each fan's chimney, with an anemometer suitable for use in vertical currents. Figs. 8 and 9 (Plate XV.) represent sections of the places where the air was measured (in the fan chimneys) in the trials of the Guibal and Schiele fans.

The restricted orifices were cut in the respective separation-doors.

(3.) The National Colliery is provided with a Schiele and a Waddle type of fan (Fig. 10, Plate XVI.). The Schiele fan was erected by the Union Engineering Company, of Manchester, in 1886. It is 15 feet 3 inches in diameter, and 3 feet wide at the periphery, the diameter of the inlet being 8 feet 10 inches, and its width 6 feet. It is driven by a horizontal engine with one cylinder, 32 inches in diameter and 3 feet stroke. The engine drives the fan by belting, in the ratio of 3.15 to 1. The cost of engine and fan was £2,100. The average annual cost of stores is £74 7s. 4d.

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The Waddle type of fan was erected in 1883 by Messrs. Llewellyn & Cubitt, of Pentre Rhondda. It is 45 feet in diameter, 1 foot 8 inches wide at the periphery, the diameter of the inlet is 15 feet, and the width 4 feet 2 inches. It differs somewhat from the ordinary type of Waddle fan, the curved blades being inclined at a greater angle to a radius. The collar of the fan did not fit very exactly. The fan is driven by an engine with a cylinder 36 inches in diameter and 3 feet 6 inches stroke. The average annual cost of stores is £23 16s. 9d.

The downcast-shaft is 17 1/2 feet in diameter and is fitted with four wire-rope guides, a, 1 1/4 inches in diameter, two being on the outside of each cage. There are two rubbing-blocks, b, fixed on each cage, and two ropes, c, (2 inches in diameter), are placed between the cages. A water-pipe, d, 1 1/2 inches in diameter, takes water from the surface to the Four-feet coal-seam (Fig. 11, Plate XVI.). The position of a byat, at a depth of 300 feet, is shown in Fig. 12 (Plate XVI.). At 1,212 feet, is a landing for the Two-feet-nine-inches coal-seam (Fig. 16, Plate XVI.). The stage for the Four-feet coal-seam is situated at a depth of 1,272 feet, and the pit is sunk to the Six-feet coal-seam at a depth of 1,353 feet from the surface.

The upcast-shaft is 14 feet in diameter, with steam and water-pipes in the shaft (Figs. 14 and 15, Plate XVI.) for a depth of 300 feet from the surface. The landing of the Two-feet-nine-inches coal-seam (Fig. 16, Plate XVI.) is situate at a depth of 1,212 feet from the surface ; a, b, and c are guide-ropes, 1 1/4 inches in diameter, extending from the surface to the Six-feet coal-seam. The Four-feet coal-seam lies at a depth of 1,272 feet, and the shaft is sunk to the Six-feet coal-seam at 1,353 feet. The position of the fan-drifts (Fig. 10, Plate XVI.) allowed of one common place of measurement for the experiments with both fans, its section being shown in Fig. 17 (Plate XVI.). The restricted orifices were cut in the separation-doors near each fan. Speaking-tubes were fitted between the engine-houses and the fan-drift. The position of the water-gauges is shown on Fig. 10 (Plate XVI.).
(4.) Pelton Colliery.—There are three fans at this colliery, two being usually at work. The two fans adjacent to the Busty (upcast) shaft, viz., the Waddle fan and the No. 2 Guibal fan, only were tested (Fig. 18, Plate XVI.). The Waddle type of fan is 31.6 feet in diameter, and 14 inches wide at the tips of the blades. The diameter of the inlet is 14 feet 1 inch. This fan is driven by a non-condensing horizontal engine, with one cylinder, 24 inches in diameter and 24 inches stroke. This fan was constructed by Messrs. Black, Hawthorn & Co., and erected in 1868. It had 8 long and 8 short vanes, and presented some differences in detail and proportion from the ordinary type of Waddle fan. The cost of fan and buildings was £940. The annual average cost of stores is £41 12s. 0d. The No. 2 Guibal fan is 36 feet in diameter and 12 feet wide, the diameter of the inlet being 13 feet. It is driven by a non-condensing horizontal engine, with one cylinder, 30 inches in diameter and 30 inches stroke, fitted with variable expansion-gear. A duplicate engine is kept for emergencies. This fan was constructed by the Grange Iron Company and erected in the year 1875. The cost of fan, engines and buildings was £3,600. The mean annual cost of stores is £31 10s. 0d. The arrangement of the fan-drifts is shown in Fig. 18 (Plate XVI.). The separation-doors, D, were arranged so as to shut off the No. 1 Guibal fan exhausting from the Low Main coal-seam upcast-shaft, the two fans with which the experiments were made exhausting from the Busty upcast-shaft only. The fan-chambers are closely adjacent to the top of the shaft, only a short length of drift being available for the air-measurements, and it was found necessary to fix the dividing strings in the frames of the separation-doors and in these apertures the air was measured (Figs. 19 and 20, Plate XVI.).

There are five shafts at this colliery of the following diameters and depths:

<table>
<thead>
<tr>
<th>Shafts</th>
<th>Diameter, Feet</th>
<th>Depth, Feet</th>
<th>Name of Shaft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downcast, No. 1</td>
<td>7</td>
<td>324</td>
<td>Old Hutton.</td>
</tr>
<tr>
<td>&quot;</td>
<td>2</td>
<td>10</td>
<td>Low Main.</td>
</tr>
<tr>
<td>&quot;</td>
<td>3</td>
<td>14</td>
<td>Busty.</td>
</tr>
<tr>
<td>Upcast, No. 2</td>
<td>4</td>
<td>10 1/2</td>
<td>No. 1 Fan Return.</td>
</tr>
<tr>
<td>&quot;</td>
<td>5</td>
<td>12 1/2</td>
<td>No. 2</td>
</tr>
</tbody>
</table>

Of these shafts, Nos. 2, 3 and 5 only were affected by the present experiments. The areas and obstructions in these shafts are shown in Figs. 21, 22, 23 and 24 (Plate XVII.). There are no obstructions in the Nos. 1 and 2 upcast-shafts. Electric bells, fitted by Messrs. John Mills & Son, Newcastle-upon-Tyne, were used for signalling between the engine-houses and the fan-drift. The positions of the water-gauges during the course of the experiments were as follows:—No. I was placed at the inlet of each fan (Fig. 18, Plate XVI.), and No. II was placed at the top of the Busty upcast-shaft. The sections of the drift where the air was measured are shown in figs. 19 and 20 (Plate XVI.), respectively, for the Waddle and Guibal fans. The restricted orifices were arranged by means of a sliding door placed over the top of the upcast-shaft.
(5.) The Towneley Colliery (Lancashire) is provided with a Waddle and a Schiele fan, the relative positions of which are shown in Fig. 25 (Plate XVII.).

The Waddle fan (built by Mr. J. E. Waddle in 1873) is 40 feet in diameter, with an inlet 12 feet in diameter and 4 feet 8 inches wide, the width at the periphery being 1 foot 6 inches. It is driven by a horizontal engine, with a cylinder 32 inches in diameter, and 4 feet stroke. The fan was in bad repair, the curved vanes, in many cases, consisting of wooden-laggings put in to replace the wasted wrought-iron plates. The collar, however, fitted somewhat efficiently.

The Schiele fan was in working condition. It is 12 feet in diameter and has an inlet 7 1/2 feet diameter, and is 3 feet 6 inches wide. It is driven by an engine with one cylinder 26 inches in diameter and 4 feet stroke, by a belt 27 inches wide, the pulleys being in the ratio of (20 feet to 4 1/2 feet) 4 4/9 to 1. The Schiele fan-drift is 6 feet above the level of the Waddle fan-drift.

The fan-drift, which is 12 feet in diameter, was reduced to a square of 8 feet by 8 feet (area 64 square feet), where the air was measured in the experiments upon both fans.

The confined position of the Waddle fan is illustrated in Fig. 26 (Plate XVII.). It was not considered safe, owing to the condition of the Waddle fan, to run it at a greater speed than 40 revolutions per minute, which was taken as the maximum. The normal speed required 47.74 revolutions per minute.

The position of the several water-gauges is shown on Fig. 25 (Plate XVII.). The restricted orifices were cut in the separation-doors adjacent to each fan.

(6.) Wingate Grange Colliery is provided with a Guibal and a Schiele fan.

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The Guibal fan (erected in 1871) is 36 feet in diameter by 12 feet wide, and is driven by a direct-acting horizontal engine, with a cylinder 30 inches in diameter and 2 1/2 feet stroke. The fan and buildings cost £2,280 16s. 8d. The annual cost of stores is £29 12s. 11d. and of repairs about £4 3s. 6d.

The Schiele fan (which was erected in 1886) is 12 feet in diameter, the width at the inlet being 3 feet 4 inches and at the periphery 2 feet, the diameter of the inlet being 7 feet 3 inches. The fan is driven by a horizontal engine, by rope-gearing in the ratio of 2.6 to 1. The cylinder is 2 feet 1 inch in diameter and 2 feet stroke. The fan and buildings cost £1,423 12s. 4d. The annual cost of stores is £38 1s. 11d. and of repairs about £4 3s. 6d.

The Guibal fan was at the time of the experiments working regularly, the Schiele fan being kept standing in reserve in case of any accident occurring to the Guibal fan.

The arrangement of the fans, drifts, separation-doors, etc., is shown in Fig. 27 (Plate XVII.).

The sections of the fan-drifts at the places of air-measurement are shown in Figs. 28 and 29 (Plate XVII.).

There are two shafts, the Lady (or downcast) shaft, and the Lord (or upcast) shaft, each 14 feet in diameter, the average obstructions of which are shown in Figs. 30 and 31 (Plate XVII.).

The shafts pass through the workable coal-seams at the following depths:

<table>
<thead>
<tr>
<th>Name of Coal-seam</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ft.</td>
<td>In.</td>
</tr>
<tr>
<td>Lady Shaft.</td>
<td>Five-Quarter</td>
</tr>
<tr>
<td>Lord Shaft.</td>
<td>Main</td>
</tr>
<tr>
<td></td>
<td>Low Main</td>
</tr>
</tbody>
</table>
Hutton 2 10 792 0 ---
Harvey 3 0 912 0 ---
Bottom of shaft --- 930 0 736 0

The shafts are 264 feet apart, and a 42 feet fault passes between them. The Five-Quarter and Hutton coal-seams are not at present being worked. The Main and Harvey coal-seams are being worked, and the chief output is from the Low Main coal-seam.
The Lord shaft is at present only open to the Low Main coal-seam. The return-air from the Harvey and the Low Main coal-seams passes up a staple to the Main coal-seam, and along a drift discharging into the Lord shaft.

Coal is at present drawn only at the Lady shaft.
Electric bells were used for signalling between the engine-houses and the fan-drift.
The position of the several water-gauges is shown on Fig. 27 (Plate XVII.).
The restricted orifices were arranged by means of a sliding-door placed in a stopping, C (Fig. 27, Plate XVII.).

(b) Description of the Experiments.
Unless prevented by unforeseen circumstances, from eleven to twelve experiments were made upon each of the ventilators. The programme consisted of making five distinct experiments upon each ventilator, each of which could be used in determining one of the points of the characteristic curve of the fan, that is, the curve of the volume produced by each ventilator when rotating at the normal velocity, for each of the varied resistances of the mine, or for each of the equivalent orifices from complete closure to very large ones.

(1) The Factive Mines.—The series of five factive mines of varying equivalent orifices, were more or less easily obtained by conditions artificially created at each mine, as follows:—
(a) The return air-drift was closed by a stopping, having an aperture of about 3 square feet, through which air was admitted to the fan, either from the atmosphere or from the mine.
(b) The opening in this stopping was enlarged to about 6 square feet.
(c) Under ordinary conditions, at three different speeds of rotation of the fan, one being the nearest speed obtainable to the normal velocity.
For the purpose of somewhat exact comparison, it would be desirable that experiments be made upon one of the ventilators running at such a speed as to produce a water-gauge equal to that produced by the other ventilator running at the normal speed of periphery, upon the mine in each case under ordinary working conditions.
(d) The separation-doors were opened, so as to facilitate the entry of air to the fan.
(e) The air was admitted freely to the fan, all obstruction to its free access being, if possible, removed.

In several instances an experiment was made to determine the amount of ventilation produced by natural means upon the mine under ordinary working conditions, when the ventilator was standing.

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occasional resistance to the ventilation produced by mechanical means. The aid, if any, afforded by natural means is much smaller than is usually anticipated. Thus, if a volume of 50,000 cubic feet of air per minute is produced by natural means alone, and in the same direction as the ventilation produced by the ventilator, and if the ventilator alone produces a volume of 200,000 cubic feet of air per minute, then the volume of air produced by the fan and natural ventilation together is not 250,000 cubic feet of air per minute. The squares of the volumes being proportional to the depressions, the sum of the squares of the volumes will be proportional to the sum of the depressions. The calculation of the total volume therefore is not determined by simple addition, but by taking the square root of the addition of the squares of the volumes. The total volume being obtained by the formula:—

\[
V_3 = \sqrt{V_1^2 + V_2^2} \\
V_8 = \sqrt{(200,000^2 + 50,000^2)} = 206,155 \text{ cubic feet.}
\]

The increased volume due to the positive action in this example of natural ventilation being only 6,155 cubic feet instead of the anticipated 50,000 cubic feet of air per minute.

The result would have been similar, but the volume produced by the fan would have been decreased, if, instead of a positive value of the natural ventilation, a negative value had been used.

A compression or negative (—) water-gauge was observed in some of the experiments made upon the ventilators at the Great Western, National and Towneley collieries. At the Great Western colliery, the readings of the No. II. water-gauge, placed on the top of the upcast-shaft, in experiments (Nos. 2, 3, 4, 5, 6 and 11 on the Guibal fan; and Nos. 1, 2, 3, 4, 5 and 11 on the Schiele fan) with restricted orifices, are of no value, owing to the restricted orifices being placed between the fans and the No. II. water-gauge, or to the opening of doors on the surface.

The readings of the No. II. water-gauge, at the place of air-measurement in experiments at the National colliery (Nos. a, 1, 2, 3, 4, 5 and 10 on the Schiele fan; and Nos. a, 1, 2, 3, 4 and 5 on the Waddle fan), and at the Towneley colliery (Nos. b, c, 1, 2, 3 and 4, on the Schiele fan; and Nos. b, c, 1, 2, 3 and 4 on the Waddle fan), with restricted orifices,

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are of no value, owing to the restricted orifices being placed between the fans and the No. II. water-gauge.

In several experiments at these three collieries it may be noted that the density and weight per cubic foot of the air in the fan-drift is greater than that of the atmosphere, showing that natural ventilation was acting against the action of the fan.

The Committee, however, with the view of obtaining definite and valuable details, stopped the ventilators and made observations of the volume and the depression produced by natural means alone. The results, as might be anticipated, proved that the current of air was often very small, and almost insufficient to turn the anemometer.

The action of natural ventilation in the experiments need not be considered, as its effects are included in the measurement of the equivalent orifice of the mine. If natural ventilation retards the circulation of the air by mechanical means, the result is merely to decrease the apparent area of the equivalent orifice of the mine, because the resistance of the mine is increased. If natural ventilation accelerates the circulation of the air, the apparent area of the equivalent orifice of the mine will be increased, because the resistance of the mine is diminished owing to its assistance. What would be the effect upon a ventilator when running in the case where natural ventilation retards that produced by the fan? The obstructive effect may be
compared to an increase in the resistance encountered by the air in passing through
the mine, and is disposed of in the measurement of the equivalent orifice of the mine,
which is slightly diminished in area. Consequently, in order to produce the same
volume of air, the ventilator must turn more rapidly when the natural ventilation is
opposed to the direction of the mechanical ventilation than when that action is
neutral.

If the action of natural ventilation accelerates the mechanical ventilation, the
resistances of the mine are reduced, and the measurement of the equivalent orifice
of the mine is somewhat larger; the ventilator might then be run at a reduced speed
to produce the same volume of air.

In determining the characteristic curve of a ventilator at least five points are requisite,
spaced somewhat widely apart, the exact position of any of the points of the curve
being immaterial, provided that they record the result of actual and accurate
observations. These ideas may be shortly demonstrated:

A mine M, when the natural ventilation is nil, is ventilated under a depression h by a
volume V, the equivalent orifice of the mine being a, and V and a are the co-
ordinates of a point upon the characteristic curve of the ventilator corresponding to
the mine M. If the natural ventilation be not nil, in the same mine M, the depression
h1 and volume V1 will be different from h and V, the orifice a1 is consequently
different from that of the mine M, and is in fact the orifice of M1. The ventilator and
natural ventilation together will produce the volume V1 under the depression h1,
through the mine M1 with the equivalent orifice a1. V1 and a1 are the co-
ordinates of

(c) Observations during the Experiments.
In each experiment, observations were made of (1) the revolutions of the fan and of
the engine; (2) the volume of air; (3) the depression; (4) the indicated horsepower;
and (5) the pressure and temperature of the atmosphere and of the air of the mine in
the fan-drift.

(1) The Revolutions of the Fan and of the Engine.—The revolutions of the fans and
engines were counted by an ordinary lever engine-counter. Electric bells were placed
near where the air was measured in the fan-drift and in the engine-house, by which
signals were readily exchanged. An observer with a centre-seconds watch in the
engine-house, after the preparatory signal had been given by the observers, gave the
starting signal, followed by similar signals at half-minute intervals to the end of the
experiment.

An independent observer, with a centre-seconds watch, gave the time at intervals of
one minute to another observer, who took note of the position of the indices of the
counter at the beginning, at intervals of one minute, and at the end of the experiment
(eight minutes). The mean of these results only is recorded, it being found that the
readings at intervals of one minute are not discordant with the mean results. The first
and last readings of the counter were also taken by another observer, to prevent
chance of error, and to avoid having to repeat any experiments whose results might
be rendered valueless if the speed of the engine or fan were incorrectly recorded.
Each experiment extended over eight minutes, and the records of the speed taken at intervals of one minute proved that the speed was nearly uniform, as the mean revolutions of the observations for eight minutes are practically the same as any of the single-minute readings.

(2) The Volume of Air.—A Casella air-meter or Biram anemometer, fitted with a simple appliance for stopping or starting the counting-gear, was employed to measure the speed of the air. The anemometers were tested at intervals during the course of the experiments and adjusted, so that practically the same correction applied in all the experiments.

In measuring the volume of air it is essential that the area of the place of measurement should be exactly determined. The place of measurement was usually in a length of arching, occasionally at the top of the upcast pit or at the top of the expanding chimney of the ventilator. The fan-drift was walled in every case, and was reduced to a rectangular form of known dimensions, by timber, etc., and accessible in all parts to the observer. Figs, 2, 8, 9, 17, 19, 20, 28 and 29 (Plates XV., XVI. and XVII.) show the sections of the various places of measurement.

The place of measurement was, in all cases, divided into sixteen equal areas by means of vertical and horizontal wires. The anemometer was held for half a minute at the centre of gravity of each of the rectangular divisions without intervals.

Two observers were delegated to make the observations, one handling the anemometer and the other observing the centre-seconds watch and recording the results. The reading of the anemometer for eight minutes was then reduced to the reading for one minute, the correction applied, and the result multiplied by the area of the place of measurement gave the volume of air in cubic feet per minute.

(3) The Depression.—The amount of exhaustion produced by the fan was observed by means of an ordinary water-gauge fitted with a U-shaped tube. The oscillations of the column of distilled water were reduced by the use of shot in the constricted portion of the tube and by protecting the end of the tube, by means of a long and thick sleeve of flannel, from the effect of the velocity of the air. Flexible indiarubber tubing was employed to connect each of the water-gauges with the positions where the observations were to be made.

One observation was made at the centre of the fan-drift or place where the air was measured, with the end of the tube pointing to the fan and at the same time as the readings of the anemometer. Simultaneous readings were also taken at the centre of the inlet to the fan, underground, etc. The readings of the water-gauges were taken at intervals of one minute during the eight minutes of each experiment.

In some experiments, a higher depression was measured at the pit bottom than on the surface. Although the readings are recorded to 0.001 inch, they are merely the calculated means of readings to 0.01 inch.

(4) The Indicated Horsepower.—A Richards indicator was used in all the experiments. Both ends of the cylinder were connected (Fig. 49*) by means of a three-way tap at the point of union, above which the indicator was placed. In cases where there were two cylinders, two indicators were employed simultaneously. Three sets of diagrams were taken during each experiment, at the beginning, at the middle, and at the end.

The indicator-springs were tested for accuracy by weights in the ordinary manner, and no spring was used which showed any material error.
Steam-gauges were fixed in close proximity to the cylinders and were read at intervals of 2 or 3 minutes. Care was taken in all cases to close all cocks attached to the cylinders while indicator-diagrams were being taken. The area of the diagram, taken at each end of each cylinder, was measured by means of an Amsler planimeter, and this area divided by the length of the diagram gave the mean height. This height, multiplied by the scale of the spring, yielded the pressure upon the piston in pounds per square inch. The horsepower was calculated from the mean of the pressures, calculated from the diagrams by the following formula:

\[
H.P. = \frac{(a \times l \times 2 \times r \times p)}{33,000}
\]

In which \(a\) is the area of the piston in square inches, after allowing for the area of the piston-rod or rods; \(l\), the length of the stroke of the piston in feet; \(r\), the number of revolutions of the engine per minute; and \(p\), the mean pressure of the steam in pounds per square inch.

(5) Atmospheric Observations.—Observations of the pressure and temperature of the air were made, as they are factors in some of the formulas which are used in the deductions from the results of the experiments. The instruments used were:—A barometer, and wet and dry-bulb thermometers, in the atmosphere at the surface; and wet and dry-bulb thermometers in the fan-drift. The instruments were observed and did not vary in any case during the course of an experiment.

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The thermometers had been tested at Kew observatory, and the aneroid barometer was adjusted by comparison with a standard mercurial barometer at intervals.

(d) Direction of the Experiments. The experiments were all made on days when the collieries were not at work, with all machinery at rest, so that all the desired experiments could be made. Two or three days, prior to the dates fixed for the experiments, were occupied in making the necessary arrangements, and getting the various appliances into working order. The observers in the fan-drift were never less than two in number, one handling the anemometer and the second observing the centre-seconds watch and booking the results, together with a few workmen holding lamps, etc. An electric-bell was placed close at hand, so that all the observations might be made simultaneously, convenient signals being previously arranged for the purpose, to be exchanged prior to, and during the experiments, and for their stoppage in case of accident. A stroke of the bell was signalled to all observers at half-minute intervals during the eight minutes' duration of each experiment. The watches at each station were relied upon for the time-observation at such point. The time of starting each experiment was fixed beforehand, and after a warning signal had been received and acknowledged, the observations began at the agreed time, with half-minute signals until the close of the experiment. The observers in the fan-drift, after placing the anemometer on the end of the rod and the thermometer in position, signalled "ready" to the engine-house, and commenced their observations at the appointed time, unless stopped by signal. The anemometer was held in each of the 16 rectangles into which the air-drift had been divided in succession, and the difference between the observed readings of the anemometer at the beginning and at the end of the experiment was recorded.
Observations of the wet and dry-bulb thermometers were made during the course of each experiment.
The observers in the external atmosphere were divided into groups: (a) Recording revolutions of engine and fan; (b) reading water-gauges; (c) indicating engine; and (d) recording atmospheric observations.
Two observers recorded the revolutions of the engine and fan, one observing the counter and the second giving the time of beginning and ending the observations. The observer in charge of this watch also exchanged bell signals with the other observers. Observers were stationed at each water-gauge taking readings at each alternate signal of the bell, but the underground observer relied upon the time of his watch. Two observers assisted in taking the indicator-diagrams, one actually taking the diagrams, whilst the second assisted him, closing the drain-cocks when required, registering each diagram as taken, recording the steam pressure at stop-valves, etc.
One observer had general charge of the experiments, and while checking the speed of the engine and fan by direct counting, took opportunities of recording the readings of the barometers, thermometers, etc. In addition, the engineman and his assistant were available for special purposes.
When the observers in the fan-drift signalled that they were ready, a reply was given to commence observations, and the water-gauge was read at intervals of one minute, the reading of the engine-counter was taken, diagrams were taken from each end of the one or more cylinders of the engine at the beginning, middle, and end of the experiment. The observer in charge recorded the readings of the barometer and thermometers, and the observations ceased as soon as the observers in the drift signalled that their results were completed.
These arrangements were carried out most successfully, owing to the assiduous application of all the observers and workmen.
The notes of the observers and the indicator-diagrams were taken at the close of each experiment to the observer in charge, who recorded all the observations on specially prepared sheets, upon which the results of the calculations were afterwards registered.

IV.—Calculations.
The records of the experiments, after the application of suitable formulae, gave results which are contained in subsequent tables. The normal velocity of the fans was, as previously specified, determined at 6,000 feet per minute. The volume of air produced at the normal velocity was calculated by the following formula:—*  \[ V_6 = V \frac{u_6}{u} \]  

* The following notation is used in the various formulas:—  
\( a \), the equivalent orifice of the mine in square feet.  
\( d \) and \( d_1 \) the weights of a cubic foot of the external and internal air.  
\( d_2 \), the mean weight \((d + d_1) \div 2\).  
\( d_3 \), the weight of a cubic foot of water.  
\( g \), acceleration of gravity, 32.1912 feet per second per second.  
\( H \), initial depression in inches of water.  
\( H_0 \), theoretical depression in feet of air-column.  
\( H_x \), theoretical depression in inches of water.  
\( h \), the observed or effective depression in inches of water.  
\( h_v \), motive column in feet of air.  
\( h_0 \), the difference between \( H \) and \( h \), in inches of water.  
\( K \), maximum manometric efficiency.
o, orifice of passage of fan.
P, the barometric height in the atmosphere, from which P1, the pressure of
the air in the fan-drift, is deduced, by subtracting the height of mercury due to the
water-gauge.
t and tv the temperatures of the external and internal air.
u, the speed of the periphery of the fan in feet per minute.
u6, the normal velocity of the fan, or 6,000 feet per minute.
V, the observed volume in cubic feet per minute.
Vs, theoretical volume of air in cubic feet per second,
V6 and h6 the volume and water-gauge at the normal velocity.
v, velocity of the air in feet per second.

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The water-gauge at the normal velocity was calculated by the formula:

[Formula 2 omitted]
The equivalent orifice was calculated by the formula.

[Formula 3 omitted]
The weight of the air of the atmosphere and of the fan-drift did not vary greatly, but
the mean (rQ of the two weights was used in the preceding formula, which after
reducing to a simple form becomes:

[Formula 4 omitted]
The weight of the air of the atmosphere and of the fan-drift was calculated by means
of Mr. James Glaisher's Hijrometrical Tables.
The useful effect in the air is calculated by the following formula:

[Formula 5 omitted]
The motive power developed by the engine is calculated by the formula previously
mentioned.
The mechanical efficiency is the ratio between the useful effect in air to the motive
power.
Theoretical depression produced by the perfect centrifugal fan is calculated by
the formula: \( u^2 / g \) (6)
The normal velocity has been uniformly assessed at 6,000 feet per minute or 100
feet per second. The normal theoretical depression is therefore the same for all the
ventilators, and equal to \( (100^2 / g =) 310.65 \) feet of air-column.

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This value is, however, usually expressed in inches of water-column calculated by
the formula: \( Hx = u^2/g \times d2/d3 \times 12 \) (7)
This value varies in the different experiments, between 4.273 and 4.668 inches.
The manometric efficiency is the ratio between the observed and the theoretical
water-gauge at the normal velocity.

The results of the calculations are appended to the foot of each column recording the
observations made during each experiment. The register of the experiments consists
of twelve similar parts, one of which relates to each of the fans tested by the Committee. Each part commences with a table of the dimensions, etc., of the fan and engine, area of the place of air-measurement, etc. Then follow numerous tables relating to the experiments, with calculations appended. The tables are each followed by a summary of the experiments, which does not require explanation (Appendix B, Tables 1 to 12).

V.—Comparative Results of the Experiments.

The results of the experiments as recorded in Appendix B (Tables 1 to 12) contain all the details necessary for the compilation of the comparative tables, Appendix C (Tables 13 to 24), from which valuable conclusions may be deduced.

(a) Relative Volumes Produced by the Ventilators.

Figs. 33 to 42 (Plates XVIII. to XXVII.) are diagrams exhibiting the characteristic curves of the ventilators when running at the normal velocity of 6,000 feet per minute. Figs. 33 to 38 (Plates XVIII. to XXIII.) show the characteristic curves of the two ventilators tested at each mine. The characteristic curves of the four Guibal fans are shown on Fig. 39 (Plate XXIV.), of the four Schiele fans on Fig. 40 (Plate XXV.), and of the four Waddle fans on Fig. 41 (Plate XXVI.). The mean characteristic curves of the three types of ventilators are shown upon each of the diagrams, and also for purposes of direct comparison on Fig. 42 (Plate XXVII.).

On these diagrams curves are drawn through the points representing the results of each experiment: the abscissae? representing the equivalent orifices or the comparative resistances of the various mines, and the ordinates being the volumes of air produced. These curves are the characteristic curves of the ventilators, and by this means the relative efficiencies of the several ventilators are clearly represented.

For all fans, the characteristic curves begin at the origin, as when the mine is closed the volume of air is necessarily nil; thence the lines rise at greater or less angles and variable curves. These curves can readily be understood, if it be assumed that (1) the ventilator is running at the normal velocity, and that (2) the mine is closed by a regulator, which being gradually opened, the volume of air will gradually increase, and this increase is shown by the curve on the diagrams.

The theoretical centrifugal ventilator, free from friction and producing the theoretical depression, will produce volumes of air proportional to the areas of the equivalent orifice, and this characteristic curve is shown by the line O B on each diagram.* The inherent resistances of the fan are of material importance, and increase with the volume of air, hence, instead of the line O B, the characteristic curve of each ventilator becomes slightly curved and depressed as shown in the various diagrams.

If the characteristic curves of the three centrifugal fans be examined, the superior efficiency of the Guibal fan is apparent for all areas of the equivalent orifice. In the Schiele and Waddle types of fans, the superiority of either fan is not very evident, but the ventilators at the several mines appear to range themselves in the following order:—Great Western (Schiele), Pelton (Waddle), National (Schiele), Towneley (Waddle), Cwmaman (Waddle), National (Waddle), Wingate Grange (Schiele), and Towneley (Schiele). The volumes produced by the Schiele ventilators is highest for those of largest diameter; the volumes in the case of the Waddle ventilators appear to decrease as the diameters increase, but it should be remembered that the fan at the Towneley colliery was old and in bad repair, and that at the National colliery is not of the ordinary type, and should more properly be termed a quasi-Waddle fan.
Table B shows, in figures, the comparative volumes of air produced by each of the ventilators upon mines with equivalent orifices of 10, 20, 30, 40 and 50 square feet. The mean volumes of air produced by each of the types of ventilators on mines with similar equivalent orifices are shown in Table C.

* [Formulae omitted]

Table B.—Comparative Volumes of Air Produced by the Several Ventilators, when Running at the Normal Velocity of 6,000 Feet per Minute, for Various Areas of Equivalent Orifices.

[Table omitted]

Table C.—Mean Comparative Volumes of Air Produced by Various Types of Ventilators, when Running at the Normal Velocity of 6,000 Feet per Minute, for Various Areas of Equivalent Orifices.

[Table omitted]

The diagrams of the characteristic curves have shown the comparative volumes produced by the ventilators tested by the Committee. But it should also be remembered, that as the experiments were confined to mines where two types of ventilators were employed, the results obtained should not and are not intended to be used as indicating the actual comparative volumes of air produced by the most efficient ventilators of the Guibal, Schiele or Waddle types.

(b) Mechanical Efficiencies of the Ventilators.
The motive power utilized or the percentage of useful effect of each ventilator was determined. In order that the percentages of useful effect obtained in the experiments may be compared, it is evidently essential that, like the volumes of air, they should be reduced to the normal velocity. It is difficult, however, to conceive what the efficiency would become when reduced to the normal velocity. It may be assumed when the velocity is diminished that the efficiency will decrease, owing to the greater proportionate value of the passive resistances of the ventilator and the engine, and vice versa; but the exact law is not known. Under these circumstances, and as many of the experiments were made at velocities approximating more or less closely to the normal velocity, it may be assumed that the percentages of useful effect obtained in the experiments may be applied to the normal velocity without appreciable error.

Figs. 43, 44 and 45 (Plates XXVIII., XXIX. and XXX.) show the curves of the percentages of useful effect of the Guibal, Schiele and Waddle ventilators. The curves of the percentages of useful effect are drawn upon the same abscissas as the characteristic curves, that is the scale of the equivalent orifices, and the percentages of useful effect are placed as ordinates. These curves begin at the origin, because, when the mine is closed, the work of the engine is entirely absorbed by the passive and other resistances of the ventilator and engine, and consequently both the power utilized and the percentage of useful effect are nil. From the origin, the curves rise at various inclinations, then bend and approach more or less closely to the theoretical
maximum useful effect, which is the horizontal line corresponding to a useful effect of 100 per cent, or unity.

It will be noted on an examination of the diagrams that the useful effects of the combined ventilators and engines are widely divergent, to a much greater extent than occurs in the case of the characteristic curves of the ventilators. The mean results of the several ventilators and engines are shown on Fig. 46 (Plate XXXI.), for purposes of direct comparison, and they tend to prove that the highest mechanical efficiency may be realized upon mines with areas of equivalent orifices varying from 35 to 40 square feet, beyond which the useful effect begins to diminish. For small equivalent orifices, the useful effect is low, and becomes nil at the origin as already explained; while it decreases for larger orifices, owing to a greater proportion of the power being absorbed in overcoming the friction of the large volumes of air passing through the ventilator.

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The mean maximum percentage of useful effect of the Guibal ventilator and engine is 54.8 per cent., whilst for the Schiele and Waddle ventilators it is lower. These results are slightly different from those obtained by a comparison of the volumes, and may be explained by the engines being of less efficient types. If the efficiencies of the engines had been the same, the mean curves shown in Fig. 46 would have been similar to the curves of the volumes shown in Fig. 42.

Table D contains the numerical values of the useful effects of each of the ventilators and engines for mines with orifices of 10, 20, 30, 40 and 50 square feet. The mean values of the useful effects of three types of ventilators and engines are recorded in Table E, for similar orifices.

Table D.—Comparative Percentages of Useful Effect of the Several Ventilators, for Various Areas of Equivalent Orifices.

[Table omitted]

Table E.—Mean Comparative Percentages of Useful Effect, for Various Areas of Equivalent Orifices.

[Table omitted]

The experiments indicate in an unqualified manner that the choice of an efficient engine very materially affects the useful effect of a ventilator: an efficient ventilator being practically valueless when driven by an inefficient engine.

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In Fig. 43, the result of experiment No. 1 on the Great Western colliery, Guibal ventilator is omitted, being made at the very low speed of 6 3/4 revolutions per minute; the low percentage of useful effect obtained in experiment No. 10, is due to the ventilator being run at 33 3/4 revolutions per minute, a speed much, below the normal velocity of 47.74 revolutions per minute, and its corresponding efficiency of about 55 per cent., when the equivalent orifice varies between 40 and 45 square feet. With the Guibal ventilator at Pelton colliery, the only experiment diverging from the curve is No. 7 (Fig. 43), and this difference appears to be due to the low speed of the ventilator (32 5/8 revolutions) during the experiment, as compared with the normal speed (53.05 revolutions).
Experiments Nos. 7 and 6 were made upon the Schiele ventilator at the Great Western colliery under similar conditions, save that the speed was increased from 139 7/8 to 171 5/8 revolutions, and Fig. 44 (Plate XXIX.) shows that the efficiency of the engine became much greater at the higher speed (59.55 to 67.16 per cent, respectively). It is probable, therefore, that the efficiency of this ventilator and engine will attain its maximum with a speed of about 170 revolutions per minute, and an orifice of about 35 square feet. The result of experiment a, at the low speed of 20 7/8 revolutions per minute, is omitted from the diagram.

In the case of the Schiele ventilator at the National colliery, divergences from the curve are shown in experiments Nos. 1, 2, 3 and 7 (Fig. 44, Plate XXIX.). The increased efficiency is due to the speed, in each case (137 1/2 and 164 3/4 revolutions) rising above the normal speed (125.23 revolutions per minute). The efficiency of this plant would probably attain 44 per cent, on an orifice of 20 square feet, and the fan running at a speed of 165 revolutions per minute. The result of experiments, at the low speed of 18 1/4 revolutions per minute, is abnormal.

Experiments Nos. 5, 6 and 7 upon the Schiele ventilator at the Towneley collieries show, in a very evident manner, that the efficiency of this plant under the same conditions, increases with the speed thus:

<table>
<thead>
<tr>
<th>No. of Experiment</th>
<th>Revolutions per Minute</th>
<th>Useful Effect (Per Cent.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>126 1/4</td>
<td>40.53</td>
</tr>
<tr>
<td>6</td>
<td>160 1/4</td>
<td>47.70</td>
</tr>
<tr>
<td>5</td>
<td>176 1/4</td>
<td>49.57</td>
</tr>
</tbody>
</table>

It is probable that this plant might yield an efficiency of 59 per cent., when exhausting from an orifice of 20 square feet and running at a speed of 175 revolutions per minute.

The divergence in No. 6 experiment upon the Schiele ventilator at Wingate Grange colliery is due to the low speed (88 3/8 revolutions) as compared with the normal speed (159.15 revolutions per minute). The abnormal results of experiments d and e, are difficult to explain.

No. 2 experiment upon the Waddle ventilator at the Cwmaman colliery, is below the curve of useful effect owing to the speed (43.15 revolutions) being below the normal speed (63.66 revolutions). The highest efficiency, about 59 per cent., appears to be attained at the normal speed on an orifice of 35 square feet.

The results of the experiments upon the quasi-Waddle ventilator at the National colliery are unsatisfactory. The divergences in Nos. 2, 6 and 7 experiments are probably due to errors of observation, and in the case of No. 10 experiment to the velocity (26 3/8 revolutions) being below the normal speed (42.44 revolutions per minute).

The results of the experiments upon the Waddle fan and engine at the Pepton colliery are unsatisfactory, and are probably due to their age, having been erected in 1868. No. 5 experiment falls below the medial curve, probably owing to the speed (41 1/2 revolutions) being below the normal speed (60.44 revolutions per minute). The low result of No. c experiment is due to the low speed of about 18 revolutions per minute.

The low plant efficiency of the Waddle ventilator at the Towneley collieries is somewhat marked, and is probably due to its condition. The following experiments show how its efficiency varied with the speed:

<table>
<thead>
<tr>
<th>No. of Experiment</th>
<th>Revolutions</th>
<th>Efficiency</th>
</tr>
</thead>
</table>
These experiments show that if this plant had been run at the normal speed (47.74 revolutions per minute) the efficiency might have realized upwards of 50 per cent, upon orifices of 30 square feet.

(c) Relations of the Volume and Depression produced by Centrifugal Ventilators.

The height of motive column \( h_1 \) in feet of air produced by a difference of temperature or by mechanical means is the cause of the motion of air in mines, and the principles of mechanics show (if there be no friction) that the velocity produced is equal to that acquired by a body falling from the same height as that of the head of motive column—

\[ v = \sqrt{2gh_1} \]  

Consequently, the theoretical volume of air passing through any equivalent orifice of area \( a \) will be—

\[ V_s = va = a \sqrt{2gh_1} \]  

if \( h \) represent the height of the depression in inches of water of a density \( d_3 \), and \( d_2 \) the density of air, then—

\[ h_1 = \frac{h}{12} \times \frac{d_3}{d_2} \]  

Substituting this value (10) in the preceding equation (9), then—

\[ V_s = a \sqrt{2g \times \frac{h}{12} \times \frac{d_3}{d_2}} \]  

The actual volume of air per second, owing to the action of the vena contracta, is—

\[ V_s = 0.65 \times a \sqrt{2g \times \frac{h}{12} \times \frac{d_3}{d_2}} \]  

and the volume of air per minute will be—

\[ V = 60 \times 0.65 \times a \sqrt{2g \times \frac{h}{12} \times \frac{d_3}{d_2}} \]  

The value of the equivalent orifice is then obtained by deduction—

\[ \text{[Formula omitted]} \]

The theoretical depression, in feet of air-column, produced by a perfect ventilator is

\[ H_0 = \frac{u^2}{g} \]  

or in inches of water—

\[ H_x = \frac{u^2}{g} \times \frac{d_2}{d_3} \times 12 \]  

The depression \( H_0 \) or \( H_x \) is not realized in practice owing to the various imperfections inherent to all classes of centrifugal ventilators; and the equation becomes, for the value of the initial depression produced when the ventilator is exhausting from a closed chamber adjoining the inlet—

\[ H = K \times \frac{u^2}{g} \times \frac{d_2}{d_3} \times 12 \]  

in which \( K \) is a fraction representing the maximum manometric efficiency realized by the centrifugal ventilator.

It may now be assumed that the centrifugal ventilator is placed upon a mine, and runs at a constant speed. Adhering to the theory of the equivalent orifice, it may be assumed that the mine may be replaced by an orifice \( a \) in a thin plate whose area can be varied as desired. If the
equivalent orifice be entirely closed, the ventilator will produce the initial depression $H$. If an opening be made between the mine and the closed chamber, and gradually enlarged, the depression decreases as the volume of air traversing the ventilator increases, and is reduced to zero, when the opening or equivalent orifice is infinite in area. If $h_0$ represents this gradual decrease of the initial depression, then the effective depression may be expressed by the equation—

$$h = H - h_0,$$  \hspace{1cm} (18)

in which $h_0$ may increase in value from zero to $H$. The difference $h_0$ between the initial and effective depressions is evidently due to the defective construction of the ventilator, and this loss increases in proportion as the volume of air produced absorbs an increasing fraction of the initial depression. If $o$ be an orifice representing the difficulty of the passage of air through the ventilator, the mine and the ventilator are then represented by two orifices $a$ and $o$, placed one behind the other, and successively traversed by the air-current induced through the orifice $a$ by the depression $h$, and through the orifice $o$ by the depression $h_0$. The various values are represented by the formula;—

[Formulae (19), (20) omitted]

The following proportions results from the preceding formulas:—

[Formulae omitted] \hspace{1cm} (21 and 22)

If the latter value be substuted in the preceding equation (18), it becomes—

[Formula omitted] \hspace{1cm} (23)

The actual depression—

[Formula omitted] \hspace{1cm} (24)

or substituting the value of $H$, as already determined (17),

[Formula omitted] \hspace{1cm} (25)

The preceding formula shows that the manometric efficiency is a variable expression, increasing with the resistance of the mine, and that

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the maximum, is attained when the orifice is at its minimum area or entirely closed; and that the depression produced, if other conditions remain constant, varies with the square of the speed of the ventilator. This formula also makes the concession that the manometric efficiency is somewhat constant for ventilators of all reasonable and similar dimensions of the same type. The actual volume of air is obtained by the introduction of the value of $h$, obtained by equation (24) into equation (13),

[Formula omitted] \hspace{1cm} (26)

and introducing the value of $H$, as determined by formula (17), then the volume of air per minute after reduction is—

[Formulae (27) and (28) omitted] \hspace{1cm} (28)
This formula shows, if the speed of the centrifugal ventilator remains constant, that (1) the volume varies inversely with the resistance of the mine, and becomes nil when the resistance of the mine is infinite or when the inlet from the mine is closed; that (2) the volume increases when the orifice of the fan or (and) the orifice of the mine is increased; that (3) the volume varies with the speed of the centrifugal ventilator if other conditions remain constant; and that (4) the volume produced by small ventilators can never equal those produced by large ventilators, as the orifice of the ventilator, which measures the resistance of the fan to the passage of the air, must necessarily, be less for a small than for a large ventilator.

It may also be recognized that the various formulas apply to centrifugal ventilators, whether air is being exhausted from or forced into a mine.

The connexion between the volume, the depression, and the equivalent orifice of the mine cannot be easily explained. It is, however, readily recognized that the volume increases as the depression falls when the orifice of the mine becomes larger. This explanation is more easily recognized if a drawing be made in which the increasing values of the orifice of the mine are placed as abscissas: this line may represent a long rectangular orifice, closed by a sliding-door which may be opened as desired. The corresponding values of the volumes of air and the depressions produced are drawn thereon as ordinates. The two resultant curves are reproduced in Fig. 32 (Plate XVII.)

The depression commences when the mine is closed with its initial value of \( Ku^2 \div g \); and as the orifice of the mine is enlarged the effective depression gradually falls and would become nil when the orifice of the mine is infinite in area; that is, when the initial depression is absorbed in overcoming the resistance of the air in passing through the ventilator when exhausting freely from the atmosphere.

The curve of the volume commences at the origin because the yield is nil when the orifice of the mine is closed. Thence it rises rapidly, gradually bends, and terminates in a horizontal line, where the asymptote has for its ordinate the volume \( 39 \sqrt{2K} \).

(d) Results of the Experiments.
(1) Fundamental Formula.—The results of the experiments may now be examined in order to establish the truth of the two fundamental formulae of centrifugal ventilators (25 and 28). In order to simplify the verification, the two formulae, by eliminating from them the equivalent orifice \( a \), may be combined into one, and the following equation is obtained:—

\[
\text{[Formula omitted]} = \quad (29)
\]

If the initial depression \( H \) be replaced by \( H \), and the constant \( M \) by \( M \), the preceding formula becomes:—

\[
h = MV^2 \quad (30)
\]

in which

\[
M = 0.00,122,546 \frac{d^2}{(o^2d^3)}
\]

Equation (30) has the advantage of avoiding the calculation of the equivalent orifice of the mine, and if the ordinates \( h \), and the abscissas \( V^2 \) be drawn, the co-ordinates of the results of the various experiments should form a straight line. This formula should be applied to the results of all experiments upon centrifugal ventilators, as it is the most convenient method of ascertaining the correctness of the results.

The formula is applicable irrespective of any of the numerous theories respecting the ventilation of mines and of the varying effects produced by natural ventilation.
The value of $M$ can only be calculated with difficulty from the results of experiments. Tables 25, 26, 27 and 28 (Appendix D) record the results of experiments upon the Guibal ventilators at the Owmaman, Great Western, Pelton and Wingate Grange collieries, reduced to the normal speed of 6,000 feet per minute. The equations of the straight lines passing through or adjacent to the various points are shown in Table F.

Table F.—Guibal Ventilators.

The observed depressions do not all approach the calculated straight lines, but they do so with sufficient accuracy to establish the truth of the theory applied to centrifugal ventilators. Tables 29, 30, 31 and 32 (Appendix D) show the results obtained by the Schiele ventilators at the Great Western, National, Towneley and Wingate Grange collieries. The equations for the mean straight lines are recorded in Table G.

Table G.—Schiele Ventilators.

The irregularities shown in the tables may in some cases be explained by the inconvenient position of the places where the air was measured, but they generally sustain the accuracy of the formulas. Tables 33, 34, 35 and 36 (Appendix D) contain the results derived from the experiments upon the Waddle ventilators at the Cwmaman, National, Pelton and Towneley collieries. The straight-line equations are detailed in Table H.

Table H.—Waddle Ventilators.

With few exceptions, these tables afford an excellent verification that the theory of centrifugal ventilators is in exact accordance with the results of the experiments, with the reservations previously expressed. It would appear from the twelve before-mentioned tables that in the case of mines with small equivalent orifices the results are lower than the results with larger orifices. This loss of depression may be attributed to many causes: to the mal-adjustment of the sliding-shutter (where such an appliance is attached to a centrifugal ventilator) and to the inclination of the vanes, which are only suitable in the case of any centrifugal ventilator to a given volume of air, etc. Consequently, the theoretical straight line cannot be followed up to the first ordinate, as it bends when applied to small values of the equivalent orifice more or less rapidly, according to the imperfections of the ventilator.

(2) Manometric Efficiencies.—The manometric efficiencies $K$ of the various ventilators may now be calculated from the constants $H$, determined by the equations and tables as detailed in Table I.

Table I.—Guibal, Schiele and Waddle Ventilators.
The results recorded in Table I. show that the Guibal ventilator fitted with expanding-chimney and so-called sliding-shutter affords the best results; the Schiele ventilator with the expanding chimney being next in position; and the Waddle type of open-running fan is third.

(3) Orifices of the Ventilators. — The orifices of the ventilators may now be calculated from formulae (31), deducing therefrom that—

\[ o = \sqrt{\frac{0.000,122,546d^2}{Md^3}} \]  

The following table (J) contains the essential dimensions, etc., of the several ventilators, together with the values of the orifices of passage of the ventilators as determined by the preceding formula.

Table J.—Guibal, Schiele and Waddle Ventilators.

The orifices of the several ventilators appear to vary with the diameter of the fan, the construction and width of the vanes, and the diameter of and width at the inlet or the area afforded, to the passage of the air.

APPENDIX A.

Observations to be made, and Instructions to the Engineers.

Six separate experiments shall be made upon each ventilator, in which the friction of the mine is varied, as follows:—(a) The return to the ventilator closed. (b) The return to the ventilator closed, with the exception of an opening of 3 square feet, (c) The opening doubled in area, (d) The mine under ordinary working conditions, with all machinery at rest (hauling-engines, winding-engines, etc.) (e) The entrance of air facilitated by opening some doors. (f) Air admitted as freely as possible from the atmosphere.

In each trial, the six experiments shall be made in the above-named order, and as nearly as possible at the normal speed of periphery, subject of course to the ability of the engines to drive the fans at the required speed when passing large volumes of air.

Two more experiments shall also be made with the mine under ordinary conditions, and the fan running at higher and lower speeds.

The normal speed of periphery shall be taken at 6,000 feet per minute.

In each experiment, observations shall be made of—(a) The number of revolutions per minute of the fan and engines, (b) The volume of air. (c) The water-gauge, (d) The indicated horse-power, (e) The height of the barometer. (f) The temperature of the air.

Notes.
(a) The revolutions of the fan and engines shall be counted by an ordinary engine-counter, and, if possible, two independent observers shall undertake this duty.

(b) The Volume of Air.—A Casella air-meter or Biram anemometer shall be employed, provided with some simple form of stopping and starting gear, say, started by the tension of a string and stopped by the reaction of a spring; that is to say, the revolutions will be recorded so long as the string is pulled tight.

The air-measurements shall be made at the same point in (1) the return air-way and in proximity to the inlet of the fan, and also at (2) the inlet (or inlets) and in (3) the shaft. If possible a length of arching shall be taken, and the place of measurement must be of some regular geometrical form. If all parts are not accessible to the observer, the place of measurement must be reduced in size by a rectangular wooden frame or doorway.

The area of the place of measurement must be divided into 16 equal areas, and a reading of the anemometer taken in each at its centre of gravity. The division shall be made by means of horizontal and vertical strings, as shown in Figs. 47 and 48.

The anemometer shall be held for 30 seconds in each position, without intervals between the readings. Two observers shall attend to this, one to handle the anemometer (standing at one side) and the other to observe the seconds’ watch and book the results.

When the resistance of the mine is varied, the position of the fan shutter or other appliance for modifying the useful effect of the fan, shall be tested, if practicable, to ascertain the position which yields the highest water-gauge at the normal speed.

Fig. 47. Fig. 48. [Diagrams of the division of the areas]

The anemometers shall be tested at intervals with the same efficient machine.

(c) The water-gauge readings shall be made at the centre of the drift (where the air is measured) with the end of the tube pointing to the fan, and at the same time as the anemometer readings. Simultaneous readings must also be taken at the centre of the inlet to the fan. The end of the tube shall be protected by a flannel cap from the effects of velocity. The readings shall be made every 30 seconds.

The water-gauge used in the experiments shall be of the ordinary form. Distilled water shall be used in the water-gauge. Flexible indiarubber tubing will be required to connect the instruments with the points of observation.

(d) The indicated horsepower shall be obtained by means of a Richard indicator. Both ends of the cylinders shall be connected, as shown in Fig. 49, with a three-way cock at the point of union, and above which the indicator shall be placed. If there are two cylinders, two indicators shall be simultaneously employed. By this means both cylinders and both ends of each cylinder will be indicated almost simultaneously. Three sets of diagrams shall be taken during each experiment, at the beginning, middle and end.

Fig. 49. [Diagram of arrangement of the indicator]

Experiments shall also be made to determine the friction of the engine without any air passing through the fan, or by detaching the fan from the engine where possible. The indicators shall be tested by weights in the ordinary manner.
(e) and (f) The readings of the barometer and thermometer in the open air, and of the thermometer alone in the drift, shall be registered. The hygrometric conditions of the inner and outer airs shall also be recorded.

Generally, all the experiments shall be made under similar conditions, either when the pits are idle or otherwise. All time observations shall be made with a centre-second watch.

Additional information shall be obtained as under:—(1) Depths and diameters of downcast and upcast shafts. (2) Obstructions (if any) in shafts, with sketches. (3) Distance apart of the shafts, with working sketches of seams. (4) Difference in surface-level of shafts. (5) Temperature at top of upcast and downcast shafts; temperature at middle of upcast and downcast shafts; if boilers, etc., are in use underground, the temperatures should also be observed (where possible) at the point where the smoke is delivered into upcast, with sketch and dimensions of the smoke-drift and volume of air passing through it. (6) Dimensions of fan, distance from pit, and dimensions of fan-drift (with plans). (7) Dimensions of engines. (8) A record of the steam-pressure at the time of taking the indicator-diagrams. (9) A record of the water-gauge at the bottom of the pit, where possible. (10) The date of erection of the fan and engines. (11) The original or estimated cost (and date) of fan, engine, boilers, building, etc. (12) The cost of maintenance, being the actual cost of stores and repairs of fans and engines. (13) Particulars of all accidents, and duration of stoppages of fan since erection.

Instruments required:—2 water-gauges: 100 feet of indiarubber tubing with wire core; 2 flannel caps for tubing; 2 thermometers, wet and dry bulb; 3 anemometers; 2 Richard indicators; 1 set of reducing-gear; 2 Bourdon steam-gauges, 60 and 150 lbs.; 2 centre-second watches; 1 aneroid barometer; 2 Harding counters; 2 three-way cocks; tool-chest; ratchet-brace and 4 drills; screw-spanner; pipe-tongs; pincers; pipe-cutter; callipers; stock and dies; taps and key; oil-tin; short lengths of steam-pipe of various diameters, etc.

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APPENDIX B.—TABLES 1 and 2.—EXPERIMENTS OF OCTOBER 27th, 28th and 29th, 1888, UPON THE GUIBAL AND WADDLE FANS AT CWMAMAN COLLIERY.

Dimensions, etc., of the Guibal Fan.

| Description | centrifugal fan of Guibal type. |
| Diameter | 30 feet. |
| Width, at inlet | 10 " |
| " at periphery | 10 " |
| Diameter of inlet | 10 feet 2 inches. |
| Normal velocity (6,000 feet per minute =) | 68.66 revolutions per minute. |

Dimensions, etc., of the Engine.

| Number of cylinders | one. |
| Diameter of the piston | 24 inches. |
| " of piston-rod, fore end | 3 3/4 " |
| Mean effective area of the piston | 446.90 square " |
| Stroke of piston | 24 " |
Ratio of transmission direct, as one to one.

Exhaust steam condensed by Morton ejector condenser.

Sundry Particulars.

Area of place of measurement (Fig. 2, Plate XV.) 112.26 square feet.

Dimensions, etc., of the Waddle Fan

Description centrifugal fan of Waddle type.
Diameter 30 feet.
Width, at inlet 3 feet 6 inches.
  " at periphery 1 foot 4 "
Diameter of inlet 12 feet 0 "
Normal velocity (6,000 feet per minute =) 63*66 revolutions per minute.

Dimensions, etc., of the Engine.

Number of cylinders two.
Diameter of the piston 40 inches
  " of right-hand piston-rod, fore end 4 3/16 "
  " of left-hand piston-rod, fore end 4 1/8 "
Mean effective area of the pistons 1,249.90 square "
Stroke of pistons 30 "
Ratio of transmission by helical gearing, as 70 to 29.

Sundry Particulars.

Area of place of measurement 86.15 square feet.

APPENDIX B.—TABLES 1 and 2.—CWMAMAN COLLIERY.

Results of Experiments on the Guibal and Waddle Fans.

[Tables omitted]

APPENDIX B.—TABLE 3.—EXPERIMENTS OF JUNE 2nd, 1889, UPON THE GUIBAL FAN AT GREAT WESTERN COLLIERY.

Dimensions, etc., of the Fan.

Description centrifugal fan of Guibal type.
Diameter 40 feet.
Width, at inlet 12 "
  " at periphery 12 "
Diameter of inlet 14 "
Normal velocity (6,000 feet per minute =) 47.74 revolutions per minute.

Dimensions, etc., of the Engine.

Number of cylinders one.
Diameter of the piston 36 inches.
  " of piston-rod, fore end 4 1/2 "
Mean effective area of the piston 1009.02 square "
Stroke of piston 36 "
Ratio of transmission direct, as one to one.

Sundry Particulars.
Area of place of measurement (Fig. 8, Plate XV.) 102.37 square feet.

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APPENDIX B.—TABLE 3.—GREAT WESTERN COLLIERY,—
Results of Experiments on the Guibal Fan.

[Tables omitted]

[221]

APPENDIX B.—TABLE 4.—EXPERIMENTS OF JUNE 3rd, 1889, UPON THE
SCHIELE FAN AT GREAT WESTERN COLLIERY.

Dimensions, etc., of the Fan.

Description centrifugal fan of Schiele type.
Diameter 15 feet 3 inches.
Width, at inlet 6 " 0 "
" at periphery 3 " 9 "
Diameter of inlet 8 " 8 "
Normal velocity (6,000 feet per minute =) 125.23 revolutions per minute.

Dimensions, etc., of the Engine.

Number of cylinders one.
Diameter of the piston 32 inches.
" of piston-rod, fore end 5 "
Mean effective area of the piston 795.39 square "
Stroke of piston 36 "
Ratio of transmission by belting, about 3.2 to one.

Sundry Particulars.
Area of place of measurement (Fig. 9, Plate XV.) 162.75 square feet.

[222-4]

APPENDIX B.—TABLE 4.—GREAT WESTERN COLLIERY.—
RESULTS OF EXPERIMENTS ON THE SCHIELE FAN.

[Tables omitted]

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APPENDIX B.—TABLE 5.—EXPERIMENTS OF JUNE 8th, 1889, UPON THE
SCHIELE FAN AT NATIONAL COLLIERY.

Dimensions, etc., of the Fan.
Description  centrifugal fan of Schiele type.
Diameter  15 feet 3 inches.
Width, at inlet  6 " 0 "
  " at periphery  3 " 0 "
Diameter of inlet  8 "10 "
Normal velocity (6,000 feet per minute =)  125.23 revolutions per minute.

Dimensions, etc., of the Engine.

Number of cylinders  one.
Diameter of the piston 32 inches.
  " of piston-rod, fore end  4 5/8 "
Mean effective area of the piston 795.61 square "
Stroke of piston  36 "
Ratio of transmission by belting, about 3.15 to one.

Sundry Particulars.

Area of place of measurement (Fig. 17, Plate XVI.) 160.97 square feet.

[226-8]

APPENDIX B.—TABLE 5.—NATIONAL COLLIER Y. - Results of Experiments on the Schiele Fan.

[Tables omitted]

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APPENDIX B.—TABLE 6.—EXPERIMENTS OF JUNE 9th 1889, UPON THE WADDLE FAN AT NATIONAL COLLIER Y.

Dimensions, etc., of the Fan.

Description  centrifugal fan of Waddle type.
Diameter  45 feet 10 inches.
Width, at inlet  4 " 2 "
  " at periphery  1 " 8 "
Diameter of inlet  15 " 0 "
Normal velocity (6,000 feet per minute =)  42.44 revolutions per minute.

Dimensions, etc., of the Engine.

Number of cylinders  one.
Diameter of the piston 36 inches.
  " of piston-rod, back end 5 "
  " of piston-rod, fore end  5 "
Mean effective area of the piston 999.2 square "
Stroke of piston  36 "
Ratio of transmission Direct, as one to one.

Sundry Particulars.
Area of place of measurement (Fig. 17, Plate XVI.) 160.97 square feet.

APPENDIX B.—TABLE 6.—NATIONAL COLLIERY.--
Results of Experiments on the Waddle Fan.

[Table omitted]

APPENDIX B.—TABLE 7.—EXPERIMENTS OF JANUARY 19th and 20th, 1889,
UPON THE GUIBAL FAN AT PELTON COLLIERY.

Dimensions, etc., of the No. 2 Fan.

Description  centrifugal fan of Guibal type.
Diameter  36 feet.
Width, at inlet 12 "
" at periphery 12 "
Diameter of inlet 13 "
Normal velocity (6,000 feet per minute =) 53.05 revolutions per minute.

Dimensions, etc., of the Engine.

Number of cylinders  one.
Diameter of the piston 36 inches.
" of piston-rod, back end 4 7/8 "
" of piston-rod, fore end 4 7/8 "
Mean effective area of the piston  688.2 square "
Stroke of piston  30 "
Ratio of transmission  Direct, as one to one.

Sundry Particulars.

Area of place of measurement (Fig. 19, Plate XVI.) 78-53 square feet.

APPENDIX B.—TABLE 7.—PELTON COLLIERY.—
Results of Experiments on the Guibal Fan.

[Tables omitted]

APPENDIX B.—TABLE 8.—EXPERIMENTS OF JANUARY 19th and 20th, 1889,
UPON THE WADDLE FAN AT PELTON COLLIERY.

Dimensions, etc., of the Fan.

Description  centrifugal fan of Waddle type.
Diameter  31 feet 7.2 inches
Width, at inlet 3 " 3 "
" at periphery 1 " 2 "
Diameter of inlet 14 " 1 "
Normal velocity (6,000 feet per minute =) 60.44 revolutions per minute.

Dimensions, etc., of the Engine.

Number of cylinders one.
Diameter of the piston 24 inches.
,, of piston-rod, back end 2 15/16 "
,, of piston-rod, fore end 3 13/16 "
Mean effective area of the piston 443.30 square "
Stroke of piston 24 "
Ratio of transmission Direct, as one to one.

Sundry Particulars.

Area of place of measurement (Fig. 20, Plate XVI.) 79.17 square feet

[238-40]

APPENDIX B.—Table 8.—Pelton colliery.—Results of Experiments on the Waddle Fan

[Tables omitted]

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APPENDIX B.—TABLE 9.—EXPERIMENTS OF SEPTEMBER 1st, 1889, UPON THE SCHIELE FAN AT TOWNELEY COLLIERY

Dimensions, etc., of the Fan.

Description centrifugal fan of Schiele type.
Diameter 12 feet 0 inches.
Width, at inlet 3 " 6 "
,, at periphery 2 " 3 "
Diameter of inlet 7 " 0 "
Normal velocity (6,000 feet per minute =) 159.15 revolutions per minute.

Dimensions, etc., of the Engine.

Number of cylinders one.
Diameter of the piston 24 inches.
,, of piston-rod, fore end 4 1/2 "
Mean effective area of the piston 515.026 square "
Stroke of piston 48 "
Ratio of transmission by belting, about 4 4/9 to one.

Sundry Particulars.

Area of place of measurement 64 square feet.

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APPENDIX B.—TABLE 9.—TOWNELEY COLLIERY.—Results of Experiments on the Schiele Fan.
APPENDIX B.—TABLE 10.—EXPERIMENTS OF AUGUST 81st, 1889, UPON THE WADDLE FAN AT TOWNELEY COLLIER Y.

Dimensions, etc., of the Fan.

Description centrifugal fan of Waddle type.
Diameter 40 feet 0 inches.
Width, at inlet 4 " 8 ",
" at periphery 1 " 6 ",
Diameter of inlet 12 " 0 "
Normal velocity (6,000 feet per minute =) 47.74 revolutions per minute.

Dimensions, etc., of the Engine.

Number of cylinders one.
Diameter of the piston 32 inches.
" of piston-rod, back end 3 11/16 "
" of piston-rod, fore end 4 1/2 "
Mean effective area of the piston 789.998 square "
Stroke of piston 48 "
Ratio of transmission Direct, as one to one

Sundry Particulars.

Area of place of measurement 64 square feet.

APPENDIX B.—TABLE 10.—TOWNELEY COLLIER Y.—RESULTS OF EXPERIMENTS ON THE WADDLE FAN.

[Tables omitted]

APPENDIX B.—TABLE 11.—EXPERIMENTS OF FEBRUARY 2nd and 3rd, 1889, UPON THE GUIBAL FAN AT WINGATE GRANGE COLLIER Y.

Dimensions, etc., of the Fan.

Description centrifugal fan of Guibal type.
Diameter 36 feet.
Width, at inlet 12 "
" at periphery 12 "
Diameter of inlet 13 "
Normal velocity (6,000 feet per minute =) 53.05 revolutions per minute.

Dimensions, etc., of the Engine.

Number of cylinders one.
Diameter of the piston 30 inches.
Area of place of measurement (Fig. 28, Plate XVII.) 88.40 square feet.

[250-252]

APPENDIX B.—TABLE 12.—WINGATE GRANGE COLLIERY.—Results of Experiments on the Schiele Fan.
[Tables omitted]

[253]

APPENDIX B.—TABLE 12.—EXPERIMENTS OF FEBRUARY 2nd and 3rd, 1889, UPON THE SCHIELE FAN AT WINGATE GRANGE COLLIERY.

Dimensions, etc., of the Fan.

Description centrifugal fan of Schiele type.
Diameter 12 feet 0 inches.
Width, at inlet 3 4
" at periphery 2 0
Diameter of inlet 7 3
Normal velocity (6,000 feet per minute =) 159.15 revolutions per minute.

Dimensions, etc., of the Engine.

Number of cylinders one.
Diameter of the piston25 inches.
" of piston-rod, fore end 3 1/4
Mean effective area of the piston 486.73 square
Stroke of piston 24
Ratio of transmission by rope gearing, about 2.6 to one.

Sundry Particulars.

Area of place of measurement (Fig. 29, Plate XVII.) 78.47 square feet.

[254-256]

APPENDIX B.—TABLE 12.—WINGATE GRANGE COLLIERY.—Results of Experiments on the Schiele Fan.
[Tables omitted]

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Appendix C.—Tables 13 - 23: summaries of experiments at each colliery.
Appendix D.—Table 25.—Cwmaman Colliery, Guibal Fan.

Appendix D.—Table 26.—Great Western Colliery, Guibal Fan.

Appendix D.—Table 27.—Pelton Colliery, Guibal Fan.

Appendix D.—Table 28.—Wingate Grange Colliery, Guibal Fan.

Appendix D.—Table 29.—Great Western Colliery, Schiele Fan.

Appendix D.—Table 30.—National Colliery, Schiele Fan.

Appendix D.—Table 31.—Towneley Colliery, Schiele Fan.

Appendix D.—Table 32.—Wingate Grange Colliery, Schiele Fan.

Appendix D.—Table 33.—Cwmaman Colliery, Waddle Fan.

Appendix D.—Table 34.—National Colliery, Waddle Fan.

Appendix D.—Table 35.—Pelton Colliery, Waddle Fan.

Appendix D.—Table 36.—Towneley Colliery, Waddle Fan.
Plates XV to XVII: Diagrams showing the layout and sections of the collieries and fans.

Plates XVIII to XXVII: Graphs showing the characteristic curves of each fan.

Plates XXVIII to XXXI: Graphs showing mechanical efficiency of each fan.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

THE CLASSIFICATION OF ORE-DEPOSITS.


In the first place, regard must be had to the distribution of the chemical elements in the earth's crust. Now, Messrs. Rosenbusch and Vogt state that the heavy metals (iron and manganese excepted) from [form] only 0.01 per cent. of that crust: even distribution of these would therefore presuppose excessively fine division. On the other hand, light metals are normal constituents of all the rocks in the earth's crust, and as such are universally and abundantly distributed. Bearing in mind the analogy traceable in certain chemical and physical properties of the heavy metals when compared with the light metals, it may be assumed a priori that the concentration of the substance of heavy metals within the earth's crust, or, in other words, the genesis of ore-deposits, is the result of identical or analogous processes in the lithosphere. The author bases his classification of the ore-deposits on these processes of concentration. He reviews the various classifications proposed by Messrs. Burat, Cotta, Naumann, Groddeck, Stelzner, and others, concluding that none of them are satisfactory, and sets forth his own, as follows—

I. Sublimation-deposits—
   (a) Syngenetic:—The sublimation of vapours took place simultaneously with the solidification, and within the mass, of a solidifying magma, as, for example, tin-ore deposits.
   (b) Epigenetic:—Sublimation-crusts in clefts and fissures,
   (c) Metagenetic:—The constituents of a rock are dissolved by pneumatolysis (Prof. Bunsen) and replaced by metallic substances.

II. Magmatic or solidification-deposits—
   (a) Syngenetic:—The ordinary form of magmatic deposits. We owe our knowledge of this type in particular to Prof. Vogt's researches.
   (b) Epigenetic:—Only conceivable when an apophysis of a magma within the country-rock consists of a schliere (banded strip) rich in metals,
   (c) Metagenetic:—Scarcely conceivable.

III. Precipitation-deposits—
   (a) Syngenetic:—Chemical precipitation takes place simultaneously with sedimentation. The deposit originates at the same time as the enclosing rock, and "grows" in the same manner as that rock. Seams, beds, etc.
(b) Diagenetic:—Concentration of the ore takes place, for example, on the muddy bottom of a sheet of water: e.g., reniform concretions of clay-ironstone.
(c) Epigenetic:—Infillings of caverns, veins, etc. No attempt is made here to classify more particularly the vein-deposits, as no sufficient genetic explanation has yet been found of the variations, metalliferous and mineralogical, that are observed. In epigenetic deposits, then, the country-rock is in existence before the ore-deposit is formed, and the ore-body grows without reference to it.
(d) Metagenetic:—The soluble constituents of a rock are dissolved, carried away, and in their stead the metallic substance is thrown down. The ore-deposit is of formation subsequent to the surrounding rock, but it is evolved at the expense of the latter.

IV. Separation-deposits—
(a) Residual deposits arise from chemical separation: a soluble rock-constituent (for example, limestone) is carried away—while a solid metallic substance (as, for example, brown iron-ore) remains unchanged behind.
(b) Deposits formed by mechanical separation: (1) Eluvial deposits, plateau-placers, plateau-drift; (2) Colluvial deposits, valley-drift.

The author explains that he uses the term "colluvial" in order to avoid the use of "alluvial," which, he thinks, is generally understood to imply a particular portion of the Quaternary epoch.

L. L. B.

THE RECENT EARTHQUAKE IN AND AROUND ROME, ITALY.

In Rome, this earthquake was of no less consequence than that of November 1st, 1895; but, exactly as in the previous case, the damage done was confined to the breakdown of sundry ancient or badly built walls. There was no injury to life or limb. The first tremors within the city, extremely slight, were registered by the seismographic instruments 2 or 3 seconds before 2.19 p.m. on July 19th, 1899: the most violent shock, with an intensity of 7 to 8 in the De Rossi-Forel scale, appears to have lasted about 10 seconds. Thereafter the tremors went on, diminishing in intensity, the total duration of the disturbance being at Rome not less than 6 minutes. These tremors were practically the repercussion of the disastrous earthquake that took place in the Latian Hills, of which full details are to be published later by Dr. Cancani. Its epicentrum lay somewhere between Frascati, Grottaferrata and Marino. From these and other localities, reports concur in describing the main shock as a double one, producing first a "jumpy" motion, and after about 4 seconds an undulatory motion. Buildings in Frascati and elsewhere suffered much damage, and two arches of the Claudian Aqueduct were thrown down in the Campagna. The area over which the seismic vibrations were perceptible to the human senses was extensive, the extreme distance at which they were felt being 80 miles from the epicentrum (Island of Ventotene). Propagation eastward and westward was less marked than that in other directions: a point, indeed, usually noted with regard to earthquakes in Latium—the travel of the seismic waves being least towards the Tyrrhenian sea, west of Rome. Seismographic instruments were, of course, affected over a much wider area, reports coming in from Catania, Ischia, Siena, Florence and Padua.

The highest velocity of propagation of the quick-travelling undulations appears to have been 5.95 miles per second, and the lowest 1.66 miles per second. Slight after-shocks were felt on the same day and the next.
THE EARTHQUAKE IN EMILIA, ITALY.
The epicentrum of this considerable earthquake lay beneath the Apennines of Parma-Reggio, in latitude north 44 degrees 30 minutes and longitude east of Greenwich 10 degrees 20 minutes. The intensity was 8 in the De Rossi-Forel scale, and reached its maximum on the north-eastern slope of the Apennines. The area of violent shock covered about 250,000 acres, but the vibrations were perceptible to the human senses over an area 70 times as great. The duration averaged about 12 seconds, though seismographic instruments registered perturbations for a much longer period; as, for instance, 40 seconds in the case of the Parma seismograph, 15 minutes in that of the Paduan microseismo-graph, and well-nigh 30 minutes in the case of the Strasburg horizontal pendulum.
The author discusses at considerable length the question of velocity of propagation of the earthquake, casting doubt on the accuracy of many of the time-records supplied. He arrives, however, at the conclusion that the true velocity lies somewhere between 1.64 and 2.55 miles per second. The shock reached Prof. Milne's observatory at Shide (Isle of Wight) at 10h. 13m. 56s. p.m. on March 4th, 1898.*

EARTHQUAKE OF BALIKESRI, ASIA MINOR.
Balikesri (40 degrees north latitude and 28 degrees east longitude of Greenwich) is the only known locality where this earthquake produced any damage, the intensity being 7 to 8 in the De Rossi-Forel scale. The epicentrum probably lay near there, but the seismic vibrations were felt as far as Smyrna in the south and Adrianople in the north, and the island of Mitylene in the east. The portion of the earth's surface thus affected would be included in a circle of 120 miles' radius, covering an area, say, of 48,500 square miles. Seismographic instruments in Southern Russia, Italy, and Germany were set in motion: the time-records given by them would, however, have been of little use but for the fortunate circumstance that one of the seismoscopes fitted up in the observatory at Constantinople founded by the author, about 90 miles distant from the epicentrum, gave a precise record. Combining this with the reports from Nikolaiev and Padua, respectively 435 and 807 miles farther away from the epicentrum than Constantinople, the mean velocity of the quick-travelling waves of preliminary tremors works out at about 5.17 miles per second. Similarly high velocities of propagation from Asia Minor to Europe having been registered in the case of the Aidin (1895) and Amed (1896) earthquakes, the author concludes that the facts do not altogether bear out Prof. Milne's contention that such high speeds may only be looked for when the seismic vibrations travel 5,000 to 7,000 miles away from the epicentrum, and that for distances up to 1,250 miles or so a speed of 1 1/4 to 2 miles per second is not exceeded.
* Fuller details regarding this earthquake are promised for publication in the Bollettino della Soceita Sismologica Italiana, vol. v (1899-1900)
It is true that, in the present case, the records obtained from Strasburg (1,150 miles) and from Ischia (750 miles farther away from the epicentrum than Nikolaiev) shows velocities of only 3.59 and 3.22 miles per second respectively, but the author believes that this is explicable on the supposition that the preliminary tremors which affected the nearer instruments of Nikolaiev were so enfeebled by the time they reached Ischia and Strasburg that they could not set in motion the instruments at those observatories. The Paduan microseismograph, on the other hand, is a highly sensitive instrument, as the records of many other earthquakes have shown.

All the foregoing remarks apply to the "waves of compression" or "longitudinal waves" of seismological theory. For the slower undulations, which travel through the earth's crust like the swell of the ocean, the seismograms show a maximum velocity of 1.55 miles per second. It would seem that in the case here dealt with the maximum length of a complete wave of the latter category did not exceed 9 miles or so. The shock was a double one, and took place about 21 minutes after noon on September 14th, 1896.*

L. L. B.

The Earthquake of La Rioja, Argentina.


The capital city of the sub-Andine province of La Rioja had been already visited by a calamitous earthquake on October 17th, 1894, but the tremors described in this paper afflicted most severely the north-western portion of the province, destroying the village of Vichina and making havoc of the mining district of Jague.

Premonitory shocks were felt in Rioja City on April 11th, 1889, at 4.30 p.m., and also at Tinogasta. They were of short duration and feeble at the former locality, but strong for several seconds at the latter. The next day, at 1.15 p.m., a violent shock, travelling from north to south, and lasting some 50 seconds, was felt in Rioja City, where some old walls tumbled down. It was this very shock that proved so calamitous in Vichina and Jague. Tremors continued throughout the day and night till 1.10 a.m. of the 13th, and the undulations were perceptible over an immense extent of country, from La Rioja right into the provinces of Catamarca, Tucuman, Santiago del Estero, Cordoba, RCuarto, etc.

The official despatches regarding Vichina and Jague state that the earthquake was preceded by an awful subterranean roar: this was followed by a terrific shock, which destroyed 328 houses in both villages, Jague especially being reduced to a heap of ruins. Yawning fissures opened up in the earth in every direction, some of them even being circular with a central depression. At the time of the earthquake a dense cloud of dust overspread the sky, obscuring the sun, the semi-darkness adding to the terrors of the scene. Nine dead bodies were found among the ruined habitations, and a great many persons were injured.

Earth-tremors began again on April 24th, and on the 28th a specially violent shock was felt at Vichina, causing a panic among the sorely-tried inhabitants, who were camped out in the open, in a state of dreadful misery and destitution.

* For further particulars the author refers the reader to vol. v. of the Bollettino della Societa Sismologica Italiana, and to his catalogue of the 1896 earthquakes in the Beitrage zum Geophysik, vol. iv., Leipzig, 1899.

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The shocks cursorily described above were registered with great exactness by the Milne seismometer, the only instrument of the kind that has yet been set up in Argentina, at the National Meteorological Office in Cordoba. Further tremors were recorded by the instrument on May 17th and June 6th, but their starting point was supposed to be much farther away than the region of the Andes.
SUBTERRANEAN WATERS AT BRUX, BOHEMIA.
The author describes exhaustively the existence of phenomena connected with underground springs in the district of Teplitz, and eruptions of water and quicksand at Brux. He points out that in the Brux district quicksand, as such, never appears to have any direct hydrostatic power, its movement being due to the erosive and transporting power of water moving under hydrostatic pressure. It is possible to remove from quicksand its contained water, which may under some circumstances amount to 40 or 50 per cent. of its volume, without the form of the former being altered, or without its power of resisting the pressure of overlying rocks being affected.
In its dry state, quicksand can be got to stand in nearly vertical walls, this property being due to the great friction between the individual grains of quartz. A very thin capillary layer of water would be sufficient to decrease this friction enormously, and it must be remembered that a mass of spheres, the surfaces of which are frictionless, would behave like a fluid. In this way, friction between the particles of quicksand practically disappears when these are soaked in water, and the quicksand then behaves as a fluid.

GARNET-DEPOSITS OF BOHEMIA.
Die bohmischen Granatlagerstatten. By Hans Oehmichen. Zeitschrift fur Praktische Geologie, 1900, pages 1-13, with 2 figures in the text.
An exhaustive bibliography of the subject forms the introduction to the paper, followed by a physiographical description of the hilly Cretaceous district in north-eastern Bohemia, where the garnetiferous deposits occur. It was this region, which, for many years, supplied the world's markets with garnets, but the industry has been subject to many vicissitudes, and nowadays the South African pyropes, or "Cape rubies," have asserted their victorious supremacy to such an extent that nearly all the Bohemian workings have been abandoned, except the extensive opencast workings at Podseditz. The South African garnets are obtained as a bye-product in washing the famous "blue ground" of the diamond districts. Nevertheless, on the hypothesis of a possible rise in prices, there is still some prospect of a revival in the Bohemian industry, particularly if restarted on a large scale and with improved mechanical methods. The more so, too, when it is remembered that the deposits cover an area of 27 square miles, only a portion of which has been worked out, and a tenth of which may be described as exceedingly rich.
The Bohemian garnet has a fine rich dark red colour, which sometimes passes into jacinth-red, and occurs exclusively in grains of very various sizes.

It is a magnesian alumina-garnet, containing a fair proportion of lime, iron, manganese and chromium oxides. Unlike other occurrences of the mineral, clearly recognizable crystals are rarely found. The specific gravity varies between 3.69 and 3.72, the biggest grains usually found average about 0.44 gramme in weight, but some have been recorded as large as pigeons' and hens' eggis. Prices, of course, reached in 1899 a lower level than ever before.
The garnetiferous deposits are, geologically speaking, of four kinds: (1) True placers made up of Pleistocene drift, such as those of Chodolitz, Podseditz, Christian, Trziblitz, etc.; (2) conglomeratic deposits, such as those of Meronitz, probably of Tertiary age; (3) tufaceous breccias, as on Linhorka Hill, near Starrey, mined as the
mother-rock of the garnet, and to all appearance genetically associated with the Tertiary basalt-eruptions; and (4) alluvia formed of materials derived from one or more of the foregoing.

In the placers, which consist of variegated sands and clays irregularly bestrewn with subangular fragments of gneiss (often garnetiferous), granulite, granite, garnetiferous serpentine, mica-schist, and spheroidal knobs of basalt, the precious stones which have been found besides garnet are fairly large zircons, smaller spinels, sapphires and rubies. At Dlaschkwowitz, in 1869, a diamond was got for the first time, but despite very careful search, no second specimen has been obtained. This diamond, now in the Prague Museum, forms a type of its own, differing entirely from the Indian and Brazilian diamonds. Moldavites (probably of meteoric origin) have been found here and there in these placers, and the author compares the similar occurrence of meteorites in the tin-placers of Billiton.

The Meronitz conglomerate was worked 30 years ago by several shafts going down some 200 feet from the surface. About 50 people were employed, belowground in the mine and aboveground in the washing-apparatus, and something like 45 cwts. of garnets was got yearly. The conglomerate passes upward into an ashen-grey aluminous marl; this again is overlain by a dolomitic calcareous marl, often highly ferruginous; and the topmost bed of all (next to the soil-cap) is a yellow loam, which often passes into a grey clay, and contains innumerable fragments of ferruginous sandstone. The conglomerate is made up of marl, semi-opals (highly characteristic of this deposit), serpentines with a growth of garnets, granite, granulite, gneiss and mica-schist bound together by a dolomitic cement. Besides cyanite, tourmaline, zircon, etc., gypsum-crystals occur containing garnets as inclusions. The materials of this conglomerate are well rolled and smaller than the materials which appear as sub-angular fragments of the Pleistocene drifts of the placers. It is noticeable that basalt is absent, and hence the conglomerate is probably older than the Tertiary basalt-masses of the neighbourhood. It is, in fact, made up of Cretaceous material and rocks derived from a long-vanished Archaean mountain-range. Thermal waters percolating through the beds thus deposited originated various chemical processes, such as dolomitization and the formation of pyrite-nodules and gypsum-crystals. The semi-opals are the result of the action of waters charged with silica upon olivine-rock in process of alteration.

The tufaceous breccia, containing serpentine fragments with included garnets, is industrially of no great importance, but its very existence helps to account for the genesis of all the deposits. Their origin is explained as follows: —At the beginning of the Tertiary period an Archaean mountain-range existed in north-eastern Bohemia, made up of gneiss, granulite, granite, mica-schist, and a lherzolitic olivine-rock; the last-named was extraordinarily rich in garnet, and was then already altered to serpentine. Subsequently,

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this mountain-range was torn asunder by violent eruptions, and completely burned by volcanic outpourings. Fragments of the Archaean rocks were caught up and enveloped in the volcanic ejectamenta, and the scree, detritus-fans, etc., resulting from the previous erosion of the Archaean massif, suffered the same fate. Then the tufaceous rocks, perhaps through renewed eruptive agencies, were tilted up; and at the beginning of the Pleistocene period all these rocks, with their complex materials, were eroded away—the least-resisting constituents, such as tuff and serpentine, disappearing all but completely, and leaving as a residuum the less destructible garnets, etc. But the Pleistocene drift, in its turn, has furnished the material for alluvial sands, the garnets in which have thus undergone no less than three migrations from their original matrix.
In 1890, there were in north-eastern Bohemia 142 owners of garnet-diggings, employing altogether 346 workpeople, and the net value of the output (for the year) was £7,835. As before mentioned, the only mine now worked on a fairly large scale is that of Podseditz, where the garnetiferous drift, 9 feet or more in thickness, lies perhaps a couple of feet below the surface.

DEVONIAN IRON-ORE DEPOSITS OP MORAVIA.

This exhaustive paper is the fruit of the author's experience as a manager of mines in the district, an experience which extends over a great number of years.

In the Devonian of that portion of Moravia which stretches north-east of the March valley, and in the neighboring tracts of Silesia, three distinct belts of iron-ore deposits may be mapped out. One of these (the most important from the industrial point of view) belongs entirely to the Lower Devonian, the second is very near the junction with the Middle Devonian, while the third is associated with diabases that come in near the junction with the Culm formation: the general strike of these ore-belts is east-north-east, coinciding with that of the underlying Archaean rocks and the overlying Culm.

The Lower Devonian, in this region, consists chiefly of a succession of quartzites and green schists (diabase-schists), with intercalated limestone-bands. The ores of the first belt are associated with the schists, and the whole formation is underlain by chlorite-gneiss and overlain by the Middle Devonian grauwackes.

The Middle Devonian consists of repeated alternations of these grauwackes with dark grey clay-slates, the former rocks predominating. As in the case of the underlying group, the strata are folded in a series of synclines and anticlines. Locally, some limestones are folded with the grauwackes.

The Upper Devonian also presents a succession of grauwacke-sandstones and clay-slates, the former being very similar to those of the Middle Devonian, while the latter show far more clearly their sedimentary origin than the Middle Devonian clay-slates, being less micaceous and not so much cleaved. In the midst of the group appears a vast mass of diabase-amygdaloids, granular and compact diabases, diabase-porphyrites and limestones. With the amygdaloids are associated the iron-ore deposits of the third belt.

The overlying Culm, again, consists of an alternation of grauwackes and clay-slates.

This region, throughout the Devonian epoch, was the scene of repeated submarine volcanic eruptions. The volcanic ejectamenta (diabases) were pulverized and deposited on the sea-floor contemporaneously with the calcareous and argillaceous material that was, later on, compacted into limestones and clay-slates. Volcanic energy was greatest at the dawn of the epoch, but it slackened little by little as the long Devonian day drew to a close.

The lithology, petrography and mineralogy of the rocks are dealt with in considerable detail, and the author very fully describes the iron-mines. At Poleitz, where the workings go down to a depth of about 200 feet, three main deposits of magnetite have been found, containing on an average 49.2 per cent. of metallic iron and 18.5 per cent. of silica. In the Meedl district, are a western and an eastern group of deposits, divided by a barren mass of altered diabase-schists. The eastern group is by far the most important, and comprises three great bands of ore, varying in thickness from 6 1/2 to 52 feet. The two lower bands are really a series of enormous lenticles folded into synclines and anticlines; and at the Eisenberg pit the ore-deposit reaches the exceptional thickness of 150 ftot. The strike of the iron-ore deposits
coincides in a general way with that of the diabase-schists and tuffs. The Meedl ore is, in the main, a compact red haematite largely impregnated with magnetite, and jasper is frequently associated with it. Further, there occur soft pulverulent magnetites and haematites (the outcome of the weathering of the more compact ores), containing more than 63 per cent. of iron and less than 6 per cent. of silica, while the compact ores average 54 per cent. of iron and 18 per cent. of silica.

The Pinke ore-field similarly comprises two groups of deposits—a northern (3 bands) and a southern (7 bands), separated by a mass of barren rock. These ores are largely associated with crinoidal and other limestones and siliceous ironstones. The best ore is a pulverulent red haematite, sometimes so strongly impregnated with finely-divided wad as to assume a brownish-black hue: the ore is then so crumbly that the wind blows it in clouds off the pit-heaps. Less common is a compact and fibrous haematite, sparsely impregnated with finely-crystalline or granular magnetite.

The Pinke ores, on the whole, are far less magnetic than those of Meedl: the percentage of iron varies from 44 to 54 and that of silica from 17 to 25. Although the amount of phosphorus never exceeds 0.2 per cent., the general habit of the ores is such that they are not available for making Bessemer pig.

The author concludes, as to the formation of the Meedl and Pinke iron-ores, that their deposition was a secondary and hydrochemical, not a contemporaneous phenomenon. Metasomatosis took place on a large scale, whereby the outward form and structure of the original layers of limestone was preserved in the re-placing iron-ore seams. It appears probable that, from above downward, the limestones were gradually dissolved away as a double carbonate, while carbonate of iron was simultaneously precipitated in their stead: this being attacked by waters highly charged with oxygen, was decomposed to hydrated oxide of iron, and the carbonic acid thus set free acted as a solvent, starting a new cycle of similar reactions. Meanwhile, the hydrate of iron, losing its combined water, became red haematite, and this in turn was reduced to magnetite, but the process of reduction taking place unequally in the mass, the two varieties of ore are now found in association. The silica seems to have been derived from the diabase-schists.

The ores of the Sternberg field occur in great lenticles, which are apparently the separate portions of one band cut by successive faults. The workable ores are always found at the contact of the clay-slates and the diabase-amygdaloids, never in the diabase-rock itself: they are mainly brown haematites and magnetites, with percentages of iron varying from 32 to 52, and silica from 13 to 28.

For complete chemical analyses, full details of the methods of working, and the history of mineral industry in the region described, the reader should consult the original memoir, which is a storehouse of facts. L. L. B.

COPPER-ORE NEAR LUDWIGSTHAL, AUSTRIAN-SILESIA.


Near Ludwigsthal, and about 5 miles from Wurbenthal, in Austrian-Silesia, is the so-called copper-adit (Kupferstollen), and a little further on the fallen-in shaft of the copper-mine, which consists of a quartz-lode 23 feet (from 6 to 8 metres) thick, bearing north-and-south, and dipping 70 to 80 degrees towards the east. The lode begins in the grey gneiss, and continues in Lower Devonian in a southerly direction. So long as the gneiss forms the enclosing rock, the lode is unproductive, with the exception of a few slight coats of malachite between the clefts and a few nests of copper-pyrites; and it is only when the lode leaves the gneiss and enters the black clay-slate of the Lower Devonian that it begins to be continuously ore-bearing.
The ores comprise copper-pyrites, bornite, earthy red oxide of copper and malachite, which latter generally fills the clefts and cracks of the quartz, while the other ores form clusters and detached masses in the lode or impregnate the quartz. In the shaft, the ores appear to be rich and abundant; but they cannot be followed up on account of water, for which reason the adit was started; but it ought to be extended about 130 feet, so as to reach the shafts.

As regards the geological and other conditions of this lode, it is due to an unmistakable filling up of the cleft with quartz, which cuts the Lower Devonian strata, that bear north-east and south-west, in a north-and-south direction; and the same is the case with the strike of the neighbouring gold-quartz lodes in the Oelberg and Hohenberg. Whether the gold-quartz lodes cut through the copper lode (in which case great wealth of ore may be expected at that place), or whether the gold-quartz lode is cut, or entirely cut off, by the copper lode, is unfortunately not yet known, although it has been ascertained that the copper-ores contain gold and silver.

Throughout the whole length that the "copper-adit" traverses the lode in a horizontal direction, and where the grey gneiss forms the enclosing rock, the copper lode is unproductive. It is true that the parallel clefts, which are peculiar to all cleft-fillings, are present, cutting through the quartz-masses from floor to roof; but neither these clefts, nor the quartz-bands between them, show any mineral worth mining except an appearance of malachite or of brown iron-ore.

Where the gneiss forms the enclosing-rock, the copper lode contains, at the floor, a regular cleft that separates the gangue mass from the enclosing rock, which cleft appears to be filled either with a mixture of clay and quartz-sand or with clean quartz-sand. The filling mass contains abundant, but not very rich copper-ore, which comprises malachite, earthy red oxides and copper-pyrites, with nodules of sandy brown iron-ore underneath; and in one place this cleft forms in the gneiss a trough 20 feet (6 metres) thick, filled with clean quartz-sand, traversed by threads of earthy red oxide of copper. The copper-shafts were still accessible 15 years ago, the lode being here about 13 feet (4 metres) thick, and nearly vertical.

Intercalated with the unproductive, unchanged quartz is good ore-bearing rock; and where the ore appears the quartz is completely subdivided and cracked in all directions. All the cracks and crevices are filled with ore; and in places separate yellow and brown grains of quartz are also apparent in the ore. As a rule, the ore-bodies thin out at a longer or shorter distance, being replaced by sterile uncracked quartz; and it is therefore evident that the metallizing has only occurred where the quartz has been previously cracked. This same peculiarity in the copper lode also occurs in gold-quartz lodes; and these contain sterile rocks and also portions richer and poorer in ore, the richer portions being almost always in the neighbourhood of diorite-irruptions; and this circumstance must have been known to the old miners centuries ago, because they always made their explorations near to the diorite.

J. W. P.

PROBABLE EXTENSION OF THE BELGIAN COAL-FIELDS.


(2) L'Allure du Terrain Tertiaire appliquee a la Recherche de la Houille. By Gustave Velge. Ibid., pages xci-xcvi.

Recent borings have shown that, although interrupted, faulted, and fractured, the Coal-measures extend from Liege through the Charleroi, Mons and Valenciennes coalfields, across the English Channel to Dover, and thence through Somerset into South Wales. On the other hand, they extend northward and eastward into Westphalia. The general aspect of this great formation is that of a basin whose southern rim is ridged up to such an extent as sometimes to be turned over on to its northern rim.

In Belgium, the Coal-measures are bordered on the north by Carboniferous Limestone, Devonian, Silurian and Cambrian strata: on the south side, the same succession is traced, but the older beds form an anticline, beyond which another Carboniferous basin appears. The question is whether, on the north of the known Coal-measures there is any hope of finding a similar fold of the Silurian succeeded, also by a Carboniferous basin—from which latter, however, the Coal-measures shall not have been swept away by denuding agencies, as was the case in the southern basin. Mr. Lohest concludes in the affirmative, both on stratigraphical and on lithological grounds, and his conclusions are supported by Mr. Habets, who thinks that the hypothetical coal-basin will be found to lie somewhere north-west of Vise. Mr. Velge draws attention to the fact that much useless labour and many costly borings in barren strata may be saved, if researches are guided by the principle of parallelism or concordance of tectonic features in superposed formations. Among the most distinguished exponents of this "working hypothesis," as British readers will remember, are Mr. Godwin-Austen and Mr. Marcel Bertrand. It is pointed out that this concordance is true of the strike and the dip: it applies to folds which may be seen repeated, like the concentric peels of an onion, from the Devonian up into the Tertiary. There is evidence that even the later Tertiaries participated in the final crumpling of the Condroz and the Ardennes, and thus it is plain that the last great uplift of the earth's crust dates from the end of Tertiary time. Mr. Stainier observes, however, that the principle of concordance of tectonic features does not always fit in with the facts, and recalls in this connexion the unsatisfactory result, from the mining-engineers's point of view, of the great sub-Wealden boring. From the brief communications on old borings for coal, made half a century ago, on Dutch territory, near Mouland and Mesch, it would appear that coal was proved, that Lower and Middle, if not Upper, Coal-measures were struck, but that further exploration was abandoned for want of capital. These communications bear on the general discussion, in so far as they strengthen the evidence for the northerly extension, (towards Limburg) of the Liege coal-field.

Baron van Ertborn asserts that the buried surface of the Palaeozoic strata in northern Belgium is a plane surface, much like the cover of a desk, slightly inclined northward. He concludes that if the Coal-measures did formerly exist in the northern area of Belgium, they were swept away by the denuding agencies which were active during the long ages that elapsed between the close of the Carboniferous period and the earliest deposition of the Cretaceous sediments. Mr. Forir, however, has made a most exhaustive study of the question, based on the results of no less than 196 borings, and shows that instead of being in its entirety a gently inclined plane, the buried Palaeozoic surface is in part broken up by sharp ridges and deep hollows.

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Further, it seems improbable that the Carboniferous in the north of Belgium should not have participated in the subsequent folding which affected the rocks of the neighbouring areas; and, being thus folded, the productive Coal-measures may indeed have been swept off the tops of the anticlines, but they will have been preserved in the synclines.

In summing up the discussion, Mr. Soreil points out the importance of making trial-borings in the neighbourhood of Eben-Emael and Eysden.

L. L. B.

COAL IN ASSOCIATION WITH CALAMINE, BELGIUM.


One of the calamine-deposits worked by the celebrated Vieille-Montagne Company is at Pandour, near Welkenraedt, at the junction of the Coal-measure sandstone and the Carboniferous Limestone. Here the ore-body occurs in three masses, separated by barren red clays, and it is in the central mass that lenticles of carbonaceous matter have been found. The lenticles average about 30 inches in length, and 10 to 12 inches in thickness: although the distance between them varies from 6 1/2 to 13 feet, they are joined one to the other, as a rule, by a very thin carbonaceous seam, but much more clayey than the lenticles themselves. This occurrence is in the midst of the calamine, about 6 feet away from the limestone-wall. Occurrences bearing some resemblance to this have been previously recorded elsewhere, but none of quite the same character. Further observation has shown that the calamine-mass is traversed by a thin band of Coal-measure shale, parallel, to the coaly lenticles which pitch 45 degrees south-east; also that the ore below the lenticles is hard and of good quality, while the ore between them and the limestone-wall, although workable, is rather clayey and comparatively poor in zinc. This clayey stuff is thought to be a decomposition-product of calamine, and to have been brought to the spot later than the original ore-deposit. Similarly, the carbonaceous lenticles are of later date than the hard calamine and belong to the Coal-measure period. Chemical analysis of the coal yielded the following results:—Volatile matter, 20 per cent., and ash, 32.40 per cent. The ash was analysed as follows:—Silica, 12.00 per cent.; iron sesquioxide and alumina, 10.15 per cent.; lime, 0.07 per cent.; magnesia, 0.05 per cent.; lead protoxide, 3.76 per cent.; zinc oxide, 4.50 per cent.; sulphur trioxide, 2.50 per cent.; and traces of manganese peroxide.

L. L. B.

METALLIFEROUS VEIN FORMED THROUGH ERUPTIVE ROCK, ARIEGE, FRANCE.


A remarkably clear example of a metalliferous vein formed under the direct influence of an eruptive rock is afforded by the Boutadiol deposit of massive or crystalline magnetite, in connection with Querigut granites in the department of Ariege; and study of this deposit leads to the same conclusions as does that of the axinite-rocks in contact with the granite of the Hautes-Pyrenees, showing the reality of the contributions made by the granite to the sediments which it metamorphoses, and also the indissoluble connexion existing between the production of these pneumatolithic emanations and the contact-metamorphism itself.

J. W. P.
THE GEOLOGY OF THE BAYERISCHER WALD, GERMANY.

Geologisches aus dem Bayerischen Walde. By Dr. E. Weinschenk. Sitzungsberichte der Mathematisch-physikalischen Classe der k. b. Akademie der Wissenschaften zu Munchen, 1899, pages 197-222, with 2 plates and 9 figures in text.

The author describes the geology of this region, characterized by alternations of granite and gneiss, the latter being extremely contorted. Among minerals of economic importance may be mentioned the occurrence of cupriferous pyrites, mined at Silberberg, and used chiefly for the production of vitriol. The deposit occurs at the contact between granite and gneiss in well-marked lenticular masses. The ores consist chiefly of magnetic pyrites, which never carries nickel; iron-pyrites; blende, with but little cadmium; argentiferous galena; small quantities of tinstone; magnetite; and ilmenite. It is noteworthy that particles of graphite also occur.

Graphite was formerly mined near Langdorf, but the workings have been abandoned on account of the poor quality of the mineral. At Passau, there is an important graphite-district, which has been worked for a considerable period, and is still being mined on a small scale by the peasantry, each landowner sinking a small shaft on his own property. The graphitic rocks are sometimes quite soft and earthy, at others compact and impregnated with iron pyrites. The contents of graphite are very variable, lying between 20 and 70 per cent., though the latter is rare. A graphite free from pyrites is more valuable than when impregnated with the latter mineral. Its mode of occurrence is quite analogous to that of the Silberberg ore-deposits, occurring in strings or lenticular masses within the gneiss. The occurrence is never very far from the contact between the granite and gneiss, and it is obvious that the existence of graphite is genetically connected with the presence of granite. The graphite-deposits frequently occur near inclusions of granular limestone, which are scattered throughout the whole area, and are characterized by the occurrence of numerous contact-minerals. Graphite generally occurs in more or less decomposed gneiss in the shape of uniform scaly impregnations, which seem also to indicate its secondary origin. The greater portion of this graphite has been used for some centuries for the manufacture of graphite-crucibles (known as Passau crucibles), which are made by crushing the rock and sifting or blowing out the finer crushed stone, by which means a concentrate containing 92 to 94 per cent. of carbon, and free from pyrites, is obtained; so that Passau graphite cleaned in this way is fully equal to the better grades of Ceylon graphite.

H. L.

THE OCCURRENCE OF OOLITIC IRON-ORES (MINETTE) IN LUXEMBURG AND LORRAINE.


These iron-ores occur over an area 12 to 18 miles (20 to 30 kilometres) broad and over 60 miles (100 kilometres) in length, extending over the south-western portion of Luxemburg, over the western portion of German Lorraine, the adjoining portion of French Lorraine, southwards to near Nancy, whilst a small point projects into Belgium. By far the greater portion of the deposit lies on the left bank of the Moselle, and forms part of a plateau which has received the name of the "Plain of Briey." The strata composing this plateau consists chiefly of Middle Jura or Dogger, below which Liassic beds occur, both having a general dip to the west. The lower beds of the Dogger consist of clays, characterized by Astarte Voltzi, over which occur strata with Trigonia navis and Ammonites Murchisonae. Above these
follow the limestones of the Middle Dogger, the Longwy Marls, the Oolitic limestones of Jaumont, and the Gravelotte Marls. The Trigonia-navis and Ammonites-Murchisonae beds contain in their lower portions several layers of oolitic iron-ores, separated by layers of sandstone, marl or limestone. The upper limit of these ferriferous schists is everywhere formed by a bed of marl characterized by its greyish-yellow colour and sandy structure. This bed is generally known as the hanging-wall marl, whilst the horizon of Astarte Voltzi is known as the foot-wall marl, and the intervening strata containing the beds of iron-ore are known as the iron-ore formation.

There are five main beds of iron-ore, called successively the Red Sandy, Red Calcareous, Yellow, Grey and Black Beds. In addition to these, there are a few beds of less importance, and generally only locally developed. The iron-ore formation attains its greatest development with a thickness of about 105 feet (32 metres), in the southernmost portion of Luxemburg and in the north of German Lorraine, thinning out towards the north and south. At its widest, the iron-ore formation has a thickness of 200 feet (61 metres), the above thickness of 105 feet (32 metres) being made up of the five main beds,

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whilst in the south the three lowermost beds alone occur, with a total thickness of only 15 feet (4 1/2 metres), the formation being but 50 feet (15 metres) thick. The formation, together with the over and underlying beds, is traversed by a great number of faults, some of which are of considerable importance, causing dislocations with a throw of 500 feet (150 metres).

The general composition of the workable portion of the individual beds is shown in the following table, in which, however, only the chief constituents are indicated: —

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<tr>
<td>Iron, Fe</td>
<td>34</td>
<td>36</td>
<td>35</td>
<td>39</td>
<td>34</td>
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<tr>
<td>Lime, CaO</td>
<td>5</td>
<td>11</td>
<td>15</td>
<td>10</td>
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<td>Alumina, Al2O₃</td>
<td>8</td>
<td>5</td>
<td>4</td>
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<tr>
<td>Silica, SiO₂</td>
<td>18</td>
<td>8</td>
<td>9</td>
<td>8</td>
<td>30</td>
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The chief constituents of the ore are hydrated oxide of iron, carbonate of lime, silica and alumina, together with smaller quantities of carbonate of magnesia, oxide of manganese and phosphoric acid. The ores average about 36 per cent. of iron, though selected samples may exceptionally reach 45 per cent. Lime varies from 5 to 20 per cent., silica from 7 to 34 per cent., and alumina from 2 to 10 per cent. The proportion of phosphoric acid is tolerably constant, averaging about 1.7 per cent. It is rare that all the layers are workable at the same time; as a rule, in one mine, not more than two beds are worth working, the workable thickness rarely exceeding 13 feet (4 metres).

The diameter of the oolitic grains which give the ore its peculiar structure averages 0.01 inch (1/4 millimetre). They consist chemically of hydrated oxide of iron and amorphous silica, the latter remaining as a skeleton when the ore is treated with dilute hydrochloric acid. Probably the granules also contain phosphoric acid. The magma in which the oolitic grains are embedded is formed by calcite or marl, and occasionally by quartz. There is no sign of stratification or parallel structure. The ores are almost universally traversed by calcareous partings, forming masses from 3 to 50 feet (1 to 15 metres) in length and up to 1/1/2 feet (1/2 metre) in thickness; or else they form ellipsoidal inclusions. Their structure is identical with that of the ore, from which they are distinguished by their greater content of lime, great hardness and paler colour. Sometimes these partings are so numerous that the entire bed is no longer worth working. When present in smaller quantity they are not a disadvantage, as they can be used for stowing the worked-out portions. The transition from these
barren partings to the true ore is quite gradual. The boundaries between the beds of
ore at the roof and floor are but rarely sharp, there being here also a gradual
transition. When the walls consist of oolitic limestone, the iron-contents of the oolitic
grains diminishes gradually, whilst where the roof or floor is of marl or sandstone,
individual oolitic grains continue in these rocks and disappear little by little.

Luxemburg.—The iron-ore formation covers an area of about 9,000 acres (37 square
kilometres). In addition to the five main layers, a bed occurs in places above the
Black Bed, which is known as the Brown Bed, and furnishes, like the former, a
siliceous ore. Most of the beds are workable in places, with the exception of the Red
Sandy Bed. The Grey Bed, 10 to 13 feet (3 to 4 metres) in thickness, and the Red
Calcareous Bed, 6 to 13 feet (2 to 4 metres) in thickness, are the most important, and
are generally workable. In 1897, Luxemburg produced 5,360,856 tons of minette-ore.
It is calculated that there are still 300,000,000 of tons of ore in existence, of which
123,000,000

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are suitable for export, and 177,000,000 can be smelted locally. Remembering that
about two-thirds of the ore is exported, it may be reckoned that the available ores
suitable for export will be exhausted in 37 years, whilst those suitable for the local
blast-furnace practice will last for about 80 years.

Germany.—The iron-ore formation of Lorraine occupies a length of 37 miles (60
kilometres) and a breadth of 2 to 9 miles (3 to 15 kilometres), covering an area of
350,000 acres (1,400 square kilometres). Of the five main beds, the Red Sandy Bed
pinches out near the river Orne, and the Red Calcareous Bed near St. Privat. In
addition to the five main layers, there are two brown layers, which are workable. The
most important, however, is the Grey Bed, averaging 11 1/2 feet (3.5 metres), and,
exceptionally, 33 feet (10 metres) thick. The Black Bed is on the average 6 1/2 feet (2
metres) thick, and is workable in many places. The Lower Brown Bed appears to be
workable almost where-ever it exists. In the area north of the river Fentsch, the
hectare (2.47 acres) produces from 95,000 to 165,000 tons of ore; between the rivers
Fentsch and Orne, 75,000 tons; between the rivers Orne and St. Privat, 40,000 to
65,000 tons; and south of the last-named place, 25,000 tons.
In 1897, 5,960 workmen were employed in these iron-ore deposits of German
Lorraine, and produced 5,360,586 tons of minette-ore. If the production remains at its
present figure, the available ore will be exhausted in about 370 years. This figure is,
however, much too high, because the amount of ore produced increases year by
year. In the three years 1895 to 1897, the increase has amounted to 37 per cent.,
and there is no doubt that it will continue throughout a long period.

France.—It has been calculated that there exist 135,000 acres (540 square
kilometres) of workable ore, which are divided into four basins, known respectively as
the Longwy, the Moselle and Meuse, the Orne and the Nancy basins. The first and
last fields are those in which most work has been done up to the present. In addition
to the five main beds, a green bed has been cut in several bore-holes below the
Black Bed. The Upper Brown Bed is also found to exist in some places. The Grey
Bed is also found in France, the most important sections averaging from 6 to 13 feet
(2 to 4 metres) of workable ore, but, exceptionally, 29 feet (8.8 metres). In the Nancy
basin, there are altogether seven beds, which have not yet, however, been correlated
with those of the northern basin. In 1897, the produce amounted to 4,120,000 tons.

Formation.—Messrs. Giesler and Braconnier are of opinion that these iron-ore beds
have been formed by sedimentary processes, and are, therefore, original beds.
These views have been questioned by many authorities, it having been often assumed that the formation was due to metasomatic processes—that is to say, that iron was introduced simultaneously with the removal of existing constituents of the rocks. The author has in a previous paper shown that according to his opinion the first-named view is the correct one. This iron-ore occurrence is one of the greatest known anywhere. Of all the ores got in the German Empire in the year 1897, about 53 per cent. came from the mining districts of Lorraine. Unfortunately, a considerable portion of this minette-ore is exported to Belgium and France, and it is therefore of the highest interest that the railway-tariff should be lowered, and that the river Moselle should be canalized, in order to afford an opportunity of conveying these ores to the blast-furnaces of Germany, seeing that these furnaces are at present compelled to draw a considerable proportion of their ore-supplies from foreign countries, especially Sweden and Spain.  

H. L.

AMBER IN EAST PRUSSIA.  
The most extensive occurrences and the most important winnings of the amber of the Baltic coast are in the province of East Prussia, and there (from the strictly legal point of view) the mineral is State property. As a matter of fact, however, the State has neither worked amber nor trafficked with it on its own account: the exploitation and sale have been for a long series of years practically monopolized by Messrs. Stantien & Becker, of Koenigsberg. At the present moment, the underground workings of the district of Samland are the chief centre of activity of the amber-exploitation, and the following geological data regarding that district are quoted from a memoir to which more detailed reference will be made further on:—

The occurrence of amber in Samland is associated with the Glaucinite formation. This is made up of sands and of loams characterized by a certain percentage of glauconite, which were laid down in the seas of the Tertiary period. According to the opinions universally held by geologists, during the formation of these deposits, and mainly during that of "blue earth," belonging to the lower portion, the indurated resin proceeding from several species of conifers (more especially from the amber-pine) was floated into the bay, where the glauconitic strata of Samland were being laid down. At that period, and even before Tertiary times, vast forests of conifers must have covered a large portion of Northern Europe, especially Scandinavia. The amber occurs, then, as a secondary deposit, disseminated throughout the "blue earth." This is a loam, greenish-grey when dry, nearly black when wet, rich in fine grains of quartz and glauconite.

This blue earth varies in thickness, and the amber is most abundantly disseminated in its lower portion—within a stratum measuring from 30 to 60 inches in height. The practicability of working is conditioned not only by the percentage of amber and by the thickness of the amber-bearing seam, but also by the amount of barren blue earth which overlies this, and by the number and thickness of water-bearing sands which are commonly interbedded with the blue earth.

From July 1st, 1899, the amber-industry entered upon an entirely new phase—the Prussian State having acquired by purchase the whole belongings of Messrs. Stantien & Becker, and thenceforth the State will itself work the mineral and trade with it on State account.

In 1899, the Government published an explanatory memorandum specifying the amounts which went to make up the total purchase price of £487,500, and also an exhaustive memoir which dealt with the amber question in a manner that did full justice to its importance. It set forth clearly the reasons which had finally determined the Government, despite undeniable difficulties, to take over the amber-industry as a
State concern, and thus to put an end to the intolerable grievances fostered by private monopoly, aiming thus at a solution which would be welcomed as equitable by all alike, and especially by the province of East Prussia. The memoir is divided into two parts, the first dealing with the Crown rights to the mining of amber in East Prussia, and the manner in which they had been utilized; and the second with the question of sale. The two first sections of the first part are especially devoted to the legal aspect of the question and to the utilization of the Crown rights: they possess an interest which is really general and permanent, quite apart from the problem for which it is assumed that a solution has now been found.

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Here are laid down the grounds of fact and of law upon which the now completed transformation of the amber-industry is based. The varying legal conditions, according as one is dealing with the province of West Prussia or with that of East Prussia, or with the deep-level workings of Samland, are portrayed. Then follows an account of the manner in which the Crown rights have been exercised from olden times down to recent days, with a description of the four different methods of winning amber. These sections are stated to be merely introductory and "for information," but on account of the exhaustive nature of the memoir we can only briefly refer to them here:

"The right to appropriate amber has assumed different forms in the coastal provinces of Prussia, where it occurs in varying quantity. It is based in part on general principles of jurisprudence, in part on legislative provisions peculiar to each province—and derived either from the right of occupancy of the ground-landlord, neighbouring owner, or discoverer, or from foreshore rights.* In those districts where the State has a prior claim on amber, as, for example, in Old Pomerania, Nearer Pomerania and Further Pomerania, the Crown confines itself to the mineral cast up by the waves, basing its right on the foreshore, which, according to Prussian law, is the property of the State.†

"Over the territory comprised within the modern province of West Prussia various special provisions are in force, according to which the amber occurrences belong in part to the Crown, in part to the ground-landlord, and in part to the city of Danzig.‡ But the legal aspect of the question in the province of East Prussia is as different as it well can be. This province is even nowadays still the main source of amber, but very early in the Christian era wide-reaching claims on behalf of the rulers of the land as to the ownership of the mineral were crystallized into law. These claims, far more exacting and extensive than mere foreshore rights (such as those existing in other parts of the country) have been ever since the domination of the Teutonic Order of Knights, laid down in innumerable decrees, regulations concerning amber, digests of law, etc., dating as far back as the middle of the 13th century.‖ Many a fierce legal conflict as to the actual delimitation of the Crown rights has been waged over these old documents, but they cannot be taken into account nowadays, as two recent laws have placed beyond doubt the postulate that the Treasury rights in East Prussia extend to all amber whatsoever, whether it be found on the foreshore, on the beach or inland.

" Further, the universal State ownership of all amber in East Prussia was recognized in the Provincial Law and codified at the beginning of the present century. The East Prussian provincial code of 1801-1802, reads in Supplement 228 to section 80, Part II., Art. 15: —

(1) Amber is the property of the State, and no one is permitted to traffic with the raw mineral, nor any one with the manufactured article, without special authority so to do, on pain of confiscation of the goods or payment of their value, as well as punishment by fine or personal durance.
Further details on this point will be found in Von Brunneck's Das Recht auf Zueignung der von der See Ausgeworfenen und angespulten Meeresprodukte und das Bernsteinregal (The Right to appropriate all that is cast up or washed ashore by the Sea and the Crown Monopoly of Amber), Konigsberg, Prussia. 1874.

† Compare section 80, Part II, Article 15 of the Code: "Harbours and sea-shores, and what is there washed up or cast up by the sea, are according to common law the property of the State."

‡ Compare Digest of the Provincial Laws of West Prussia, published April 19th, 1814 (page 103), sections 73 to 80, Part II., Article 15 of the General Code; Law concerning the Extension of the West Prussian Provincial Code to the City of Danzig and its Dependent Territory of February 16th, 1857 (page 87).

‖ See also Von Brunneck, op. cit., where the above-mentioned deeds are catalogued, and their more essential parts reproduced in print; also Tesdorff, Gewinnung, Verarbeiten und Handel des Bernsteins in Preussen von der Ordenszeit bis zur Gegenwart, (Winning, Dressing and Traffic of Amber in Prussia, from the time of the Order of Knights to the Present Day), Jena, 13fc7.

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(2) All amber whatsoever, whether scooped up or dug out, or obtained in any other fashion, must be delivered up at the Amber Chamber in Koenigsberg, whereupon to those who have found the amber upon their own estate there shall in recompense be paid one-tenth part of the value of the amber so delivered, due estimation thereof having been made by the aforesaid Amber Chamber.

"These rights of the Treasury received a fresh sanction in the Law of February 22nd, 1867 (digest, page 272), whereby firstly the punishment to be meted out for illegal appropriation of amber was settled; and, secondly, the provisions of the Civil Code regarding amber were incorporated in Article 4 of the East Prussian Provincial Code, as follows: —

(1) Amber, whether found in the Baltic or on the shores thereof, as also in the Frisches Haff and the Kurisches Haff, or whether it occurs inland, is reserved as the property of the State.

(2) Whosoever, without being authorized to collect amber, by chance finds, fishes or digs it up, becomes thereby possessed of the rights and duties of a finder."

"Of the various methods of winning amber that of mining it in deep levels is nowadays by far the most important, and although the Crown rights in East Prussia are all-embracing, this particular method of winning tends so inevitably to limit the practical exercise of the rights of the State that in the matter of deep-level mining these may be denoted as imperfect. It may be quite true that the amber hidden away in the soil of East Prussia is the unquestioned property of the Prussian State: but the assertion of this right is barred by the right of the landowner. If the latter chooses to resist, no legal weapon lies ready to the hand of the State whereby he can be forced to disgorge. The General Mines Act of June 24th, 1865, is not applicable to amber. While this Act allows, under certain provisos, any person to seek and win minerals, even on other people's property, this is not the case with amber. The preamble of the Act accounts for the exclusion of that mineral on the grounds that amber in Prussia was never at any time made subject to the provisions of general mining jurisprudence, and that moreover the winning thereof was fully dealt with in the Provincial Codes. In this connexion, however, one should bear in mind the different conditions which prevailed when the Mining Code was drawn up, as amber was then to be got without engaging in actual mining operations. The legal situation in East Prussia presents, therefore, this anomaly: that the landowner cannot, without leave
from the Treasury, proceed to win amber on his own estate; while the Treasury
cannot give effect to the Crown rights, or even undertake exploration-work on private
property without the consent of the landowner. The bearing of this state of affairs in
relation to deep-level workings is the more important that, on Government property,
geological research has so far failed to reveal any amber-deposits that give the
slightest hope of being worth the cost and trouble of working.
"In the time of the Teutonic Order of Knights† the dwellers by the sea on the coast of
Eastern Prussia were bound to collect, fish and "spear"‡ amber, and in return for a
slender wage to deliver it up to the officers of the order.

* General Code, Part I., Article 9, sections 9 to 22, and 43 to 72.

† This was a military brotherhood, which in the Middle Ages gradually conquered and
Christianized the remoter parts of Prussia, then inhabited by the Pagan Vends. The
knights built castles and churches, taught the conquered tribes the Gospel and the
arts of peace, and played in some respects much the same part as our missionaries
do nowadays in the wilds of Africa.—L.L.B.

‡ By "fishing" was understood the catching up of amber in nets from the sea-water
[probably in the lagoons], and by "spearing" the grubbing out of the mineral from the
sea-bottom by long poles or pikes and then drawing it up in so-called "traps."

The Grand Master, Duke Albert, in 1518, with the view of making more profit out of
the monopoly, entered into contracts with various merchants from Königsberg,
Danzig, Lubeck, Augsburg and Antwerp, whereby new markets were opened up to
the mineral even in far-off countries. But as the cost of management and winning
increased, and the profits correspondingly decreased, the successors of Duke Albert
sought to regain the unrestricted enjoyment of the monopoly and to free themselves
from contracts which had become burdensome. But a full measure of success did
not attend these efforts until the time of the Great Elector, who in 1644 issued
exhaustive Regulations regarding Amber. The territory where the mineral occurs
was split up into several districts, each under the headship of a so-called 'Beach-
ranger.' The duty of the Ranger was to exercise constant supervision over those
shore-dwellers who were bound to win amber, and to guard against fraud. The better
pieces of amber were sold at public auction, while the pieces of less value were sold
at a fixed scale of prices to the guilds of amber-turners, who flourished in such cities
as Lubeck, Kolberg, Koslin, Stolp, Danzig, Elbing and Königsberg. During the
whole of this time the Government rights were vigorously upheld. Severe punishment
was meted out to those who stole amber, sentence being passed by a special so-
called 'Amber Tribunal.' In order to obviate the chance of secret misappropriation,
no worker in amber was allowed to settle within the territory of the Order of Knights,
and every grown man was bound every three years to swear the so-called 'Shore-
oath' before the officers, to the effect that he would never misappropriate any amber
himself and that if he became aware of such misappropriation on the part of any one
of his relatives he would denounce the guilty person to the authorities.* The
successors of the Great Elector issued repeatedly new regulations regarding the
utilization of the State monopoly, but on the whole the system underwent no
essential change until the beginning of the present century.

"Then, the constant diminution in the profits of the monopoly, and the need of
improving the revenues of the State, which made itself strongly felt after the events of
1806-1807, led the Government to consider the advisability of changes in the system.
In 1811, the monopoly was farmed out, first of all to a syndicate, whereof the chief
member was Mr. Charles Douglas, and later on, to him alone, and in his hands it
remained till 1835. During those years the quit-rent varied somewhat, but the annual average was £1,500. Although the burden of obligatory winning of amber and the restrictions imposed by the 'shore-oath' were thus taken off the shoulders of the coastal population, the condition of that population was still far from prosperous. The Government thereupon resolved in 1836 to farm out the monopoly to the dwellers by the sea. Separate contracts were signed with the large landowners whose property abutted on the coast, and the inhabitants of the fishing-villages formed amber-farming syndicates under fairly autonomous management. The total yearly income to which the quit-rents amounted averaged, as before, £1,500. This state of affairs lasted till 1867. The economic condition of the coastal districts had certainly improved under the new regime, but the latter was attended with so many disadvantages in other respects that in 1870 a complete change of system was resolved upon. Thereby a new road was opened up not merely to the winning of the raw mineral, but to the trade in, and manufacture of amber. In the contracts with the dwellers by the sea-shore, those who paid the agreed quit-rents were not only allowed to 'collect, fish, and spear' amber, but also to dig it in the cliffs or banks. Now the digging was carried on in a very unmethodical fashion in open workings: and the smaller syndicates, having but little capital to back them, dug the mineral in a most wasteful manner. They under-cut the cliffs, so that these fell an easy prey to the waves of the sea, and thereby hastened the destruction of the coast-line, especially of the western coast of Samland. The fall of the coast-hills resulted in the overwhelming invasion of blown sands, to the manifest damage and ruin of the tilled fields. The consequence was that the conditions of agricultural labour in those districts steadily grew worse, and a mass of unemployed hands drifted to the amber-workings.

"As a further consequence, in concluding fresh contracts for the winning of amber on June 1st, 1867, the Prussian Government expressly withdrew the permission hitherto granted to the dwellers by the sea-shore to dig for the mineral in the cliffs or banks, and reserved to the Treasury complete freedom to determine what should be done in that matter. To the larger landowners permission was given to dig for amber only up to December 31st, 1869, under special provisos for compensation in case of damage incurred through their workings. In the course of the following year permission was extended to Messrs. Stantien & Becker, and to a few other contractors, to start open diggings on the sea-shore under certain restrictions. But the enormous expenditure which this entailed, and the unceasing destruction of the sea-cliffs, combined with the initiation of the deep-level winning of amber to bring about the stoppage of open workings in 1874. Amber has in recent days been won only by dredging and diving, by collecting, 'fishing and spearing' along the sea-shore, and by deep mining.

"In 1859, dredging operations, which had been carried on for the purpose of widening the navigable channel in the Nehrung, near Schwarzort, having disclosed the presence of large quantities of amber, Messrs. Stantien & Becker sought in July, 1861, permission to dredge for the mineral, and on May 1st, 1862, the Government signed a contract to that effect, holding good till 1868. On the expiry of this contract, the Government, desirous of favouring free competition, offered the right of dredging at public auction; but, failing to receive any bids, the authorities concluded a fresh contract with the above-mentioned firm, to hold good till 1882. The results obtained by dredging became yearly more and more remarkable, not only from the abundance, but from the beauty of the mineral, much to the advantage of the State treasury. On the expiry of the second contract, the dredging-rights were again put up
at auction, but again failed to attract bidders, and they were again farmed out to Messrs. Stantien & Becker up to November 30th, 1900, in consideration of an annual payment of £10,000. In 1886, however, the falling-off in the amber-harvest was so serious, owing doubtless to the exhaustion of the uppermost layers of the bottom of the Haff or lagoon, that the contractors declared that they were working at a loss, and gave notice to terminate the contract on November 30th, 1890. Once again the endeavour to farm out the dredging-rights by public auction proved utterly fruitless, and since then dredging-operations for amber have been suspended.

"In 1869, for the first time, the right of winning amber along the foreshore of Gross Dirschheim, Brusterort and Klein-Kuhren, by diving, was put up at public auction, and was granted to the sole bidders, Messrs, Stantien & Becker. In 1874, this firm purchased similar rights along the Palmnicken foreshore, in 1881 along the contiguous shores of Sorgenau, Kraxteppellen and Gross-Hubnicken as well, and in 1885 along those of Kreislacken and Marscheiten. Diving-operations were conducted in all these localities on a great scale, with very profitable results for the contractors. But it was only natural that in the course of years the amount of amber got by diving over a comparatively restricted area should decrease. The Treasury suffered a corresponding diminution of revenue. The last contract for diving, signed with Messrs. Stantien & Becker in 1885, expired on May 18th, 1891. Further offers made by that firm were rejected, because the persons who had purchased the right to win amber along the beach complained that their interests had suffered injury through the diving-operations. When in 1893, several landowners on the Samland coast of the Baltic prayed for the grant of diving-rights the Government maintained its previous refusal.

"The winning of amber by collecting, fishing and spearng along the shore, in accordance with the practice which has obtained since 1837, is in the case of Crown property put up at public auction, and in the case of other property given out freely, not, however, as in former days, to amber-farming syndicates, but to the several landowners, municipalities, etc., whose lands abut on the shore. Not only is this system of free grant favourable to the occupier from the economic point of view, but it appears indispensable when one considers that the farming-out of the right to third parties would lead to endless bickerings between the seekers for amber and the occupiers of the land. Wherefore the right to win amber along the beach has been freely conceded to 32 communes and landowners. Messrs. Stantien & Becker, so far as the Crown property along the Samland coast was concerned, obtained the right at public auction, and in respect of their own property got it by free grant, like other landowners. Meanwhile the amount of amber obtained along the beach has of late steadily diminished, and several of those to whom the right had been farmed having given notice to terminate their contracts, the State revenues from that source have correspondingly decreased. The total quit-rent for beach-winning now amounts to only £350 per annum, whereas in 1867-1879 the annual average was £1,400, and in 1879-1885, £650. From those portions of Crown property which have been leased for amber winning to others than Messrs. Stantien & Becker, the State at present derives the insignificant income of £105.

"As already mentioned, the method of winning by deep level, that is, by mining the amber-bearing stratum or blue earth, is nowadays, and probably will be for a long time to come, the most profitable and the most widely followed. At present these mining operations have been carried out only on such portions of the western coast of Samland as had become the absolute property of Messrs. Stantien & Becker, property which they mostly acquired many years ago. Earlier endeavours, attempted on Crown property as well as on that of other private owners, to win amber by mining, met with failure. For instance, in 1873, at Nortycken, about 2 miles south of
the coast, an unsuccessful attempt was made to start a Government mine. A shaft, in part lined with iron, in part with masonry, was sunk at great expense, but the lie of the strata in the neighbourhood was such that it was found impossible to drive levels along the amber-bearing stratum, and the attempt was given up in 1879. Meanwhile, by a contract dated November 20th, 1875, the Treasury had conceded to Messrs. Stantien & Becker the right to mine amber over an area of about 15 acres of the Palmnicken estate for the next 8 years in consideration of the payment of £2,000 for every morgen of productive area in the mine. The amber production from underground workings proved abundant beyond all expectations, and by dint of unceasing efforts Messrs. Stantien & Becker were successful in opening up constantly new markets to keep pace with the increasing production. In the course of years the original contract was supplemented and completed by several subsidiary contracts, whereby further areas were leased to the firm, and on the other hand the quit-rents payable to the State were gradually increased. In the third contract, of July 16th, 1883, the right to mine for amber was assigned to this firm on further portions of its own estates of Palmnicken, Kraxtepellen, Bardau, Gross- and Klein-Hubnicken. The forfeit to be paid for each morgen worked was fixed at £2,500, and the minimum annual quit-rent to be paid, quite independently of the progress of the mining operations, was fixed at £15,000.

"The contract was to hold good for 18 years (up to November 4th, 1901), but the firm was allowed to give notice of termination, provided this took place not later than November 4th, 1891, or November 4th, 1896. In 1891, it became evident that the areas conceded by the contract of 1883 were not extensive enough to permit of well-planned mining operations. Thereupon, in response to the application of the contractors, mining rights over further areas were leased to them, but the forfeit payable for each morgen had now risen to £2,625, and the annual quit-rent to £33,880. The raising of the minimum annual quit-rent was justified on the ground of the stoppage of dredging for amber in the Kurisches Haff on December 1st, 1890; but it was agreed on both sides that if the right to dredge were profitably disposed of elsewhere, the annual quit-rent for deep-level workings would be again reduced to £15,000. The Palmnicken mine was worked from 1874 onwards, but on account of the exhaustion of that portion of the field, operations were brought to a close there in February, 1896. At present workings are being pushed north of the western coast of Samland in the Anna mine. The amount of raw amber obtained from deep-level workings during the last 25 years is very considerable. During the years 1892 to 1896 (both inclusive) the annual total averaged 498 metric tons.

L. L. B.

LIGNITES IN THE COLOGNE BASIN, RHINE PROVINCE.

The Cologne basin is closed towards the south and open towards the north, its deepest axis being more or less exactly indicated by the course of the river Rhine. The rim is formed of Devonian strata, upon which Tertiary rocks of Oligocene age repose unconformably. They only crop out at the foot of the hills, being covered by alluvial deposits in the valleys. The thickness of the Oligocene strata is considerable, a bore-hole of a depth of 820 feet (250 metres), put down near Bruhl, not having traversed them. As the roof of these deposits is a further 246 feet (75 metres) above the level of the mouth of the bore-hole, the greatest known thickness of the Oligocene rocks in the basin of Cologne may be taken as above 1,060 feet (325 metres). The strata consist chiefly of plastic clay, quartzose sand, and beds of lignite,
with, in some places, various igneous rocks, chiefly tufaceous. The total length of this
deposit may be taken at 15 1/2 miles (25 kilometres), average width 3 miles (5
kilometres), and its thickness at 89 feet (27 metres), but in some places it reaches
340 feet (104 metres). The cubic contents of the deposit, therefore, amount to
4,683,000,000 cubic yards (3,575,000,000 cubic metres) of workable coal. The
average composition of the principal deposit of lignite, dried at 212° Fahr., is as
follows: —

<table>
<thead>
<tr>
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<th>Per cent.</th>
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<tbody>
<tr>
<td>Carbon</td>
<td>66.38</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>5.54</td>
</tr>
<tr>
<td>Oxygen and nitrogen</td>
<td>23.55</td>
</tr>
<tr>
<td>Ash</td>
<td>5 to 6</td>
</tr>
</tbody>
</table>

The hygroscopic moisture varies between 19.68 and 23.55 per cent. The quantity of
water in the freshly-mined coal is a very important element for practical purposes. It
averages 48 per cent., varying between 62 and 39 per cent. The percentage of ash
varies between 4 and 10 per cent.

The modern method of mining consists almost exclusively of stripping and opencast
working, various methods of haulage, including aerial wire-rope haulage, being
employed.

This coal is generally made into briquettes, the production of which is due to the
property of the crushed lignite to cohere into a compact mass, cemented together by
the oil and resins present, when exposed to a high pressure, say up to 1,500
atmospheres. The lignite, as it comes from the mine, is crushed in rolls, dried until its
water contents are reduced to 16 or 18 per cent., and then transported by means of a
screw-carrier to the presses, in which the briquettes are moulded. Each briquette-
press produces 1,000 tons of briquettes annually, for which 393,000 cubic yards
(300,000 cubic metres) of coal, as standing in the deposit, are consumed. From 30 to
35 per cent. of the total coal got is used for firing. H.L.

PRECIOUS-STONE PLACERS NEAR HINTERHERMSDORF, SAXONY.

Die Edelsteinseife des Seufzergrundels bei Hinterhermsdorf in Sachsen. By Hans
Oehmichen. Zeitschrift fur Praktische Geologie, 1900, pages 13-17, with two figures
in the text.

These deposits have been known for the last 300 years, and have been often
described by the older writers. They occur on the banks of a small streamlet, which
has carved for itself a deep runnel out of the Brongniarti-zone of the Cretaceous
sandstone of Saxon Switzerland. This Quader Sandstone is the dominant rock of the
district, here and there covered by Drift or broken through by basalt. Where the
streamlet flows through the Drift-formation, sands are found, so rich in magnetite and
titanite as to be almost black. If a handful of the sand be taken up it is easy to pick
out of it fragments of hornblende, augite, bronzite, beautifully coloured and
sometimes fairly large jacinths, and ceylanite. More careful examination reveals
zircons, spinels, grains of glass-green diopside, and prisms of apatite. Corundum
also is said to have been obtained. At one time it was proposed to start ironworks in
the neighbourhood, in which the sands would figure as the ore-supply, but the idea
appears to have been abandoned.

The original rock from which these sands were derived was first recognized by Prof.
Beck, in the course of his official mapping of the district. It is a boss of Tertiary
olivine-hornblende basalt, which crops up west of the Hohwiese with associated tuffs
and breccias. In these breccias are curious inclusions as big as a man's fist,

extremely rich in spinel and bronzite: they are comparable, in the author's opinion,
with the diamantiferous garnet-diopside masses of the Kimberley district, and bear
out Sir A. Geikie’s remark that there is a definite set of conditions of temperature and pressure (as yet unknown to us) connected with pyroclastic phenomena, which peculiarly favours the formation of various precious minerals. L. L. B.

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THE IRON-ORE DEPOSITS OF THE KERCH PENINSULA, SOUTHERN RUSSIA.


These deposits have been known since 1832, but after one or two unsuccessful attempts to turn them to account (from 1840 to 1860), they remained buried in oblivion till 1896. Then a group of Russian and foreign engineers made a fresh study of the ores, with the result that they are now reckoned among the most important deposits of the kind in the Russian Empire. Mining-plant on a big scale has been put down, narrow-gauge railways built, and blastfurnaces were in course of erection when the author wrote his paper.

The peninsulas of Kerch and Taman exhibit a series of synclinal basins and anticlinals, the formation of which is doubtless connected with the upheaval of the Caucasus on the one hand and the Crimean Chatyr Dagh on the other. With these orogenic movements, which are still going on, but with diminished intensity, may be associated the mud-volcanoes and naphtha-wells characteristic of the region, as well as the great eruption of a century ago.

The two mining-basins of Kerch and Kamysh Burun are separated by the steep anticlinal of Jerzhava: the basins on their further sides flatten out, affording a wide surface suitable for opencast workings. The ore-deposit, at first hidden beneath the buildings of Kerch, reveals itself by its characteristic yellow colour at the very gates of the town, close by the Tartar mosque, and is seen to strike northward through the suburban gardens with a steepish dip of 45 degrees. It then turns north-eastward, disappears for a time, re-appearing south of Katerless: all the wells dug in that village have struck the ore, which belongs to the upper division of the Pontic (Lower Pliocene), before getting down to the water-bearing stratum of the Meotic (Lowermost Pliocene) limestone. Ultimately the strike curves round southward to the bay. The area of this mining-field is rather more than 7,800 acres, and the available ore is estimated to amount to 100,000,000 metric tons, of which about a tenth can be got by opencast working. About 2 miles to the north-east lies the small basin of Baksy, the area of which is about a quarter of that of the Kerch basin.

Midway up the cliffs of Kamysh Burun (130 feet is their average height), the iron-ore, in the form of a broad brown belt, can be seen from the deck of any vessel making for Kerch Roadstead: as the cliffs weather away, the ore-masses break off and are piled up on the beach in tumbled blocks. By means of this cliff-section geologists have been enabled to follow the course of the deposit inland. It extends southward to Lake Churubash, and the ridge of Sarmatic (Upper Miocene) limestone on the farther shore of that lake was at one time held to denote the termination of the Pontic (Lower Pliocene) basin, and therefore of the iron-ores. They reappear, however, still farther south, constituting the basin of Eltingen. It is estimated that the available ore of Kamysh Burun and Eltingen together amounts to between 150,000,000 and 200,000,000 metric tons. Southernmost of all lies the basin of Yanish Takil, where indeed the outcrops in the cliffs are poor in iron-ore; inland, however, the basin flattens out, and proves to be rich enough to warrant working.

As seen in the cliffs of Kamysh Burun, the most complete exposure known of this ore-deposit, it is made up of a shell-bed floor bound together by a ferruginous cement (podrudok), ferruginous clays, 10 to 12 feet of yellow, brown and black pisolites, followed by black iron-sand with as much as 15
per cent. of manganese, a 20 inches thick cockle-bed, the shells of which are filled with manganiferous iron-ore and vivianite-crystals, then a band of sandy siliceous ore, and finally a roof of clay bespattered with gypsum-crystals. But it is rare to find all these beds together: generally the deposit consists of brown pisolithic bands traversed by blackish veins, which, where they are thickest, are rich in vivianite-crystals. At Katerless and Eltingen, the black iron-sand with 15 per cent. of manganese is predominant.

The author tabulates 21 chemical analyses of the ores of Kamysh Burun and Kerch, from which the following percentages may be quoted: —

<table>
<thead>
<tr>
<th></th>
<th>Minimum.</th>
<th>Maximum.</th>
</tr>
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<tbody>
<tr>
<td>Iron</td>
<td>25.90</td>
<td>44.90</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.35</td>
<td>17.30</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.60</td>
<td>3.25</td>
</tr>
<tr>
<td>Sulphur (Kerch ores only)</td>
<td>0.02</td>
<td>1.00</td>
</tr>
</tbody>
</table>

The ores have been tried at the Ougree ironworks in Belgium and by the Briansk Company, Yekaterinoslav, and it has been shown that they yield satisfactory results when smelted alone, as well as in mixture with other ores. The new ironworks established at Kerch will use the ore largely in the form of briquettes (to which lime and coke-dust is added), agglomerated together by Bietrix presses.

L. L. B.

COAL IN SERVIA.


Coal-deposits are abundant in Servia, but mining operations are conducted on methods scarcely less primitive than those of the Chinese, and in the whole country there are only about a dozen pits at work, with an insignificant output. Many of the deposits are far away from railways or from the Danube, a circumstance which complicates the problem of transportation. The net result is that imports of coal, and even of lignite, into Servia increase year by year, while the prices paid are high, too high in the authors' opinion.

The Morava coal-field, the only one that is described in this paper, lies in the district of Alexinatz, and extends over a belt of country some 13 miles in length. The State railway runs all along the western edge of the coal-field. The Coal-measures are of Tertiary age, and end abruptly against massive gneiss. The seams in this field have been worked for about 15 years: of the two principal seams, one is over 16 feet thick, and the other varies between 7 and 14 feet in thickness.

On the right bank of the Morava, on the road from Belgrade to Alexinatz, is the concession belonging to Mr. Appel. Here the strike of the seams is north and south, with a westerly dip of 22 degrees. The floor of the thickest seam is a very compact fine-grained sandstone, and the roof is a compact, laminated oil-shale, some 170 feet thick. This shale can be ignited with a match, and burns with a long flame, like that of beechwood. Experiments have shown that on distillation it yields 25 per cent. of paraffin; nevertheless no industrial use of it has been made so far. The sandstones themselves soon pass into paraffin-shales, and it appears probable that other coal-seams will be struck in these shales, overlying which is the valley-drift of the Morava. The coal is highly bituminous, breaks into large pieces, and sells in the northern provinces at £5 8s. per truck. Carriage from the pit-mouth to the railway-station costs 33s. per truck.
The Johannis colliery, near Alexinatz, is worked by a shaft 180 feet deep, properly tubbed, and provided with ascending and descending cages. The first level (100 feet below bank) runs northward, and is more than 600 feet long; the second level (70 feet below the first) follows the seam. The coal here is less compact than that previously described, is of a shiny black, very hard and clean, and costs at the railway-station: large, £4 per truck; small, £3 per truck; duff, £1 5s. to £2 per truck. The average selling price is 5s. 1d. per metric ton, and the costs amounting to 3s. 7d., the net profit works out at 1s. 6d. per metric ton. L. L. B.

SUBMARINE IRON-ORE DEPOSITS IN THE GULF OF FINLAND.
That portion of the Gulf of Finland in which the island of Jussaro is situated has been for many generations recognized as dangerous to navigators, on account of the aberrations of the compass set up by the rocks and hidden reefs. The magnetic survey recorded in this paper leads to the following conclusions: —

The above-mentioned aberrations of the compass are due to the existence of vast deposits of highly magnetic ores, striking east and west, beneath the sea-waves. Divers have brought up several samples of the ore, and it has been observed that the "upper poles" of the deposits always attract the northern end of the needle. It cannot be asserted that there is a combined magnetic effect produced by all the ore-deposits taken together, unless it be at a considerable distance from the magnetically anomalous area, and then only very much weakened. Within the anomalous area the northern end of the needle points in any direction, influenced solely by the lie of the nearest ore-pole.

The Segersten deposit, the most considerable of all, ranges along a sharp curve past the islands of Orrokobben, Stenlandet and Lerharu, for at least 2 1/2 miles, has an estimated thickness [breadth] of 80 or 100 feet, and goes down to a great depth. The Vaster Gadden deposit is much more irregular, and indicates a less intense concentration of ore; it would appear, moreover, not to extend so much in depth. The vertical magnetic intensity is especially strong in the case of the Segersten deposit, amounting to four times the intensity of the horizontal component of the earth's magnetism. Moreover, in the course of the measurements, the horizontal magnetic intensity of the Segersten ore was found to be high enough, at a distance as great as 300 feet north of the nipping-out of the deposit, to counteract the influence of the earth's magnetism, the northern end of the needle in that area pointing on the whole southward.

The investigations made in regard to the iron-ore deposits on the island of Jussaro itself, deposits which were actively worked during the first half of this century, have shown that they are of very secondary importance compared with the submarine ore-body of Segersten. The practical outcome of these researches is that in the spring of 1898 a company was formed, with the avowed purpose of exploring more fully the Segersten deposit by means of borings. This exploration-work may be expected to throw light on the character of the ore and the possibility of mining it.

L. L. B.

THE PEATS OF FINLAND.
The author defines peat, as it occurs in Finland, as consisting of plant-remains more or less decomposed, but with their structure in fair preservation, of very variable appearance and characteristics. The peat is divisible into two main categories: —

1. Peat formed from vascular plants, such as the roots, stems, seeds, etc., of reeds, rushes, horsetails, ling, and so on (Carex, Phragmites, Scirpus, Eriophorum, Calluna); and

2. Peat formed from mosses such as Sphagnum, Amblystegium, etc.

A description is given of the associated Quaternary sands, clays and coprolitic deposits (known as Gyttja). There is also a pseudo-peat, called dytorf, formed by the precipitation of humic salts and of iron and lime-salts from acid waters: along the edges of this deposit, it is full of drifted remains of twigs, tree-trunks, etc.

With regard to the fossilization process which attends the formation of true peat, the author points out that where the cellulose of plants survives, this survival is probably due to impregnation with tannic acid. If the cell-walls of all plants had consisted of pure cellulose, hardly the faintest trace of them would be found fossil. In the Finland peat, so far as the recent flora is concerned, 63 per cent. of the known indigenous trees were found and 50 per cent. of the shrubs, but of the non-ligneous, herbaceous vegetation, apart from the aquatic plants, scarcely a specimen occurs.

It is by the formation of ligneous and suberous (cork) material that cell-walls become sufficiently tough to resist decomposition-processes under water. Silicification has something to do with the survival of the horsetails and a few of the mosses, but there is no example in Finland of the preservation of peat plants by calcification. Tannic acid plays a far more important part in the process of peat-formation than had been hitherto suspected.

A careful descriptive catalogue, with illustrative plates, is given of the various plant-remains found in the Finland peat; among the trees we notice species of birch, alder, ash, oak, pine, hazel, poplar, lime and elm. This exhaustive memoir concludes with an historical study of the Quaternary flora of the Duchy.

L. L. B.

MODE OF FORMATION, &c, OF THE ARGENTIFEROUS DEPOSITS OF KONGSBERG, NORWAY.


A whole series of observers, from Prof. G. Bischof onwards, have drawn attention to the fact that metallic silver may be got from the natural sulphide by the simple process of passing steam or hot air over that mineral, and the inference is obvious that the native silver found in such, mines as those of Kongsberg lias been formed naturally by an analogous process. The author remarks, however, that many mining-engineers have hitherto shown themselves inclined to scepticism on this point.

Munster proved that from silver sulphide of compact structure, a similarly compact metallic silver is obtainable, whereas a porous sulphide yields the metal in form of threads, fibres, or moss. Prof. Liversedge has shown that moss-copper is produced by a reaction similar to that mentioned above, and Dr. Regnault has got metallic mercury from cinnabar in the same way. It is claimed that at Kongsberg the natural process can be followed step by step, and the remarkable illustrations which accompany this paper appear to bear out the author’s contention. The rapidity with which the reaction takes place is beautifully shown by the little masses of sulphide
clinging to the ends of the curling fibres of native silver. These fibres might well be termed 'plants' (to which they have a curious resemblance), growing on the surface of the sulphide, but not deeply rooted in it. The transformation into metal seems, in some cases, to spread gradually from a thin layer through a whole block of the sulphide, in such wise that blocks of native silver weighing nearly 1/2 ton have been found at Kongsberg. Just as it is rare, however, to find these masses without some admixture of silver-glance, so is it equally rare at Kongsberg to come upon large masses of the sulphide that are not to a greater or less extent interpenetrated or encrusted by native silver. In those mines ruby silver-ore is comparatively rare, but the same phenomena of transformation have been observed in it as in the more abundant silver-glance. Moreover, it can be shown that some of the native silver of Kongsberg is not derived from the sulphides, but has crystallized direct out of a metalliferous solution. It occurs, for instance, in the clefts and joint-surfaces of the anthracite which is associated abundantly with those ore-deposits; and some of it, too, is combined with mercury in varying quantities, the amalgam containing from 4 to as much as 23.07 per cent. of mercury. Still, on the whole, it may be said that native silver in the form of crystals, as distinct from fibrous, hair- or moss-silver, plays a very subordinate part at Kongsberg. The proportions of the annual output from the mines are variously estimated by different authorities, but, while citing these, the author comes to the conclusion that the true proportions are:—Native silver, 90 to 95 per cent of the total, and silver-glance, 10 to 5 per cent. of the total, the average annual production of the metal there being 160,750 ounces Troy.

The minerals which constitute the gangue of the Kongsberg veins are, in the order of their abundance:—Calc spar, fluorspar, quartz and anthracite. Heavy spar is common only in a few of the veins. Besides the remarkable frequency of anthracite, it may be noted that much of the calc spar contains inclusions of bitumen and coal. Apart from silver-glance, the most important ores in that locality are iron-pyrites, zinc-blende, galena, magnetic pyrites, chalcopyrite, with (occasionally) mispickel, cobalt-bloom, and a few still rarer ores. Indeed, with the exception of iron-pyrites, all the foregoing play so very trivial a role in the Kongsberg deposits that the mass of silver is greater than that of all the other heavy metals put together. The succession in time of the Kongsberg minerals appears to have been as follows:—(1) quartz; (2) metalliferous sulphides, native silver, anthracite and the older calc spar; (3) fluorspar and heavy spar, with a little adularia and albite; and lastly (4), three or four generations of calc spar, a younger quartz and a younger iron-pyrites-formation, axinite, magnetic pyrites, and zeolites. These successive periods are not sharply defined, but melt one into the other. The formation of the silver-glance and the primary silver

began at the end of the first quartz-generation, and then took place in the main simultaneously with the deposition of the anthracite, the older calc spar, and several of the sulphide ores. It continued in a lesser degree during the crystallization of the fluorspar and the younger generations of calc spar. The reduction of the silver-glance to metallic silver took place earlier than the formation of the main mass of calc spar and fluorspar, magnetic pyrites, and younger iron-pyrites, probably almost immediately after the silver-glance had crystallized out. It may be remarked parenthetically that later on some of the silver was reconverted into silver-glance. On the whole, the author considers that the deposits which show the greatest similarity to those of Kongsberg are the ore-bodies of Andreasberg in the Harz, and he recapitulates their identical characteristics. He then draws attention to the fact that, at Kongsberg, especially rich ore is struck at the points of intersection of the fahlbands. It is plain that these fahlbands have had some extraordinary influence on
the solutions percolating through the vein-fissures. Remembering that these solutions were rich in carbonic acid, the explanation appears to be that the pyrites in the fahlbands was attacked by them, and the hydrogen sulphide thus set free precipitated the silver from solution in the form of sulphide. The association of anthracite or of bituminiferous calcspar with the richer portions of the veins is so striking that the Kongsberg miners assert that no silver-ore is to be found unaccompanied by carbonaceous material.

Turning then to the general geology of the district, the author describes among the principal rocks ophitic olivine-gabbro (hyperite), and grey gneiss or "squeezed granite" (of which chemical analyses are tabulated), in places pyritiferous. The area was in former ages the scene of numerous and vast igneous eruptions, and the formation of the metalliferous deposits is to be regarded as one of the later effects of vulcanicity. The ores are not the product of lateral secretion, nor were they brought in from above, but they came up from below. It is stated, by the way, that the greatest vertical depth so far reached in the Kongsberg mines is 2,300 feet; three mines are between 1,650 and 2,300 feet deep; and nine are from 970 to 1,650 feet deep.

The paper concludes with references to occurrences of native gold, which have apparently originated in much the same way as the native silver of Kongsberg, and there is a short appendix dealing with the amount of pyrites in the fahlbands.

L. L. B.

PYRITES-MINES OF SOUTHERN SPAIN AND PORTUGAL.

The numerous deposits of pyrites in the Huelva district of Southern Spain lie within a zone, 80 miles (130 kilometres) long, running from east to west, and about 12 miles (20 kilometres) broad. The western end of this zone crosses the Portuguese frontier at the important mine of San Domingo, which lies a few miles west of that frontier. All the other important mines, Rio Tinto, Tharsis, La Zarsa, Lagunazo, Aguas Tenidas, Sotiel, San Miguel, etc., lie within the kingdom of Spain. Huelva is the port for the whole central and eastern portion of the ore-fields, lying 52 miles (83 kilometres) by rail from Rio Tinto, 42 miles (67 kilometres) from Aguas Tenidas, and 28 miles (45 kilometres) from the old main mine of Tharsis. The navigable river Guadiana affords a means of transport for the western mines, namely, for those of San Domingo, and for the two mines owned by the Bede Metal Company. Only the pyrites-deposits will be considered here, and not the deposits of manganese-ore, upon which Prof. Klockmann is preparing a memoir.

Geology.—The coastal area on the Atlantic Ocean between Cadiz and the Portuguese frontier consists of Tertiary and Quaternary deposits. Somewhat further northward, on either side of the long zone of pyrites-deposits, there occurs a series of locally metamorphosed slates, in which the existence of Silurian and Carboniferous fossils has been proved, and these slates are traversed by numerous outbursts of porphyry. Further north still, the western portion of the Sierra Morena consists mainly of Cambrian and Azoic slates. Within the east-and-west zone, in which the pyrites-deposits occur, fossils have been found in several localities, which partly belong to the Silurian, partly to the Carboniferous age (Posidonomya Becheri, Goniatites sphaericus, etc.). On account of these fossil discoveries, the number of which, however, is but small, and further on account of the petrographic character of the rocks, Prof. Gonzalo y Tarin has distinguished in this district the two formations of Silurian and Carboniferous Culm. Devonian fossils have not been
found here, and according to the above-named author, Devonian strata are supposed to be wanting. This conclusion does not, however, appear to the author to be clearly proved, as the fossil discoveries are but few and are scattered over a very wide area. The slates have but few distinguishing petrographical characteristics, and their appearance cannot therefore be used as the basis of a detailed subdivision. It is consequently quite possible that the view of Prof. Klockmann that there is a continuous series of Silurian, Devonian and Carboniferous may prove to be correct. The slates have often been subjected to dynamo-metamorphosism, and are very frequently phyllitic. The strike is generally to the east, and the dip a fairly steep one. Transverse slatey cleavage is often noticeable.

Within the pyritic zone occur a considerable number of eruptive dykes of porphyries, with a highly variable degree of acidity, the silica ranging from 70 to 40 per cent. Quartz-porphyry is very frequent. Diabase-porphyry also occurs in various intermediate stages. It may be said that there is here a fairly continuous series of highly differentiated eruptive rocks in all stages, from the basic to the acid extremities. Prof. Gonzalo y Tarin concludes that these eruptive rocks are intrusive, while Prof. Klockmann, on the other hand, maintains that they are bedded, forming sheets, everywhere conformable with the slates, and are even in places accompanied by deposits of tuff. The occurrence of porphyries in the Huelva district does not, however, admit of the definite conclusion that they are interstratified, as maintained by Prof. Klockmann. Further, it is by no means certain that the rocks which he considers to be tuffs and ashes are really of this nature. They may quite well be more recent breccias. The author therefore concludes that the eruptive rocks of this region are in fact dykes of more recent age, and more particularly occur in the form of bedded dykes.

The coastal strip along the Atlantic, between Cadiz and the Portuguese frontier, is mantled over by Tertiary and Quaternary sedimentaries. The attempt by previous observers to map out the pyrites-deposits in three parallel belts is not borne out by the author's studies. Within the before-mentioned zone, occur a large number of important deposits of pyrites, lenticular in shape, some of which are of enormous size, occasionally over 500 feet (150 metres) in width. The lenticular form is evident not only in the horizontal,

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but in the vertical direction, so that the pyrites often pinches in depth, in some cases at comparatively shallow depths. In most cases, these lenses are parallel to the surrounding slates and porphyritic rocks, and they occur strikingly often in intimate relation with the latter. Thus the porphyry very frequently forms one wall of the deposit, sometimes the hanging-wall and sometimes the foot-wall. It occasionally happens that deposits of pyrites, for example No. 2 deposit of Rio Tinto, lie between two bedded flows of porphyry which are only separated from each other by slates a few feet thick. In marked contradistinction to the well-known often strikingly clearly striated pyrites of Rammelsberg, the Huelva pyrites is distinguished by its perfectly massive structure without any signs of striation or bedding. As previously remarked, the South Spanish pyrites deposits are remarkably similar to many other European deposits, such as those of Roros, Vigsna, and Sulitelma in Norway, Rammelsberg in the Harz, Schmollnitz in Hungary, and Agordo in Italy, so much so that it may be concluded with some degree of safety that their formation must have taken place under similar conditions. Therefore the author agrees with Prof. Gonzalo y Tarin that the Huelva pyrites, as we now find it, is a direct result of the porphyry-injections which took place after the crumpling and folding of the stratified rocks.

Tables of dimensions and illustrative sections are given, to show the extreme irregularity of the lenticles, as well as their enormous thickness and their still greater length. The author calculates that in its upper portions the Rio Tinto deposit, for every
fcot in depth, yields as much pyrites as Gellivaara does iron-ore, while the moderately extensive deposits of San Domingo, on the Portuguese side of the frontier, and Aguas Tenidas, are comparable as to yield of ore with various German and Swedish mines.

An examination of the area of the various deposits leads to the conclusion that the total quantity of pyrites originally present in all these deposits must have been approximately as follows:—Rio Tinto, from 175,000,000 to 200,000,000 tons; Tharsis, say, 30,000,000 to 35,000,000 tons; and San Domingo, from 15,000,000 to 20,000,000 tons. Of the other deposits, there is probably none that exceeds 10,000,000 tons. The majority may vary from a few up to 5,000,000 tons. Altogether, then, it may be assumed that the original quantities of pyrites present in the workable Huelva deposits down to a depth of 1,000 to 1,300 feet (300 to 400 metres) should be calculated at least at 250,000,000, and at the utmost at 300,000,000 or 400,000,000 tons. In these figures many poor impregnations of pyrites, which are only of geological interest, have not been included.

The calculations made in past years as to the mass of workable ore available were vitiated by the neglect of the fact that the Huelva deposits are lenticular in the vertical plane as well as in the horizontal. Making the necessary deductions, it is estimated that the remaining ore available on the Rio Tinto property is 135,000,000 tons, about one-half of which (in the author's view) will prove practically barren of copper. He foresees, in consequence of the diminished value of the ore and the increased cost of working which follow the same ratio as the increase in depth, that the Rio Tinto field may be worked out within the next 50 years, if not earlier. The original Tharsis mines will hardly hold out so long, but the company has been careful to purchase new properties. The output of the San Domingo mine is already on the down grade, and this seems to be the case also with. Aguas Tenidas. It is estimated that the total amount of pyrites worked out of the Huelva field since 1850, when modern mining operations may be said to have begun, until the end of 1896, is roughly 63,000,000 tons. The Romans appear to have got out no less

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than 30,000,000 tons in their time. Now, although the amount of less than 100,000,000 tons so taken away represents in mass only a third or a quarter of the available ore, it is really the most valuable portion that has gone, considering its high percentage of copper and its low cost of working.

Seven chemical analyses are tabulated—three of the Rio Tinto, two of the Tharsis, and two of the San Domingo ores, wherein the percentages vary as follows:—

<table>
<thead>
<tr>
<th></th>
<th>Minimum Percentage</th>
<th>Maximum Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur, S</td>
<td>44.60</td>
<td>49.60</td>
</tr>
<tr>
<td>Iron, Fe</td>
<td>38.70</td>
<td>45.55</td>
</tr>
<tr>
<td>Copper, Cu</td>
<td>2.26</td>
<td>5.81</td>
</tr>
<tr>
<td>Zinc, Zn</td>
<td>trace</td>
<td>0.35</td>
</tr>
<tr>
<td>Lead, Pb</td>
<td>0.52</td>
<td>1.52</td>
</tr>
<tr>
<td>Arsenic, As</td>
<td>0.21</td>
<td>0.47</td>
</tr>
<tr>
<td>Magnesia, MgO</td>
<td>trace</td>
<td>0.13</td>
</tr>
<tr>
<td>Lime, CaO</td>
<td>0.14</td>
<td>0.90</td>
</tr>
<tr>
<td>Insoluble matter (Silica, SiO2)</td>
<td>0.73</td>
<td>11.10</td>
</tr>
<tr>
<td>Oxygen (in oxide of iron, O2)</td>
<td>0.15</td>
<td>1.07</td>
</tr>
<tr>
<td>Water, H2O</td>
<td>0.05</td>
<td>0.95</td>
</tr>
</tbody>
</table>

In addition to these constituents, there is often a trifling proportion of silver (0.0025 to 0.0340 per cent.) and gold (in quantities equal to about 1/100 of the silver) with traces of antimony, bismuth, nickel, cobalt, tellurium, selenium, thallium, etc.
The ores are predominantly iron pyrites (FeS2), with a relatively small admixture of chalcopyrite, but in the Aguas Tenidas mine copper is all but absent, and the ore there is, moreover, free from arsenic. The secular weathering of the surface of the land in a practically sub-tropical climate accounts for the persistence of a deep ferruginous gossan, averaging 35 feet in thickness, but sometimes as much as 160 feet thick. It consists mainly of oxides and hydrates of iron, yielding 50 to 55 per cent. of the metal, with a little sulphur and an infinitesimal proportion of arsenic, but the copper has been completely oxidized and dissolved out of it. In one of the Rio Tinto mines, the junction between the gossan and the fresh pyrites is marked by an earthy porous layer, several inches thick, rich in silver and gold, to an average value of £7 10s. per ton. Evidently the formation of this earthy layer is connected with the processes of oxidation which went on in the gossan.

It appears to be a definite law, as shown by an examination of the various deposits, that the copper contents of the pyrites diminish in depth. This may be specially well illustrated by a section of the San Domingo mine, where the content of copper has gone down from 4.5 per cent. between 65 and 130 feet (20 and 40 metres) to about 1 per cent. at 460 feet (140 metres). Similar results are noticeable at Dionisio, near Rio Tinto.

With regard to the future of the Huelva district, it may be noticed that since about 1890 the Huelva copper-production has remained practically constant, whilst the world's production has increased enormously. In 1880, the Huelva district accounted for 25 and 31 per cent. of the world's copper-production, whilst in 1896 it was only producing 14 per cent., and these mines have, therefore, had to yield their leading position in the copper market to Montana and Michigan. It seems tolerably certain that, as to the production of copper, the Huelva district is now at its highest point. It can only maintain its production at its present high rate for a few more decades, and then will commence to decline. This is due to the facts already pointed out: namely, that firstly the deposits narrow going downwards; secondly, that the pyrites becomes poor in copper in depth; and, thirdly, that the cost of mining must increase considerably as depth is attained. In most of the mines, the greater portion of the upper zone, which is rich in copper, has been got at a comparatively low cost of production, and many mines are therefore rapidly approaching the more costly and, at the same time, poorer portions of the deposit. At Rio Tinto, the position will, however, be more favourable for, say, the next 50 years. However, even here a marked increase in the amount of copper-production is not to be expected. It is, therefore, noticeable that whilst the copper production of Huelva has reached its maximum, the production of export pyrites is still on the increase. This is due largely to the recent process introduced in San Domingo and in Tharsis, in which the poorer pyrites is not roasted to extract the copper. The sulphur therefore remains unaltered in the pyrites, and after the copper-extraction has been completed, or, say, after 6 or 8 years, the ore can be shipped as pyrites poor in copper.

The author concludes that the impression he obtained from his journey in the Huelva district was that the other pyrites-mines of Europe, and especially those of Norway, were not likely to be in a worse position than they had been up to the present in respect of the competing influence of Huelva. Huelva would only be able to maintain its present colossal production of about 3,000,000 tons per annum for a limited number of years, after which it will be more than ever necessary to fall back upon the remaining deposits of Europe. The Huelva districts, most of the mines of which are in the hands of English capitalists, afford an extreme example of the Anglo-American method of working, i.e., extraordinarily "intensive" scale of operations in a limited period; the Germano-Scandinavian principle, namely, a moderate speed of
MINERAL RESOURCES OF SHANTUNG, CHINA.
Zeitschrift fur Praktische Geologie, 1899, pages 206-209.
This paper gives in brief the results of a prospecting journey undertaken in the course of 1898 by Dr. Buchrucker, a German mining engineer.
Shantung is separated from the Central Asian mountain-system that terminates northward in the Hwai range by a wide fertile plain, which represents probably an old fault-depression filled up by detritus washed down from the hills and alluvial gravels, etc., deposited by the Hwang Ho. Shantung, on the east of this plain, is very similar in orographic and geological structure to the provinces of Shansi and Honan on the west of it. In all alike, the fundamental rocks are crystalline schists, gneisses and granites, overlain by Cambrian and Silurian strata. These, in turn, are covered by a vast stretch of Carboniferous rocks, especially productive Coal-measures. The Rothliegende which, in regular succession, comes on the top of the Carboniferous, overlaps on to the Silurian, and no strata of Old Red Sandstone age have so far been discovered in Shantung.

The coal-fields, excepting that of Poshan, are worked by means of shafts. These average only 65 feet in depth, as the general water-level of the country is very soon reached. Mining only goes on for 6 to 8 months in the year, and is completely suspended at harvest-time and during the rainy season. Meanwhile the water rises in the pits, and it generally takes 2 months to drain them again. The methods of drainage, haulage, and of mining generally are incredibly primitive. The shifts work for 24 hours at a stretch, and the Chinese pitman's maximum wage is barely 6d a day. The coal is of a meagre, anthracitic character, and yields much ash: coke is produced on a small scale. There is reason to believe that, with deeper shafts and more extended exploration of the vast area of Coal-measures, more highly bituminous seams will be found.
The author notes that the Tsi-nan-fu basin, enumerated by Richtthofen among the Shantung coal-fields, has been since recognized as of small importance, and the workings in it have been abandoned.
Intimately associated with the coal of I-chau-fu are huge lenticles of haematite, recalling a similar occurrence in Saxony. They were mentioned by Richthofen, but he does not appear to have realized how great a mass of them is present. The ore is of excellent quality, it can be got in opencast workings, and the close proximity of the sea-coast suggests facilities of transport.
The Shantung rivers carry gold, but the present results of the washings are not such as to encourage any attempt to work the alluvia on the European system, although the Chinaman contrives to make a living out of them. Better results, however, are obtained from the laterite, near its line of junction with fresh, undecomposed rocks in the east and south-west of the province: the rocks are granite and gneiss, traversed by grey quartz-veins.
Native copper, in lumps as big as a man's fist, occurs north of Mongyin; and silver and fahlores north-east of that locality, while galena is recorded from Fei-hsien. An extensive deposit of workable mica is found several days' journey from Kiowchau Bay. The slabs are about 20 inches in diameter, 1 inch or more thick, and beautifully transparent: the matrix is "giant granite." Missionary Williamson's report of the existence of diamonds was long ignored or disbelieved, but they are now known to occur on the right bank of the I-ho, where the Chinese often plough them up in the fields after heavy rain. The stones are mostly colourless octahedra, but some are
yellow or have a greenish tinge: the natives do not attempt to cut them or use them for personal adornment, but they bore holes for wiring porcelain together with the rough diamond, and they use the stones as currency or pawn them.

L. L. B.

TIN-DEPOSITS ON THE RIVER ONAN, EASTERN SIBERIA.


With the exception of Pitkaranta, where the production of tin is insignificant, the only Russian deposits of cassiterite are in the territory of the Transbaikal, on the river Onan and its affluents. The Onan joins with the Ingoda to form the Shilka, which in its turn unites with the Argouni to form the river Amur, which empties into the Pacific Ocean.

Up to the present, the existence of cassiterite on the Onan has been recognised at the four following points: — (1) Near the village of Olovianny Rudnik, on the left bank of the Onan. (2) Opposite this same village on the right bank of the Onan, in the valley of the Little Kulinda, an affluent of the Onan. (3) Near the village, of Nizhni Sharanai, on the right bank of the Onan. (4) Near the village of Zavitinskoie, in the valley of the Sludianka, on the right bank of the Ingoda, at 10 versts (6 miles) above the affluents.

The geology of the country is very uniform throughout the whole region in which these deposits occur. The predominant rocks are granite and clay-slates. It has been recognized that cassiterite exists for a distance of more than 70 miles along the Onan, and this fact would point to the existence of a large tin-bearing region, where there is every reason to suppose that new deposits of this mineral may yet be discovered.

From the information obtained, it appears that in the numerous gold-placers which exist here, whenever gold is washed a quantity of cassiterite is also obtained, which confirms amply the above supposition that a large region rich in tin must exist.

Up to the present, the country has scarcely been explored, for the population is exceedingly scattered and in a very rudimentary state of civilization. The native Buriats know the country better than any one else, but they are careful to conceal the knowledge of any deposits which they discover, for fear of finding themselves driven out from the ground which they are working. In their justification, they are fond of reminding us that they never received any reward for having pointed out the existence of deposits of stonite, but that, on the contrary, whenever they have done so, they have been recompensed by having to move from their own lands and shift their villages, leaving to others the advantage of working the deposits.

The first deposits of cassiterite on the river Onan were discovered in 1811. The Governor-General of Irkutsk informed the Minister of Finance about them, writing to the effect that the indigenous Buriat tribes encamped at the mouth of the Tsotsul, an affluent of the Onan, had discovered and handed to the chief, Halzan Mordaiew, a mineral from which tin had been extracted. According to an analysis made by a Mr. Kharinsky, the mineral contained from 1.30 dolia to 1.50 dolia of fine metal per pud. The Governor-General sent the above Kharinsky into the district where the ore had been found. Specimens were sent to St. Petersburg, which yielded per pud of ore 6 pounds 50 dolia of very ductile tin. Experiments showed that the metal was pure and of a high quality.

The same year, the manager of the Nerchinsk works reported to the Minister of Finance that having been informed by a peasant named Litvintzew that the natives were working mineral deposits on the river Onan, he sent a mining engineer into this country, who reported upon his return that he had found many ancient workings, and
that, judging by their number, the natives must have been occupied in this industry for a very long time.

In addition to the deposits pointed out by the natives, others were discovered in their neighbourhood, viz: — (1) The deposits of Kulinda, discovered in 1813-14, which were worked to 1818. (2) The deposits of Sharanai, discovered in 1815, which were only surface-workings, and abandoned in 1820. (3) The deposits of Zavitinskoe, discovered in 1817, were abandoned in 1821 as being too poor.

The deposits which had been pointed out by the Buriats, and which received the official denomination of primitive deposits, were, and still remain, the centre of the tin-production. For reasons to be given below, these deposits were abandoned in 1852, and no further attention was paid to them until they were revisited by the author in 1898.

These so-called primitive deposits are situated 1 or 2 miles from the village of Olovianny, by the Onan, in a deep valley formed on the north side by the Rudnichnaia, and on the south by Mount Slantsevaia. The general direction of the valley is at right-angles to the Onan. The rocks that outcrop are grey argillaceous schists, very compact. Near the summits of the above-named hills, these schists come to the surface, whilst in the centre of the valley they are overlain by a deposit of alluvium from 10 to 14 feet (1 1/2 to 2 sagenes) thick. Mr. A. P. Gherassimow ranks these schists among the grits and schists which he has examined on the Ingoda and Shilka, and places them temporarily in the upper series of the pre-Cambrian formation. These schists rest, as is seen in the banks of the Onan, upon granite, and are traversed by a large number of veins of milky-white quartz, running about north-north-west, and dipping west-south-west at an angle from 60 to 80 degrees. The general direction of these veins is very regular, although they present here and there curves and deviations, as is the case with all veins. Their thickness is between 28 to 32 inches (0.7 to 0.8 metre) and 3 to 6 inches (0.09 to 0.15 metre). Most of these veins show in their walls chiefly mica (pale yellow muscovite). Sometimes, however, they consist of greisen. The cassiterite is found both in the walls of the veins and in the quartz itself.

Although this deposit had been known since the commencement of the century, it could not be said that it had been either exploited or properly explored. It was true that after its discovery it was proposed to work it on a considerable scale, but this intention was never executed. The work done up to the year 1834 was irregular, and neither followed the veins nor cut across them. These facts are not astonishing, seeing that the work was not under the direction of officers of the Department of Mines, but was carried on by foremen, from whom no knowledge of the mineral deposits was to be expected. It is therefore not difficult to understand why so little attention was paid to these workings. Whatever work was commenced seriously, was abandoned before the year 1830, and any work done after that was not done on any systematic plan. The writer must, however, add that these later workings were conducted more regularly than those which were executed in accordance with the plans officially approved. It must be noted that the greater portion of the tin and tin-ore produced for the Crown, came from the alluvial deposits which occur in the middle portion of the deep valley.

As regards the matrix, properly speaking (the veins of quartz in which the cassiterite is disseminated), it had been very little worked; it had only been cut in surface-workings opened at some of the points of outcrop, especially in the eastern side of the southern face of Mount Rudnichnaia. All the work done has been irregular, and on account of the narrowness of the veins such a depth was soon reached that it was difficult to advance any further. It must be borne in mind that all these works were executed with picks and wedges. The amount of work done was
therefore but little, the quartz being very hard. Attempts were subsequently made to work by fire-setting. Seeing that the wood used as fuel had to be floated down from the Upper Onan, the adoption of this system could hardly be looked upon as reasonable. A shaft was sunk on the bank of the river, water from which was raised by means of a noria worked by horses, and was then used for washing the ore. The ore washed by this process naturally became highly expensive. After the year 1837, the work was organized on the basis that each workman was bound to produce somehow and from somewhere a 1/4 pud of pure ore. This regulation naturally caused the debris of the ancient workings to be washed over again, and under these conditions the production of tin became so costly that after the year 1852 the Governor stopped it altogether.

These 40 years of working in the only tin-deposits existing in the Russian Empire have not been productive of any advantage, but on the contrary have been distinctly injurious. The abandonment of these deposits, although it was due to the fact that they were worked badly, has been interpreted as meaning that the deposits themselves were not sufficiently productive. It is difficult to understand how this opinion has arisen, although it is true that but little has been written on the subject of these tin-mines. The most detailed and scientific is a report by Mr. M. J. Kovriguine, an officer of the Department of Mines, appearing in the Journal des Mines for 1830, under the form of a report concerning his explorations in 1829. Mr. Kovriguine's opinion was, upon the whole, favourable, but it must be remembered that he, being a stranger, laid great weight upon what the natives of the country told him. In his report he stated that the veins of quartz containing cassiterite pinched out rapidly both in strike and in depth, and as greater depth was reached, the quantity of cassiterite diminished. It would seem that this utterance of Mr. Kovriguine had caused the unfavourable opinion which had been formed of these deposits. If his view were correct, it was certain that the working of these deposits would be very difficult.

The author's opinion, formed from the first time he visited the mines, was that there can be no question as to the veins not being sufficiently extensive. The workings show that the same vein has been cut in many different places, apparently wherever it cropped out on the surface, and that some of these points were a considerable distance from each other on the two hills already named. There was, therefore, no question but that the veins continued very satisfactorily in strike. The author had made certain explorations, and especially on a vein situated to the east of the aquamarine cutting in the upper portion of Mount Rudnichaia, which was especially convenient of access. This vein having been worked more than the others, the author considered that if he could determine the cause which led to its abandonment he might be able to form conclusions as to the reason of the general abandonment of all the deposits. He was able to determine that this vein continued in depth, did not diminish in thickness, and even showed some slight tendency to widen, the greatest depth reached being 40 feet (5 1/2 sagenes).

Up to the present time, it was impossible to say how many veins there really were, seeing how little work had been done. The alluvial deposits that existed in the centre of the valley everywhere contained tin. They had been worked on behalf of the Crown, but the workings had never reached bed-rock. Deposits on the river Kulinda and near the village of Sharanaiskaia differ essentially from these so-called primitive deposits. In the latter place, veins of granite are seen, penetrating argillaceous schists. The granite is tin-bearing, but the quantity of tin which it contains is unknown.

According to statistics contained in the archives, one pud of rock contained 2 1/2 pounds of tin, or, say, 6 1/2 per cent. There was no reason to believe that this figure was an exaggeration, but it was probably less than the truth.
As regards the working conditions of the tin-deposits, they may be looked upon as highly favourable. No great ditches or works will be required to bring the water on to the spot. The geographical position is also as favourable as it possibly could be. A railway is being constructed which will pass within about 2/3 mile of the deposit below the Onan, where the Onan station is being built. This line will be a section of the Russian-Manchurian railway. It will start from the station of Kaidalovaia (70 miles from the town of Chita), where it crosses the Ingoda, then runs along the bank of the Mogoitoni, crosses the valley of the River Aga, passes at a distance of about 5 miles from the copper-deposits, of which something will be said below, and at 75 miles from Kaidalovaia runs close to the deposit of tin-ore. After having crossed the Onan at this point, the line runs along the river Turga, enters the deep valley of Tsunguruk, passes near the Hara-Nor lakes at a distance of from 6 to 8 miles from wolframite-deposits, which will be mentioned below; the line then crosses the river Onan-Borza, and after crossing the Nerchinsk mountains, enters the Chinese frontier near the Mutny stream.

This railway is of enormous importance for the tin-deposits; without mentioning that it facilitates communications with Chita, Irkutsk, and European Russia, this same railway will allow the tin to be carried to the Pacific Ocean, and will thus put these deposits on an equality with those of China, the Malay Peninsula, and islands of the Malay Archipelago.

The river Onan, beside which these deposits are situated, is also an important factor, as it is capable of furnishing water and hydraulic power, and, moreover, could yield large quantities of timber, the upper portion of the river being very densely wooded.

Ten miles north-east from the tin deposit, in a chain of mountains bordering the river basin of the Aga, a deposit of copper is situated in the deep valley of Mount Chuchi, which was worked between the years 1830-40, and known as the Aga copper-mines. There is scarcely any information about this deposit, even in the archives of the Nerchinsk works. As far as regards the natives, they remember that this deposit was worked intermittently, and they do not know the reason why it was abandoned. The only remains of the ancient workings are the small shaft, which has fallen in, a drift, and some unimportant surface-workings. The geological structure of this region is in general similar to that characterizing the stanniferous region, with this difference, that the argillaceous schists are principally met with at the mouth of the valley, whilst in the upper portion they become quartzose and horny in structure. Between these schists are beds of sandy and calcareous rocks, containing copper compounds disseminated through them. Up to the present, the copper has only been met with in the oxidized state, but it is probable that in depth sulphide-ores will appear. The main vein is very wide, 7 to 10 feet (1 to 1 1/2 sagenes) and more. The quantity of copper contained in the ore appears to be 7 per cent. Further explorations are urgently required.

The wolfram-deposit is situated in the Adun-Chillon mountain-range, on Mount Shirlow, where famous mines of topaz, beryl, and aquamarine were worked in the eighteenth century. This mountain is traversed in many directions by veinlets of rock with veins of topaz, which consists of fine grains of crystallized quartz, in which, in addition to the quartz-crystals, there are small crystals of topaz, molybdenite, arsenical-pyrites and iron-ochre. In this vein, the crystals of precious stones occur which made the reputation of the Adun-Chillon range. In some poor descriptions which exist of the mines it is said that large quantities of wolfram occur in these topaz-veins. All the ancient workings have fallen in to such an extent that it is impossible to enter them without a great deal of fresh work. The author has therefore only been able to examine the ancient spoil-heaps, and found that the chief of these
contained large quantities of the purest wolfram, analysis having yielded up to 70 per
cent.

[305]

II.—BAROMETER, THERMOMETER, Etc., READINGS FOR THE YEAR 1898.
By M. WALTON BROWN.
The barometer, thermometer, etc., readings have been supplied by permission of the
authorities of Glasgow and Kew Observatories, and give some idea of the variations
of atmospheric temperature and pressure in the intervening districts in which mining
operations are chiefly carried on in this country.
The barometer at Kew is 34 feet, and at Glasgow is 180 feet, above sea-level. The
barometer readings at Glasgow have been reduced to 32 feet above sea-level, by
the addition of 0.150 inch to each reading, and the barometrical readings at both
observatories are reduced to 32° Fahr.
The statistics of fatal explosions in collieries are obtained from the annual reports of
H.M. Inspectors of Mines, and are also printed upon the diagrams (Plates XXXIII. and
XXXIV.) recording the meteorological observations.

Table I.—Summary of Explosions of Fire-damp or Coal-dust during 1898, in the
several Mines-Inspection Distibcts.

<table>
<thead>
<tr>
<th>Mines-Inspection Districts</th>
<th>Fatal Accidents</th>
<th>Non-fatal Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. Deaths</td>
<td>Injured.</td>
</tr>
<tr>
<td>Durham</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Ireland</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Liverpool</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Manchester</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Midland</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Newcastle-upon-Tyne</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Scotland, East</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Do. West</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>South Wales</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>South-Western</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Staffordshire, North</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Do. South</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Yorkshire</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Totals</td>
<td>12</td>
<td>27</td>
</tr>
</tbody>
</table>

* These figures do not agree with those recorded in Mines and Quarries: General
  Report and Statistic for 1898, Part I., page 28

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Table II.—List of Fatal Explosions of Fire-damp or Coal-dust in Collieries during
1898, in the several Mines-Inspection Districts.

<table>
<thead>
<tr>
<th>1898 Colliery</th>
<th>Mines-Inspection districts</th>
<th>Deaths No.</th>
<th>Persons Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 28, 5.15 p.m.</td>
<td>Drumpeller (Nos.3 and 4 Pits)</td>
<td>Scotland, West</td>
<td>4</td>
</tr>
<tr>
<td>Mar. 5, 10.0 a.m</td>
<td>Whinney Moor</td>
<td>Yorkshire</td>
<td>1 0</td>
</tr>
</tbody>
</table>
Table III.—List of Non-fatal Explosions or Fire-damp or Coal-dust in Collieries during 1898, in the several Mines-Inspection Districts.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Location</th>
<th>District</th>
<th>No. of Persons Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 2</td>
<td>1.40 p.m.</td>
<td>Thankerton</td>
<td>Scotland, West</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>7, 8.0 a.m.</td>
<td>Lanemark</td>
<td>Scotland, West</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>7, 10.30 a.m.</td>
<td>Fishley (No. 4)</td>
<td>Staffordshire, South</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>10, 11.0 p.m.</td>
<td>Whitehill</td>
<td>Scotland, West</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>11, 12.30 p.m.</td>
<td>South Rhondda</td>
<td>South Wales</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>19, 7.30 a.m.</td>
<td>Waunecirch</td>
<td>Do.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>20, 11.50 a.m.</td>
<td>High-house</td>
<td>Scotland, West</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>24, 6.30 p.m.</td>
<td>Dumbreck</td>
<td>Do.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>25, 3.0 a.m.</td>
<td>Clydach Merthyr</td>
<td>South Wales</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>26, 10.0 a.m.</td>
<td>Deans (Oil-shale)</td>
<td>Scotland, East</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>29, 7.30 a.m.</td>
<td>Golden Vein, Bryn</td>
<td>South Wales</td>
<td>2</td>
</tr>
<tr>
<td>Feb. 2</td>
<td>5.0 p.m.</td>
<td>Varteg Hill</td>
<td>South Western</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>6, 3.0 a.m.</td>
<td>Pemberton</td>
<td>South Wales</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>15, 1.30 p.m.</td>
<td>Copy Hall</td>
<td>Staffordshire, South</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>18, 7.30 a.m.</td>
<td>Jordan</td>
<td>Yorkshire</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>18, 9.15 p.m.</td>
<td>Phoenix</td>
<td>Liverpool</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>21, 7.30 a.m.</td>
<td>Madeley Wood (Blesta Hill clay pit)</td>
<td>Staffordshire, North</td>
<td>1</td>
</tr>
<tr>
<td>Mar. 1</td>
<td>6.0 p.m.</td>
<td>Dalquaharran</td>
<td>Scotland, West</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4, 10.25 a.m.</td>
<td>Shilbottle</td>
<td>Newcastle-upon-Tyne</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>5, 6.30 a.m.</td>
<td>Peel</td>
<td>Midland</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>5, 9.30 a.m.</td>
<td>Cornsiloch</td>
<td>Scotland, East</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>8, 9.30 p.m.</td>
<td>Meiklehill</td>
<td>Scotland, West</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>12, 3.0 a.m.</td>
<td>Blaendare Slope</td>
<td>South Western</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>12, 7.0 a.m.</td>
<td>Glengarnock</td>
<td>Scotland, West</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>16, 6.20 a.m.</td>
<td>Foxfield</td>
<td>Staffordshire, North</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>16, 9.30 a.m.</td>
<td>Motherwell</td>
<td>Scotland, East</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>17, 12.0 noon</td>
<td>Souterhouse</td>
<td>Scotland, West</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>18, 1.0 p.m.</td>
<td>Lanefmark</td>
<td>Do.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>18, 10.30 a.m.</td>
<td>Newcastle</td>
<td>Midland</td>
<td>1</td>
</tr>
</tbody>
</table>

Table III.—Continued

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Location</th>
<th>District</th>
<th>No. of Persons Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar. 21</td>
<td>6.30 a.m.</td>
<td>Tanfield Lea</td>
<td>Newcastle-upon-Tyne</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>21, 11.30 a.m.</td>
<td>South Rhondda</td>
<td>South Wales</td>
<td>1</td>
</tr>
</tbody>
</table>
22, 7.0 p.m. North Skelton Durham 1
28, 7.45 a.m. Rankinston Scotland, West 2
April 1, 8.0 Haughhead Do. 1
2, 6.45 Cornsilloch Scotland, East 1
2, 7.0 Lanemark Scotland, West 1
6, 2.0 p.m. Trowell Moor Midland 1
11, 5.0 a.m. Fergushill Scotland, West 1
15, 10.40 p.m. Deans (Oil-shale) Scotland, East 1
19, 11.0 a.m Cornsilloch Do. 1
19, 5.0 p.m. Gorseinon South Wales 2
19, 7.0 Holywell, Halkyn Tunnel Liverpool 1
21, 9.10 a.m. Bedlington (A) Newcastle-upon-Tyne 1
26, 4.0 p.m. Holmes (Oil-shale) Scotland, East 1
28, 8.0 a.m. Auchenhavie Scotland, West 5
29, 2.0 Tannochside Do. 2
May 2, 9.45 p.m. Byers Green Durham 1
5, 6.15 a.m. Harrington (No. 9) Newcastle-upon-Tyne 2
5, 12.30 p.m. Aldridge Staffordshire, South 1
6, 6.0 Kenmuirhill Scotland, West 1
7, 1.30 Dechmont Do. 1
10, 3.0 a.m. Ravensworth (Shop) Newcastle-upon-Tyne 1
11, 2.15 Birkrigg Scotland, East 2
13, 12.0 noon Polbeth (Oil-shale) Do. 1
15, 11.0 p.m. Glyncdr South Wales 1
23, 9.0 Ashmore Park Staffordshire, South 1
25, 10.45 a.m. Slapewath Durham 1
27, 8.0 Cwmavon Slant South Wales 1
June 3, 11.30 Pumperston (Oil-shale) Scotland, East 1
4, 12.40 p.m. Railey Fell Durham 1
5, 10.30 Tanfield Lea Newcastle-upon-Tyne 2
6, 7.0 a.m Hazlehead Yorkshire 1
9, 2.0 Bryn Navigation South Wales 1
13, 6.0 Tanhouse Yorkshire 1
17, 7.15 North Blaina South Western 1
22, 9.0 p.m. South Rhondda South Wales 1
24, 10.0 a.m. Redhill Yorkshire 1
28, 8.0 Pollok Scotland, West 1
30, 6.45 Thankerton Do. 1
July 1, 1.15 p.m. Kirkwood Do. 1
7, 8.30 a.m. Tewgoed South Wales 2
7, 8.50 West Cannock Staffordshire, South 5
8, 3.45 p.m. Throckley Newcastle-upon-Tyne 1
12, 6.0 a.m. Valley Yorkshire 1
11, 3.0 p.m Meiklehill Scotland, West 1
20, 5.0 Cannock Chase Staffordshire, South 1
23, 6.15 a.m. Cornsilloch Scotland, East 1
27, 12.0 noon Pennyvenie Scotland, West 1
27, 6.30 p.m. Blaen-cae-gurwen South Wales 1
29, 4.0 Woodhall Scotland, West 2
Aug. 9, 11.0 a.m. Brayton Domain (No. 4) Newcastle-upon-Tyne 1
10, 5.0 Tanhouse Yorkshire 1
11, 5.30 p.m. Dyllas South Wales 1
12, 1-40 Souterhouse Scotland, West 1
14 9-50 Caprington Do. 1
### Table III.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Colliery</th>
<th>Districts</th>
<th>No. of Persons Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 19</td>
<td>9.30 a.m.</td>
<td>Cymmer Glyncorwg</td>
<td>South Wales</td>
<td>1</td>
</tr>
<tr>
<td>22</td>
<td>1.30</td>
<td>Lay Hall</td>
<td>Liverpool</td>
<td>2</td>
</tr>
<tr>
<td>25</td>
<td>8.30 a.m.</td>
<td>Cwmavon Slant</td>
<td>South Wales</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>3.30</td>
<td>Velinfran</td>
<td>Do.</td>
<td>1</td>
</tr>
<tr>
<td>27</td>
<td>11.30</td>
<td>Tong (No. 1)</td>
<td>Yorkshire</td>
<td>1</td>
</tr>
<tr>
<td>Sept. 6</td>
<td>1.30 p.m.</td>
<td>Llynfi Valley</td>
<td>South Wales</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>8.0 a.m.</td>
<td>Bridgeness</td>
<td>Scotland, East</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>9.15 a.m.</td>
<td>Dalziel and Broomside</td>
<td>Scotland, West</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>7.0 a.m.</td>
<td>Glencraig</td>
<td>Scotland, East</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>2.0 a.m.</td>
<td>Cwmavon Slant</td>
<td>South Wales</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>2.0 p.m.</td>
<td>Bridgeness</td>
<td>Scotland, East</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>9.0 a.m.</td>
<td>Dalziel and Broomside</td>
<td>Scotland, West</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>8.20 a.m.</td>
<td>Liest</td>
<td>South Wales</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>9.0 p.m.</td>
<td>North Skelton</td>
<td>Durham</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>7.20 a.m.</td>
<td>Rosebank</td>
<td>Scotland, East</td>
<td>1</td>
</tr>
<tr>
<td>27</td>
<td>3.30 p.m.</td>
<td>Brownside</td>
<td>Do.</td>
<td>1</td>
</tr>
<tr>
<td>30</td>
<td>10 a.m.</td>
<td>Backworth</td>
<td>Newcastle-upon-Tyne</td>
<td>1</td>
</tr>
<tr>
<td>Oct. 5</td>
<td>6.0 p.m.</td>
<td>Whitehill</td>
<td>Scotland, West</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>3.0 a.m.</td>
<td>Primrose</td>
<td>South Wales</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>6.45 a.m.</td>
<td>Newhouse</td>
<td>Scotland, West</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>8.0 a.m.</td>
<td>Glynea</td>
<td>South Wales</td>
<td>2</td>
</tr>
<tr>
<td>24</td>
<td>7.30 a.m.</td>
<td>Rheola</td>
<td>Do.</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>12.0 m'night</td>
<td>Crawshay's Cwm</td>
<td>Do.</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td>1.30 p.m.</td>
<td>Westburn</td>
<td>Scotland, West</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>6.30 a.m.</td>
<td>Woodilee</td>
<td>Do.</td>
<td>1</td>
</tr>
<tr>
<td>31</td>
<td>4.30 a.m.</td>
<td>Motherwell</td>
<td>Scotland, East</td>
<td>2</td>
</tr>
<tr>
<td>31</td>
<td>7.0 a.m.</td>
<td>South Medomsley</td>
<td>Newcastle-upon-Tyne</td>
<td>2</td>
</tr>
<tr>
<td>31</td>
<td>7.30 a.m.</td>
<td>Longrigg</td>
<td>Scotland, East</td>
<td>1</td>
</tr>
<tr>
<td>Nov. 1</td>
<td>11.0 a.m.</td>
<td>Dargavil</td>
<td>Do.</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1.0 a.m.</td>
<td>Horseley</td>
<td>Staffordshire, South</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>7.10 a.m.</td>
<td>Gateside</td>
<td>Scotland, West</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>11.0 a.m.</td>
<td>Blairhall</td>
<td>Scotland, East</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>4.30 p.m.</td>
<td>Cwmavon Slant</td>
<td>South Wales</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>11.30 a.m.</td>
<td>Holmes (Oil-shale)</td>
<td>Scotland, East</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>12.45 a.m.</td>
<td>Rosehall</td>
<td>Scotland, West</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>8.40 a.m.</td>
<td>Foxley</td>
<td>Do.</td>
<td>2</td>
</tr>
<tr>
<td>23</td>
<td>9.0 a.m.</td>
<td>Cwrt-y-bettws</td>
<td>South Wales</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>1.30 p.m.</td>
<td>Alexandra</td>
<td>Liverpool</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>10.0 a.m.</td>
<td>Whitworth</td>
<td>South Western</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>12.50 p.m.</td>
<td>South Moor, Hedley Pit</td>
<td>Durham</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>7.45 a.m.</td>
<td>Cymmer Glyncorwg</td>
<td>South Wales</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td>10.45 a.m.</td>
<td>Cymmer Glyncorwg</td>
<td>South Wales</td>
<td>2</td>
</tr>
<tr>
<td>28</td>
<td>6.0 p.m.</td>
<td>Arniston</td>
<td>Scotland, East</td>
<td>2</td>
</tr>
<tr>
<td>30</td>
<td>12.0 noon</td>
<td>Broad Oak</td>
<td>Manchester</td>
<td>1</td>
</tr>
</tbody>
</table>
Dec. 5, 6.30 a.m Bourtreehill Scotland, West  1
" 5, 11.0 p.m Dalziel and Broomside Do.  1
" 7, 7.30 a.m West Longrigg Scotland, East  1
" 7, 4.0 p.m Moor Road, Chorley Manchester  1
" 14, 12.30 " Cartwright Midland  1
" 15, 5.40 a.m Glenboig (Fire-clay) Scotland, East  2
" 15, 11.0 " Cwrt-y-bettws South Wales  2
" 16, 6.15 " Fairlie Scotland, West  3
" 26, 12.30 " Westrigg Scotland, East  1
" 27, 7.30 " Drumpeller Scotland, West  1
" 28, 10.0 2 Addiewell (Oil-shale) Scotland, East  1
" 29, 10.30 " Monkland Do.  1
Total  201
The following table shows the progress of the membership during the last three years:

<table>
<thead>
<tr>
<th>Year ending August 1st.</th>
<th>1898.</th>
<th>1899.</th>
<th>1900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honorary Members</td>
<td>50</td>
<td>29</td>
<td>30</td>
</tr>
<tr>
<td>Members</td>
<td>859</td>
<td>870</td>
<td>883</td>
</tr>
<tr>
<td>Associate Members</td>
<td>115</td>
<td>126</td>
<td>132</td>
</tr>
<tr>
<td>Associates</td>
<td>103</td>
<td>109</td>
<td>108</td>
</tr>
<tr>
<td>Students</td>
<td>51</td>
<td>62</td>
<td>59</td>
</tr>
<tr>
<td>Subscribers</td>
<td>22</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Totals</td>
<td>1,180</td>
<td>1,219</td>
<td>1,235</td>
</tr>
</tbody>
</table>

The continuing increase of the membership is a matter of congratulation. 110 members of all classes have been added to the register during the past year, and after allowing for losses by deaths and resignations, there is a net increase of 16 members.


The Library has been maintained in an efficient condition during the year. The additions by donation, exchange and purchase, have been: —

<table>
<thead>
<tr>
<th>Category</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bound volumes</td>
<td>390</td>
</tr>
<tr>
<td>Pamphlets, Reports, etc.</td>
<td>299</td>
</tr>
<tr>
<td><strong>A total of</strong></td>
<td><strong>689</strong></td>
</tr>
</tbody>
</table>

And the Library now contains about 8,389 volumes, and 2,299 unbound pamphlets. The sets of some of the files of publications are incomplete, owing to the loss of volumes or parts, and it is urgently desired that members will return the missing volumes, etc., to the librarian. The Council have been reluctantly compelled to decide that unbound publications shall be withdrawn from circulation. Members would render useful service, to the profession, by presentations of books, reports, and plans to the Library, where they would be available for reference.

By arrangement with the Literary and Philosophical Society of Newcastle-upon-Tyne, the members of either Institution are permitted to refer to the books in the Library of the other society. The members are also permitted to enter the Museum of the Natural History Society, in Newcastle-upon-Tyne.

The Library contains the complete publications (maps, memoirs, etc.) of the Geological Survey of the United Kingdom. They are available for reference by members, but may not be removed.

The Durham College of Science, at the suggestion of the Council, has arranged a three years’ course of lectures for colliery-engineers, enginewrights, and apprentice mechanics, commencing in October in each year. The lectures are delivered on Saturday afternoons, and the course is as follows: —


**1901-2.** Michaelmas Term, (5) Theoretical Electricity, and (6) Haulage and Winding. Epiphany Term, (7) Steam-engines and Boilers, and (8) Electrical Engineering.


Several colliery-owners have paid the fees (30s. per annum) and railway-expenses of pupils attending the classes from their respective collieries. During the past year, the lectures during the Michaelmas Term were attended by 89 students, 52 sat for examination, and 28 passed; and during Epiphany term there were 74 students, 49 were examined, and 30 passed.

The adoption of a composition, varying with age, payable in lieu of future subscriptions, has been generally approved, as evidenced by the number of members who have compounded. The scale of rate is: — Under 30 years of age, £31; over 30 years, £27; over 40 years, £24; over 50 years, £21; and over 60 years, £17.

The Report of the Committee of the North of England Institute of Mining and Mechanical Engineers, and the Midland Institute of Mining, Civil and Mechanical Engineers on Mechanical Ventilators has been published by The Institution of Mining Engineers. The thanks of the Institute were due to the members of the Committee for the interesting and valuable report which has been drafted by their honorary secretary.

An Account of the Strata of Northumberland and Durham as proved by Borings and Sinkings has been published in six volumes. Members are desired to send copies of
any unpublished sections of strata in these counties, or their section books on loan, in order that they may be published in a supplementary volume.

The prices of the Transactions (vols. i. to xxxviii.) have been considerably reduced, and members are desired to complete their sets before the stock is exhausted (vols. iii., iv., v., vi. and xxi. are now out of print).

Arrangements have been made for the holding of meetings for the reading of papers and discussions by the junior members, and the Council trust that the associates and students will attend and ensure their success.

Mr. M. Walton Brown has been appointed to represent the Institute at the conference of corresponding societies of the British Association for the Advancement of Science to be held at Bradford in September, 1900. Messrs. M. Walton Brown, C. C. Leach, H. Louis and John Vivian attended, as delegates, at the receptions of the Societe des Ingenieurs Civils de France in connexion with the Paris Exhibition from June 15th to 20th, 1900. Messrs. Alexander Agassiz and R. P. Rothwell represented the Institute at the commemoration exercises held in October, 1899, to celebrate the hundredth anniversary of the foundation of the Connecticut Academy of Arts and Sciences. Mr. John Daglish represents the Institute on the Council of the Durham College of Science. Mr. W. Cochrane is the representative of the Institute on the Science and Art Committee, and Mr. Henry Ayton on the Scholarships Committee of the Northumberland County Council. Mr. W. Cochrane also represents the Institute on the board of directors of The Institute and Coal Trade Chambers Company, Limited.

Prof. H. Louis gave evidence on behalf of the Institute before the Department Committee upon the work of the Geological Survey of the United Kingdom.


Mr. G. C. Greenwell, one of the original members, a past-president and an honorary member, in order to further promote the original object for which the Institute was founded, namely “for the purpose of forming a society to meet at fixed periods and discuss the means for the ventilation of coal-mines, for the prevention of accidents, and for general purposes connected with the winning and working of collieries,” has offered a donation of £100 to provide for the annual award of gold, silver and bronze medals for papers recording the results of experience, and the deductions and practical suggestions of the writers, for the avoidance of accidents.

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The following additional exchanges have been arranged during the year:—

Geological Survey of the Colony of Natal.
The University Geological Survey of Kansas.

The Council are of opinion that the experience of the past has proved the desirability of forming a Benevolent Fund in connexion with the Institute, similar to the Benevolent Fund of the Institution of Civil Engineers, established in 1864, when the membership of that Institution was much less (1,040) than the present membership (1,235) of the Institute. There is no doubt that a well-managed and adequately-supported Benevolent Fund would prove advantageous to members who may be overtaken by misfortune. The question of the promotion of a general fund is being considered by The Institution of Mining Engineers.
Prizes of books have been awarded to the writers of the following papers communicated to the members during the year 1898-99: —

"The Western Interior Coal-field of America." By Mr. H. Foster Bain.  
"Transvaal Coal-field." By Mr. William Peile.  
"The Ore-deposits of the Silver Spur Mine and Neighbourhood, Texas, Queensland." By Mr. H. G. Stokes.

The papers contributed during the year are as follow: —

"The Driving of a Stone-drift at the West Wylam Collieries." By Mr. Sidney Bates.  
"The Kalgoorlie Gold-field." By Mr. S. J. Becher.  
"Description and Proposed Methods of Operating Vinton No. 3 Colliery, Vintondale, Pennsylvania, U.S.A." By Mr. Clarence R. Cloghern.  
"Some Silver-bearing Veins of Mexico." By Mr. Edward Halse.  
"Automatic Sprayer for Preventing Accumulations of Dust in Mines." By Mr. R. Harle.  
"The Coal-fields of Natal." By Mr. Wm. Taylor Heslop.  
"The Composition of Certain British Coals." By Prof. Henry Louis.  
"Ore-deposits of Mount Lyell, Tasmania." By Mr. J. J. Muir.  
"The Mineral Resources of Tasmania." By Mr. John J. Sandeman.

The connexion with The Institution of Mining Engineers has now existed for eleven years. During the past year, meetings have been held at Sheffield in September, 1899, in London in June, 1900, and in Paris, in connexion with the International Congress of Mining and Metallurgy, in June, 1900. The members may be congratulated upon the number and varied nature of the papers printed in the Transactions, and the Council trust that similar contributions will be forwarded as liberally in the future.

The rooms of the Institute have been used by the following Societies, etc.: — Bee-keepers' Association, Clerks' Provident Association, Congregational Union of England and Wales, Economic Society, National Telephone Vocal Society, Northern Allotments Society, and the Northern Architectural Society.

In conclusion, the Council desire to impress upon the members

[ix] that the success of the Institute in the future is dependent upon an increase in the membership, so as to meet the increased expenses incurred by its connexion with The Institute of Mining Engineers.

REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts for the twelve months ending June 30th, 1900.

The total receipts during that period were £2,687 14s. 7d. Of this amount, £127 was paid as life-compositions in lieu of annual subscriptions, and £74 2s. represented subscriptions paid in advance, leaving £2,486 12s. 7d. as the ordinary income of the year, as compared with £2,579 4s. 2d. in the previous year. The decrease is caused by the fact that in the previous year one and a half year's interest on the mortgage of the Institute and Coal Trade Chambers Company, Limited, was included, and in that year also interest was received from the bankers on sums deposited with them, which have since been withdrawn for the purpose of payment of the cost of alterations to the Wood Memorial Hall.

The ordinary expenditure amounted to £2,069 12s. 7d., leaving a balance of ordinary receipts over ordinary expenditure of £417. There was also paid the balance of the cost of alterations to the Wood Memorial Hall, £378 1s., making the total payments for the year £2,447 13s. 7d.
During the year, £421 15s. has been written off the amount of subscriptions and arrears. This large sum is due to the Council having removed from the list all members who had failed to respond to numerous applications for subscriptions and arrears. The collection of the amounts due in many cases has been placed in the hands of the solicitors, and a portion will subsequently be recovered and credited to the year in which the sums are received. It is to be regretted that, even after the amount has been struck off as shown above, there is still a very considerable sum in arrear, the amount of subscriptions for the year 1899-1900 yet unpaid being £286 10s., and for previous years £60 18s. The Committee would impress upon the members the necessity for the payment of subscriptions at the time when they become due, in order to avoid the considerable inconvenience and loss which are otherwise caused.

John G. Weeks.

July 21st, 1900.

[x]

ACCOUNTS.
The Treasurer in Account with The North of England Institute of Mining and Mechanical Engineers.
For the year ending June 30th, 1900.

<table>
<thead>
<tr>
<th>Dr.</th>
<th>June 30th, 1899</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To Balance at Bankers</td>
<td>527</td>
<td>18</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&quot; in Treasurer's hands</td>
<td>47</td>
<td>0</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&quot; Outstanding Amount due for Authors' Excerpts</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>June 30th, 1900.</td>
<td>575</td>
<td>3</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To Dividend of 7 1/5 per cent. on 146 Shares of £20 each in the Institute and Coal Trade Chambers Company, Limited, for year ending June 30th, 1900</td>
<td>219</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&quot; Interest on Mortgage of £1,400 with the Institute and Coal Trade Chambers Company, Limited</td>
<td>49</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&quot; Sale of Transactions</td>
<td>31</td>
<td>18</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To Subscriptions for 1899-1900 as follows: —</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>677 Members</td>
<td>@ £2 2s.</td>
<td>1,421</td>
<td>14</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>85 Associate Members</td>
<td>@ £2 2s.</td>
<td>178</td>
<td>10</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>90 Associates'</td>
<td>@ £1 5s.</td>
<td>112</td>
<td>10</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>53 Students</td>
<td>@ £1 5s.</td>
<td>66</td>
<td>5</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>69 New Members</td>
<td>@ £2 2s.</td>
<td>144</td>
<td>18</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 New Members (not yet elected)</td>
<td>@ £2 2s.</td>
<td>31</td>
<td>10</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21 New Associate Members</td>
<td>@ £2 2s.</td>
<td>44</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 New Associates</td>
<td>@ £1 5s.</td>
<td>7</td>
<td>10</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 New Associate (on account)</td>
<td>@ £1 5s.</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 New Students</td>
<td>@ £1 5s.</td>
<td>12</td>
<td>10</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2,020</td>
<td>10</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>23 Subscribing Firms</td>
<td></td>
<td>96</td>
<td>12</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2,117</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To Life Compositions: —

3 New Members | £72 | 0 | 0 |
1 New Member (not yet elected) | 24 | 0 | 0 |
<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 New Student</strong></td>
<td>31 0 0</td>
</tr>
<tr>
<td><strong>Less</strong>—Subscriptions for current year paid in advance at the end of last year</td>
<td>86 2 0</td>
</tr>
<tr>
<td><strong>Add</strong>—Arrears received</td>
<td>155 14 0</td>
</tr>
<tr>
<td><strong>Add</strong>—Subscriptions paid in advance during the current year</td>
<td>74 2 0</td>
</tr>
<tr>
<td><strong>Cr.</strong> June 30th, 1900.</td>
<td>£3,262  18 4</td>
</tr>
<tr>
<td><strong>By Circulars, etc.</strong></td>
<td>67 13 7</td>
</tr>
<tr>
<td><strong>Cleaning Offices</strong></td>
<td>33 12 1</td>
</tr>
<tr>
<td><strong>Coals, Electric Light, Gas and Water</strong></td>
<td>54 1 11</td>
</tr>
<tr>
<td><strong>Expenses of General Meetings</strong></td>
<td>22 3 0</td>
</tr>
<tr>
<td><strong>Fire Insurance</strong></td>
<td>13 7 9</td>
</tr>
<tr>
<td><strong>Furniture and Repairs</strong></td>
<td>33 8 3</td>
</tr>
<tr>
<td><strong>Incidental Expenses</strong></td>
<td>11 1 8</td>
</tr>
<tr>
<td><strong>Library—Binding</strong></td>
<td>69 0 8</td>
</tr>
<tr>
<td><strong>Books</strong></td>
<td>39 0 7</td>
</tr>
<tr>
<td><strong>Postages—Circulars</strong></td>
<td>46 13 3</td>
</tr>
<tr>
<td><strong>Correspondence</strong></td>
<td>9 18 9</td>
</tr>
<tr>
<td><strong>Reports</strong></td>
<td>12 8 8</td>
</tr>
<tr>
<td><strong>Prizes for Papers</strong></td>
<td>6 6 0</td>
</tr>
<tr>
<td><strong>Rates and Taxes</strong></td>
<td>21 6 9</td>
</tr>
<tr>
<td><strong>Rent of Offices</strong></td>
<td>22 1 10</td>
</tr>
<tr>
<td><strong>Reporting General Meetings</strong></td>
<td>18 11 0</td>
</tr>
<tr>
<td><strong>Salaries, Wages, Auditing, etc.</strong></td>
<td>380 16 9</td>
</tr>
<tr>
<td><strong>Stationery, etc.</strong></td>
<td>29 5 10</td>
</tr>
<tr>
<td><strong>Telephone Rent, etc.</strong></td>
<td>5 13 8</td>
</tr>
<tr>
<td><strong>Translations of Papers</strong></td>
<td>2 14 0</td>
</tr>
<tr>
<td><strong>By The Institution of Mining Engineers</strong></td>
<td>1,192 12 0</td>
</tr>
<tr>
<td><strong>Less</strong>—Amounts paid by Authors for Excerpts</td>
<td>0 7 0</td>
</tr>
<tr>
<td><strong>By Wood Memorial Hall: Alterations</strong></td>
<td>378 1 0</td>
</tr>
<tr>
<td><strong>Cr.</strong></td>
<td>2,447 13 7</td>
</tr>
</tbody>
</table>
We have examined the above account with the books and vouchers relating thereto, and certify that, in our opinion, it is correct.

G. BENSON AND SON,
Chartered Accountants.

Newcastle-upon-Tyne,
August 4th, 1900.

[xii]

Dr.
The Treasuries in Account with Subscriptions, 1899-1900.

<table>
<thead>
<tr>
<th>Description</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>To 870 Members.</td>
<td>1,732</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>45 of whom have paid Life Compositions.</td>
<td>825</td>
<td>£2 2s.</td>
<td></td>
</tr>
<tr>
<td>To 126 Associate Members, 8 of whom have paid Life Compositions.</td>
<td>247</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>To 109 Associates</td>
<td>@ £1 5s.</td>
<td>136</td>
<td>5</td>
</tr>
<tr>
<td>To 62 Students</td>
<td>@ £1 5s.</td>
<td>77</td>
<td>10</td>
</tr>
<tr>
<td>To 23 Subscribing Firms</td>
<td>@ £2 2s.</td>
<td>96</td>
<td>12</td>
</tr>
<tr>
<td>To 69 New Members</td>
<td>144</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>To 15 New Members, not yet elected</td>
<td>31</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>To 3 New Members, paid Life Composition</td>
<td>72</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>To New Member, not yet elected, paid Life Composition</td>
<td>24</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>To 21 New Associate Members</td>
<td>@ £2 2s.</td>
<td>44</td>
<td>2</td>
</tr>
<tr>
<td>To 7 New Associates</td>
<td>@ £1 5s.</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>To 10 New Students</td>
<td>@ £1 5s.</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>To 1 New Student, paid Life Composition</td>
<td>31</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

2,659 8 0

To Arrears, as per Balance Sheet 1898-99 | £506 | 2 | 0 |

Add—Fines | 1 | 7 | 0 |

Add—1 Member, paid for 1898-99 | 2 | 2 | 0 |

509 11 0

3,168 19 0

To Subscriptions Paid in Advance | 74  | 2  | 0  |

£3,243 1 0
<table>
<thead>
<tr>
<th>Cr.</th>
<th>PAID.</th>
<th>UNPAID</th>
<th>STRUCK OFF LIST.</th>
</tr>
</thead>
<tbody>
<tr>
<td>By 677 Members, paid</td>
<td>£2 2s.</td>
<td>1,421 14 0</td>
<td></td>
</tr>
<tr>
<td>By 106 &quot; unpaid</td>
<td>£2 2s.</td>
<td>222 12 0</td>
<td></td>
</tr>
<tr>
<td>By 33 &quot; struck off list</td>
<td>£2 2s.</td>
<td>69 6 0</td>
<td></td>
</tr>
<tr>
<td>By 9 &quot; dead</td>
<td>£2 2s.</td>
<td>18 18 0</td>
<td></td>
</tr>
<tr>
<td>825</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By 85 Associate Members, paid</td>
<td>£2 2s.</td>
<td>178 10 0</td>
<td></td>
</tr>
<tr>
<td>By 22 &quot; unpaid</td>
<td>£2 2s.</td>
<td>46 4 0</td>
<td></td>
</tr>
<tr>
<td>By 11 &quot; struck off list</td>
<td>£1 5s.</td>
<td>23 2 0</td>
<td></td>
</tr>
<tr>
<td>118</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By 90 Associates, paid</td>
<td>£1 5s.</td>
<td>112 10 0</td>
<td></td>
</tr>
<tr>
<td>By 8 &quot; unpaid</td>
<td>£1 5s.</td>
<td>10 0</td>
<td></td>
</tr>
<tr>
<td>By 10 &quot; struck off list</td>
<td>£1 5s.</td>
<td>12 10 0</td>
<td></td>
</tr>
<tr>
<td>By 1 &quot; dead</td>
<td>£1 5s.</td>
<td>15 0</td>
<td></td>
</tr>
<tr>
<td>109</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By 53 Students, paid@ £1 5s.</td>
<td>66 5 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>By 6 &quot; unpaid</td>
<td>£1 5s.</td>
<td>7 10</td>
<td></td>
</tr>
<tr>
<td>By 2 &quot; struck off list</td>
<td>£1 5s.</td>
<td>2 10</td>
<td></td>
</tr>
<tr>
<td>By 1 &quot; dead</td>
<td>£1 5s.</td>
<td>15 0</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By 23 Subscribing Firms</td>
<td>96 12 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>By 69 New Members, paid</td>
<td>£2 2s.</td>
<td>144 18 0</td>
<td></td>
</tr>
<tr>
<td>By 15 New Members, not yet elected</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------- paid@£2 2s.</td>
<td>31 10 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>By 3 New Members, paid Life Composition</td>
<td>72 0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>By 1 New Member, not yet elected, paid Life Composition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By 21 New Associate Members, paid</td>
<td>£2 2s.</td>
<td>44 2 0</td>
<td></td>
</tr>
<tr>
<td>By 6 New Associates, paid@ £1 5s.</td>
<td>7 10 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>By 1 New Associate, paid on account</td>
<td>1 1 0</td>
<td>0 4 0</td>
<td></td>
</tr>
<tr>
<td>By 10 New Students, paid</td>
<td>£1 5s.</td>
<td>12 10 0</td>
<td></td>
</tr>
<tr>
<td>By 1 New Student, paid Life Composition</td>
<td>31 0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,244 2 0</td>
<td>286 10 0</td>
<td>128 16 0</td>
<td></td>
</tr>
<tr>
<td>By Arrears</td>
<td>£154 7 0</td>
<td>60 18 0</td>
<td>292 19 0</td>
</tr>
<tr>
<td>Add—Fines</td>
<td>1 7 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>155 14 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,399 16 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By Subscriptions paid in advance</td>
<td>74 2 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,473 18 0</td>
<td>347 8 0</td>
<td>421 15 0</td>
<td></td>
</tr>
<tr>
<td>347 8 0</td>
<td>2,473 18 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>£3,243 1 0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[xiv]
General Statement, June 30th, 1900.

Liabilities.

<table>
<thead>
<tr>
<th>Item</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subscription paid in advance</td>
<td>74</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Stationery</td>
<td>15</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>The Institution of Mining Engineers</td>
<td>39</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total Liabilities</strong></td>
<td>129</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Capital</td>
<td>11,199</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td>£11,328</td>
<td>16</td>
<td>10</td>
</tr>
</tbody>
</table>

Assets.

<table>
<thead>
<tr>
<th>Item</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance of Account at Bankers</td>
<td>753</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>in Treasurer’s hands</td>
<td>61</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>Outstanding amount for Authors’ Excerpts</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td>815</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Arrears of Subscriptions</td>
<td>347</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>146 Shares in the Institute and Coal Trade Chambers Company, Limited (at cost)</td>
<td>3,130</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Investment with the Institute and Coal Trade Chambers Company, Limited (Mortgage)</td>
<td>1,400</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td>4,530</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(Of the above amount, £350 is due to Life Subscriptions Account, leaving £578 14s. not invested.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Furniture Sold</td>
<td>32</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Value of Transactions and other Publications, as per Stock Account</td>
<td>454</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Books, Pictures, Maps, Furniture and Fittings</td>
<td>5,150</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td>£11,328</td>
<td>16</td>
<td>10</td>
</tr>
</tbody>
</table>

We have examined the above account with the books, vouchers and securities relating thereto, and certify that, in our opinion, it is correct. We have accepted the assets, books, pictures, etc., and Transactions and other Publications as valued by your Officials.

JOHN G. BENSON AND SON,
Chartered Accountants.
Newcastle-upon-Tyne,
August 4th, 1900.

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OFFICERS, 1900-1901.

PRESIDENT.
Mr. J. G. WEEKS, Bedlington, R.S.O., Northumberland.

VICE-PRESIDENTS.
Mr. T. W. BENSON, 24, Grey Street, Newcastle-upon-Tyne.
Mr. THOMAS FORSTER BROWN, Guildhall Chambers, Cardiff.
Mr. J. L. HEDLEY, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne.
Mr. J. H. MERIVALE, Togston Hall, Acklington, Northumberland.
Mr. M. W. PARRINGTON, Wearmouth Colliery, Sunderland.
Mr. W. O. WOOD, South Hetton, Sunderland.

COUNCIL.
Mr. R. S. ANDERSON, Benwell View, Bentinck Road, Newcastle-upon-Tyne.
Mr. HENRY AYTON, 122, Rye Hill. Newcastle-upon-Tyne.
Mr. R. DONALD BAIN, H.M. Inspector of Mines, Springwell Hall, Durham.
Mr. GEORGE FRED. BELL, H.M. Inspector of Mines, 20, Wentworth Place, Newcastle-upon-Tyne.
Mr. W. C. BLACKETT, Acorn Close, Sacriston, Durham.
Mr. H. F. BULMAN, Barcus Close, Burnopfield, R.S.O., Co. Durham.
Mr. M. H. DOUGLAS, Usworth Colliery, Washington, R.S.O., Co. Durham.
Mr. THOMAS E. FORSTER, 3, Eldon Square, Newcastle-upon-Tyne.
Mr. THOMAS E. JOBLING, Bebside, Northumberland.
Mr. A. C. KAYLL, Gosforth, Newcastle-upon-Tyne.
Mr. PHILIP KIRKUP, Leafield House, near Chester-le-Street.
Mr. H. LAWRENCE, 7 and 8, Post Office Chambers, Newcastle-upon-Tyne.
Mr. C. C. LEACH, Seighill Colliery, Northumberland.
Prof. HENRY LOUIS, 9, Summerhill Terrace, Newcastle-upon-Tyne.
Mr. R. A. S. REDMAYNE, Seaton Delaval Colliery, Newcastle-upon-Tyne.
Mr. T. O. ROBSON, Chowdene Cottage, Low Fell, Gateshead-upon-Tyne.
Mr. F. R. SIMPSON, Hedgefield House, Blaydon-upon-Tyne.
Mr. J. SIMPSON, Heworth Colliery, Felling, R.S.O., Co. Durham.

Ex-officio - Past Presidents.
Sir LINDSAY WOOD, Bart., The Hermitage, Chester-le-Street.
Mr. G. B. FORSTER, 3, Eldon Square, Newcastle-upon-Tyne.
Mr. JOHN DAGLISH, Rothley Lake, Cambo, R.S.O., Northumberland.
Sir LOWTHIAN BELL, Bart, D.C.L., F.R.S., Rounton Grange, Northallerton.
Mr. W. COCHRANE, St. John's Chambers, Grainger Street West, Newcastle-upon-Tyne.
Mr. J. B. SIMPSON, Bradley Hall, Wylam-upon-Tyne.
Mr. A. L. STEAVENSON, Durham.
Mr. T. DOUGLAS, The Garth. Darlington.
Mr. GEORGE MAY, The Harton Collieries, South Shields.
Mr. WILLIAM ARMSTRONG, Wingate, Co. Durham.

TREASURER.
Mr. REGINALD GUTHRIE, Neville Hall, Newcastle-upon-Tyne.

SECRETARY.
Mr. M. WALTON BROWN, Neville Hall, Newcastle-upon-Tyne.

LIST OF MEMBERS,
AUGUST 4, 1900.

PATRONs.
His Grace the DUKE OF NORTHUMBERLAND.
The Most Noble the MARQUIS OF LONDON DERRY.
The Right Honourable the EARL OF LONSDALE.
The Right Honourable the EARL OF DURHAM.
The Right Honourable the EARL GREY.
The Right Honourable the EARL OF RAVENSWORTH.
The Right Honourable the EARL OF WHARNCLIFFE.
The Right Reverend the LORD BISHOP OF DURHAM.
The Very Reverend the DEAN AND CHAPTER OF DURHAM.

WENTWORTH B. BEAUMONT, Esq.
BARON BARNARD.

HONORARY MEMBERS.
* Honorary Members during term of office only.

Date of Election.
1 The Right Honourable the EARL of RAVENSWORTH, Ravensworth Castle, Gateshead-upon-Tyne Nov. 3, 1877
4* R. DONALD BAIN, H.M. Inspector of Mines, Springwell Hall, Durham Dec. 12, 1890
5* W. BEATTIE-SCOTT, H.M. Inspector of Mines, Park Avenue, Handsworth, near Birmingham Dec. 10, 1887
6* Prof. P. PHILLIPS BEDSON, Durham College of Science, Newcastle-upon-Tyne Feb. 10, 1883
7 THOMAS BELL, 15, The Valley, Scarborough Dec. 12, 1896
8* Prof. G. S. BRADY, Durham College of Science, Newcastle-upon-Tyne. Transactions, etc., sent to Mowbray Villa, Sunderland Nov. 6, 1875
9 Dr. BRASSERT, Bonn-on-the-Rhine, Germany Dec. 8, 1883
10 JOSEPH DICKINSON, South Bank, Sandy Lane, Pendleton, Manchester Dec. 13, 1852
12 Prof. WILLIAM GARNETT, 116, St. Martin's Lane, London, W.C. Nov. 24, 1894
13 Sir ARCHIBALD GEIKIE, Director-General of the Geological Survey of the United Kingdom, 28, Jermyn Street, London, S.W June 11, 1898
14* JOHN GERRARD, H.M. Inspector of Mines, Worsley, Manchester June 11, 1892
15 GEORGE CLEMENTSON GREENWELL, Duffield, Derby Oct. 14, 1899
16* Rev. H. PALIN GURNEY, Principal, Durham College of Science, Roseworth, Gosforth, Newcastle-upon-Tyne Jan. 19, 1895
17* HENRY HALL, H.M. Inspector of Mines, Rainhill, Lancashire March 4, 1876
18* J. L. HEDLEY, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne April 9, 1892
19* Prof. A. S. HERSCHEL, Observatory House, Slough, Bucks Aug. 3, 1872
20* Prof. G. A. LEBOUR, Durham College of Science, Newcastle-upon-Tyne. Transactions, etc., sent to Radcliffe House, Corbridge-upon-Tyne Nov. 1, 1879
21*Prof* HENRY LOUIS, Durham College of Science, Newcastle-upon-Tyne. Transactions sent to The Secretary, Durham College of Science, Newcastle-upon-Tyne Dec. 12, 1896

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Date of Election.


23 Sir CHARLES MARK PALMER, Bart., Grinkle Park, Loftus, R.S.O., Yorkshire. Transactions sent to The Mechanics' Institute, Jarrow-upon-Tyne Feb. 12, 1895


27*Prof. H. STROUD, Durham College of Science, Newcastle-upon-Tyne Nov. 5, 1892

28 M. E. VUILLEMIN, Mines d'Aniche, Nord, France Sept. 7, 1878

29*FRANK N. WARDELL, H.M. Inspector of Mines, Wath-upon-Dearne, near Rotherham Feb. 4, 1865

30*Prof. ROBERT LUNAN WEIGHTON, Durham College of Science, Newcastle-upon-Tyne. Transactions, etc., sent to 21, North Terrace, Newcastle-upon-Tyne April 2, 1898

MEMBERS.
Marked * have paid life composition.

Date of Election and of Transfer.

1 Abraham, David, Pencoedcae, Merthyr Tydvil June 8, 1895

2 Aburrow, Charles, P.O. Box 534, Johannesburg, Transvaal Feb. 13, 1892


4 Adams, Henry Hopper, Waihi, New Zealand April 10, 1897

5 Adamson, Thomas, Kurhurbaree Colliery, Giridih, Bengal, India Feb. 10, 1894

6 Agassiz, Alexander, Museum of Comparative Zoology, Cambridge, Massachussets, U.S.A. Feb. 9, 1895


8 Aitkin, Henry, Falkirk, N.B. March 2, 1865

9 Akerman, Ernest, Minas de Cala, por Santa Olalla, Huelva, Spain Aug. 5, 1899


11 Allan, John F., Apartado de Correo, No. 121, Mexico, D.F. A.M. Feb. 10, 1883

M. June 8, 1899

12 Allan, T. Alexander, c/o Gibbs, Bright and Company, Melbourne, Australia Feb. 11, 1893

13 Allchurch, Enrique, Calle Las Heras, 273, Buenos Aires, Argentine Republic June 8, 1895
M. Aug. 3, 1889
15 Anderson, C. W., Cleedon Park, Sunderland Aug. 21, 1852
16 Anderson, R. Hay, Apartado Postal, 866, Mexico, D.F. Aug. 4, 1894
17 Anderson, R. S., Ben well View, Bentinck Road, Newcastle-upon-Tyne [Member of Council] S. June 9, 1883
A.M. Aug. 4, 1888
M. Aug. 3, 1889
18 Angus, James, Ochiltree House, Ochiltree, Ayrshire, N.B. Oct. 8, 1892
19 Angwin, B., c/o Holman Brothers, Broad Street House, London, E.C. Nov. 24, 1894
20 Appleby, Harry Walton, Trafalgar Works, Bradford, Yorkshire Oct. 8, 1898
21 Appleby, W. R., Minnesota School of Mines, The University of Minnesota, Minneapolis, Minnesota, U.S.A. April 14, 1894
22 Archer, Oakeley, 156, Hereford Street, Christchurch, New Zealand. June 13, 1896
23 Archer, T., 11, Regent Terrace, Gateshead-upon-Tyne July 2, 1892
24 Archer, William, Victoria Garesfield, Lintz Green, Co. Durham A. Aug. 6, 1892
M. Aug. 3, 1895
25 Argall, Philip, P.O. Box 843, Denver, Colorado, U.S.A. June 21, 1894
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Date of Election and of Transfer.
26 Armstrong, Lord, C.B., LL.D., D.C.L., F.R.S., Cragside, Rothbury (Past-President, Member of Council) May 3, 1866
27 Armstrong, Henry, Chester-le-Street A.M. April 14, 1883
M. June 8, 1889
28 Armstrong, William, Wingate, Co. Durham (Past-President, Member of Council) S. April 7, 1867
M. Aug. 6, 1870
31 Ashworth, John, 8, King Street, Manchester April 25, 1896
32 Atherton, James, 13, Mawdsley Street, Bolton Aug. 1, 1896
33 Atherton, Thomas William Turner A.M. June 11, 1898
M. Dec. 10, 1898
34 Atkinson, Claude W., Glendale, Woodland Place, Penarth, South Wales Aug. 6, 1892
35 Atkinson, L. B., 10, Westbourne Road, Penarth, South Wales Aug. 6, 1892
36 Atkinson, R. H. M. Buddle, Riding Mill-upon-Tyne April 10, 1897
37 Aubrey, R. C., Teviotdale, Churcltown, Southport Feb. 5, 1870
38 Austin, W. Lawrence, P.O. Box 941, Denver, Colorado, U.S.A. June 21, 1894
39 Ayton, Ernest F., El Bote Mining Negociacion, Zacatecas, Republic of Mexico Aug. 1, 1891
40 Ayton, Henry, 122, Rye Hill, Newcastle-upon-Tyne (Member of Council) S. March 6, 1875
A.M. Aug. 2, 1884
M. June 8, 1889

41 Bailes, E. T., Wingate, Ferryhill A. M. June 7, 1879
M. June 8, 1889

42 Bailes, T., Jesmond Gardens, Newcastle-upon-Tyne Oct. 7, 1858

43 Bailey, Archibald Duncan, c/o S. G. Bailey and Company, Limited, Stafford
Mills, Stroud, Gloucestershire Oct. 8, 1898

44 Bailey, Edward Trenholm, Mining Engineer, Sandakan, British North Borneo
A.M. June 13, 1896
M. June 12, 1897

45 Bain, Harry Foster, Assistant State Geologist of Iowa, Des Moines, Iowa, U.S.A.
Dec. 10, 1898

46 Bain, R. Donald, H.M. Inspector of Mines, Springwell Hall, Durham (Member of
Council) S. March 1, 1873
M. Aug. 5, 1876

47 Bainbridge, Emerson, 4, Whitehall Court, London, S.W.S. Dec. 3, 1863
M. Aug. 1, 1868

48 Baldwin, Ivo William, Oakleigh, Ruardean, Gloucestershire Feb. 10, 1900

49 Ballard, Robert, Menzies, Western Australia April 10, 1897

50 Banks, Thomas, 60, King Street, Manchester. Transactions sent to 17, Park
Avenue, Eccles, near Manchester Aug. 4, 1877

51 Barber, George Marriott, Soemalata, Celebes, Dutch East Indies
April 28, 1900

52 Barker, M. W., 110, Stapleton Hall Road, Stroud Green, London, N. April 8,
1893

53 Barnard, Robert, The Retreat, Sitramore P.O., Bengal, India Dec. 11,
1897

54 Barrett, C. R., Whitehill Hall, Chester-le-Street S. Nov. 7, 1874
A.M. Aug. 7, 1880
M. Dec. 11, 1886

55* Bartholomew, C. W., Blakesley Hall, near Towcester Dec. 4, 1875

56 Bates, Sidney, Mickley Colliery Offices, Stocksfield-upon-Tyne A. Feb. 8, 1890
M. June 8, 1895

57 Bates, Thomas, The Grange, Prudhoe-upon-Tyne Feb. 9, 1895

58 Bates, Thomas L., Government Inspector of Collieries, Hamilton, Newcastle,
New South Wales Feb. 12, 1898

59 Batey, John, Newbury Collieries, Coleford, Bath Dec. 5, 1868

60 Baumgartner, W. O., South Hetton, Sunderland S. Sept. 6, 1879
M. Aug. 3, 1889

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Date of Election and Transfer.

61 Bawden, James Barnet, Pillar House, Keswick, Cumberland Dec. 11, 1897

62 Bawden, William John, New Bultfontein Diamond Mining Company, Limited,
Beaconfield, South Africa Oct. 14, 1899

63 Bayldon, Daniel Henry, New Zealand Mines Trust, Limited, Mutual Life
Buildings, Martin Place, Sydney, New South Wales Feb. 8, 1890

64 Bell, Sir Lowthian, Bart., D.C.L., F.R.S., Rounton Grange, Northallerton
(Past-President, Member of Council) July 6, 1854
65 Bell, George Fred., H.M. Inspector of Mines, 20, Wentworth Place, Newcastle-upon-Tyne (Member of Council) S. Sept. 6, 1879
A.M. Aug. 6, 1887
M. Aug. 3, 1889
66 Bell, Walter, c/o Pyman, Bell and Company, Hull S. Oct. 8, 1889
M. Feb. 10, 1894
67 Bennett. Alfred H., Dean Lane Collieries, Bedminster, Bristol A.M. April 10, 1886
M. June 8, 1889
68 Bennett, Henry, Rio Tinto Mines, Huelva, Spain Dec. 9, 1889
69 Benson, J. G., 12, Grey Street, Newcastle-upon-Tyne Nov. 7, 1874
70 Benson, T. W., 24, Grey Street, Newcastle-upon-Tyne (Vice-President, Member of Council) Aug. 2, 1866
71 Berkley, C., Marley Hill, Swalwell, R.S.O., Co. Durham Aug. 21, 1852
72 Berkley, Frederick, Hamsterley Collieries, Ebchester, R.S.O., Co. Durham A.M. Dec. 9, 1882
M. June 8, 1889
73 Berkley, R. W., Marley Hill, Swalwell, R.S.O., Co. Durham S. Feb. 14, 1874
A.M. Aug. 7, 1880
M. June 8, 1889
74 Beynon, J. C. S., P.O. Box 1364, Johannesburg, Transvaal June 10, 1893
75 Bibby, William, Raub Australian Gold Mining Company, Limited, Raub, Pahang, Malay Peninsula Jan. 19, 1895
76 Bigg-Wither, Harris, The Mount, Gathurst, near Wigan, Lancashire Jan. 19, 1895
77 Bigland, J., Henknowle, Bishop Auckland June 3, 1857
78 Binks, John Charles, Norchard Colliery, Lydney, Gloucestershire April 28, 1900
79 Bishop, James, Grey Valley Coal Company, Brunnerton, Greymouth, New Zealand April 13, 1889
80 Black, W., Lovaine House, Lovaine Place, Newcastle-upon-Tyne April 2, 1870
81 Blackburn, William Stevenson, Aire Villas, Astley, Woodlesford, near Leeds Dec. 10, 1887
82 Blackett, W. C, Acorn Close, Sacriston, Durham (Member of Council) S. Nov. 4, 1876
A.M. Aug. 1, 1885
M. June 8, 1889
83 Blakemore, W., Fernie, British Columbia Oct. 12, 1895
84 Bolam, Philip, Seaton Burn Colliery, Newcastle-upon-Tyne A. Dec. 12, 1891
M. Aug. 3, 1895
85 Bolton, Edgar Ormerod, Executor of Colonel Hargreaves, Colliery Offices, Burnley April 12, 1890
86 Bolton, H. H., Newchurch Collieries, near Manchester Dec. 5, 1868
87 Borlase, W. H., Greenside Lodge, Glenridding, near Penrith Aug. 4, 1894
88 Boucher, A. S., Kempsey House, near Worcester Aug. 4, 1883
89*Bracken, Thomas Wilson, Government Railway, Lagos, West Africa Oct. 14, 1899
90 Bradford, George, Newton House, Darlington Oct. 11, 1890
91 Bramwell, Hugh, Great Western Colliery, near Pontypridd, Glamorganshire S.Oct. 4, 1879
A.M. Aug. 6, 1887  
M. Aug. 3, 1889  
92 Braschi, Victor M., Bajos de Portacoeli, No. 11, Apartado 830, City of Mexico, Mexico A.M. Feb. 12, 1898  
M. Aug. 6, 1898  
93 Breakell, John E., La Mina "Estrella" de Bolivar, Ibaque, Tolima, Republic of Colombia, South America. Transactions sent to Brassington-by-Wirksworth, Derbyshire April 25, 1869  

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Date of Election and of Transfer.  
94 Breakell, Thomas, Brassington, near Derby Feb. 11, 1893  
95 Breckon, J. R., 32, Norfolk Street, Sunderland Sept. 3, 1864  
96 Breidenbach, Theodore, The Toronto and Western Mines Development Company, Sirdar Mine, P.O. Box 151, Rat Portage, Ontario, Canada Dec. 10, 1898  
97 Brewer, William Morten, 28, Broad Street, P.O. Box 130, Victoria, British Columbia April 2, 1898  
98 Britten, T. J., P.O. Box 494, Johannesburg, Transvaal June 21, 1894  
99 Broad, Wallace, P.O. Box 283, Bulawayo, Rhodesia, South Africa April 28, 1900  
100 Broja, Geheimer Bergrath Richard, 77, Kaiser-Wilhelm-strasse, Breslau, Germany Nov. 6, 1880  
101 Bromly, A. H., 18, Eldon Street, London, E.C. Nov. 24, 1894  
102 Broome, George Herbert, The Westport Cardiff Coal Company, Limited, Seddonville, via Westport, New Zealand Oct. 9, 1897  
103*Brough, Bennett H., Cranleigh House, Woodham, near Addlestone, Surrey A.M. Dec. 10, 1887  
M. June 8, 1889  
104 Brough, Thomas, New Seaham Colliery, Sunderland S. Feb. 1, 1873  
A.M. Aug. 2, 1879  
M. June 8, 1889  
105 Brown, Archibald T., 372, Flinders Lane, Melbourne, Australia Aug. 5, 1893  
106 Brown, Douglas Philip, Oakley, Carysfort Road, Boscombe June 11, 1898  
107 Brown, M. Walton, 10, Lambton Road, Newcastle-upon-Tyne (Secretary, Member of Council) S. Oct. 7, 1871  
M. Aug. 3, 1878  
108 Brown, Thomas Forster, Guildhall Chambers, Cardiff (Vice-President, Member of Council) Aug. 1, 1861  
109 Brown, Westgarth Forster, Fairview, Dynas Powis, near Cardiff S. Aug. 6, 1887  
M. Aug. 5, 1893  
110 Browning, John Samuel, Nelson, New Zealand April 2, 1898  
111 Bruce, John, Port Mulgrave, Hinderwell, R.S.O., Yorkshire S. Feb. 14, 1874  
A.M. Aug. 7, 1880  
M. June 8, 1889  
112 Bryham, W., Douglas Bank Collieries, Wigan Aug. 3, 1865  
113 Buckle, Christopher Ernest, c/o T. T. Leonard, 4, Gordon Avenue, Bangalore, Mysore Province, South India Feb. 10, 1900  
114 Buglass, J., Stobswood, via Acklington, Northumberland A. Dec. 10, 1892  
M. Aug. 3, 1895  
115 Buikley, F. Groendycke, Denver, Colorado, U.S.A. Oct. 12, 1895
Feb. 13, 1892
117 Bulman, H. F., Barcus Close, Burnopfield, R.S.O., Co. Durham (Member of Council)  
A.M. Aug. 6, 1881  
M. June 8, 1889
118 Bunkell, Henry B., P.O. Box 1463, Johannesburg, Transvaal  
April 8, 1893
119 Bunning, C. Z., c/o Borax Consolidated, Limited, Constantinople, Turkey  
S. Dec. 6, 1873  
A.M. Aug. 5, 1882  
M. Oct. 8, 1887
Feb. 9, 1889
121*Burn, Frank H., Carlton House, Newcastle-upon-Tyne  
S. Feb. 9, 1889  
A. Aug. 4, 1894  
M. Aug. 3, 1895
122 Burnett, Cuthbert, Grange Iron Works, Durham  
June 8, 1895
123*Burns, David, Vallum View, Burgh Road, Carlisle  
May 5, 1877
124 Burrows, J. S., Green Hall, Atherton, near Manchester  
S. Oct. 11, 1873  
M. Aug. 4, 1877
125 Butt, Thomas Philip Edward, P.O. Box 538, Johannesburg, Transvaal  
Dec. 11, 1897
126 Butters, Charles, 20, Bishopsgate Street Within, London, E.C.  
Feb. 10, 1894
127 Cameron, Ian, The Tharsis Sulphur and Copper Company, Limited. 135, West George Street, Glasgow  
Aug. 4, 1894

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Date of Election and of Transfer.
128 Campbell, H. H., Sutton Hall, St. Helen's, Lancashire  
Jan. 19, 1895
129 Campbell, The Rev. Joseph, Te Aroha, New Zealand  
A.M. Dec. 12, 1896  
M. Feb. 13, 1897
130 Campbell-Johnston, R. G, Nelson, British Columbia  
Nov. 24, 1894
131*Candler, T. E., East Lodge, Crook, Co. Durham  
S. May 1, 1875  
A.M Aug. 4, 1883  
M. June 8, 1889
132 Carnes, Charles Spearman, Cornwall House, Murton Colliery, Sunderland  
Aug. 1, 1891
133 Carr, T., Lilywhite Terrace, Four Lane Ends, Hetton-le-Hole, R.S.O., Co. Durham  
Feb. 10, 1894
134 Chalmers, J. A., c/o J. S. Sheldrick, 96, Gresham House, Old Broad Street, London, E.C Dec. 9, 1893
135 Chambers, J. S., Little Italianskaja, No. 5, St. Petersburg, Russia  
Oct. 10, 1896
136 Chandle, Charles, P.O. Box 221, Coolgardie, Western Australia  
S. Nov. 6, 1880  
A. Aug. 3, 1889  
M. Dec. 12, 1896
137 Channing, J. Parke, 34, Park Place, New York City, U.S.A  
April 25, 1896
138 Charleton, A. G, 5, Avonmore Road, Kensington, London, W.  
Aug. 6, 1892
139 Charlton, William, Guisbrough, Yorkshire  
Feb. 12, 1898
Charlton, William, Linares, Provincia de Jaen, Spain  April 8, 1893
Charlton, William John, Ashington Colliery, Morpeth, Northumberland  April 25, 1896
Cheesman, E. Taylor, Claravale Colliery, Ryton-upon-Tyne  A. Aug. 2, 1890
Cheesman, Herbert, Hartlepool Aug. 6, 1892
Cheesman, I. T., Throckley Colliery, Newcastle-upon-Tyne  Feb. 1, 1873
Childe, Henry S., 59, Westgate, Wakefield  A.M. Feb. 12, 1887
Claghorn, Clarence R., Vintondale, Cambria County, Pennsylvania, U.S.A.  Aug. 5, 1899
Clark, Henry, Cowper House, Norton, Stockton-upon-Tees  April 8, 1899
Clark, Robert, Hyderabad Deccan Company, Limited, Secunderabad, India  Feb. 15, 1896
Clark, R. B., Springwell Colliery, Gateshead-upon-Tyne  S. May 3, 1873
Clark, R. B., Springwell Colliery, Gateshead-upon-Tyne  M. Aug. 4, 1877
Clark, William, Cranbury Lodge, Park Lane, Wigan  Dec. 10, 1898
Claudet, Arthur C, 6 and 7, Coleman Street, London, E.C.  Aug. 3, 1895
Clifford, William, 232, Fifth Avenue, Pittsburg, Pennsylvania, U.S.A.  Feb. 9, 1895
Clough, James, Balmarsund House, Balmarsund, Bedlington, R.S.O., Northumberland  S. April 5, 1873
A.M. Aug. 3, 1878
M. June 8, 1889
Cochrane, B., Aldin Grange, Durham  Dec. 6, 1866
Cochrane, W., St. John's Chambers, Grainger Street West, Newcastle-upon-Tyne (Past-President, Member of Council)  Aug. 1, 1861
Coghlan, F. M., Catorce, S.L.P., Mexico  Dec. 9, 1893
Collins, Arthur Launcelot, 14 and 15, Broad Street Avenue, London, E.C  Feb. 13, 1892
Collins, Horatio, Paarl Central Gold Mining and Exploration Company, Limited, P.O. Box 245, Johannesburg, Transvaal  Aug. 4, 1894
Collins, H. B., 121, West George Street, Glasgow  April 14, 1894
Collins, William Francis, P.O. Box 170, Coolgardie, Western Australia  April 10, 1897
Colquhoun, A. J., School of Mines, Vancouver, British Columbia  A.M. July 14, 1896
M. Dec. 10, 1898
Colquhoun, T. Grant, Beal Bank House, Acklington, Northumberland  Dec 14, 1889

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Date of Election and of Transfer.
Commans, R. E., 6, Queen Street Place, London, E.,C.  Nov. 24, 1894
Cook, J. Watson, Binicteh Hall, Bishop Auckland  Oct. 14, 1893
Cooke, Gervase, No. 1, The Bund, Shanghai, China  June 11, 1898
170 Cooke, Henry Moore Annesley, The Ooregum Gold Mining Company of India, Limited, Oorgaum, Province of Mysore, India Dec. 12, 1896

171 Corbett, V. W., Chilton Moor, Fence Houses Sept. 3, 1870
172 Corbould, W. H., P.O. Box 796, Rossland, British Columbia, w/a New York June 8, 1895
173 Corlett, George Stephen, Wigan Dec. 12, 1891
174 Coulson, F., 10, Victoria Terrace, Durham S. Aug. 1, 1868 M. Aug. 2, 1873
175 Coulthard, Francis, Brighton Villa, Hensingham Road, Whitehaven June 8, 1889
176 Coulthard, John, Brunnerton, Greymouth, New Zealand April 8, 1899
177 Cowper-Coles, Sherard Osborn, Grosvenor Mansions, Victoria Street, Westminster, London, S.W. Dec. 9, 1899

178 Cox, John H 10, St. George's Square, Sunderland Feb 6, 1875
179 Crankshaw, Joseph, Montcliffe, Horwich, near Bolton Aug. 5, 1899
180 Craven, Hiram, Jun., Sunderland April 12, 1890
181 Craze, James Mayne, Coolgardie, Western Australia Aug. 7, 1897
182 Crighton, John, Bramhall House, Hazel Grove, Stockport June 11, 1898
183 Crone, Charles Herbert, Killingworth, near Newcastle-upon-Tyne Oct. 14, 1899
184 Crone, J. R., Tudhoe House, via Spennymoor Feb. 1, 1868
185 Crookston, Andrew White, 188, St. Vincent Street, Glasgow Dec. 14, 1895
186 Cross, John, 77, King Street, Manchester June 5, 1869
187 Croudace, C. J., Pendre House, Holywell, North Wales Nov. 2, 1872
188 Croudace, Thomas, Lambton Lodge, Lambton, Newcastle, New South Wales Nov. 6, 1862
189 Currie, Walter, P.O. Box 220, Bulawayo, Rhodesia, South Africa April 25, 1896
190 Curry, Michael, Cornsay Colliery, Durham Aug. 6, 1898
191 Cutten, William Henry, Dunedin, New Zealand Aug. 5, 1899
192 Daglish, John, Rothley Lake, Cambo, R.S.O., Northumberland (Past-President, Member of Council) Aug. 21, 1852

193 Daglish, William Charlton, Littleburn Colliery, near Durham Dec. 12, 1896
195 Dale, Sir David, Bart., West Lodge, Darlington Feb. 5, 1870
196 Dan, Takuma, c/o Mitsui Mining Company, No. 9, Yamashiro-cho, Tokio, Japan April 14, 1894
197 Daniel, Peter Francis, Greymouth, New Zealand April 8, 1893
198 Darby, J. H., Pen y Garth, Brymbo, Denbighshire Feb. 9, 1895
199 Darling, Fenwick, South Durham Colliery, Darlington Nov. 6, 1875
200 Darlington, James, Black Park Colliery, Ruabon, North Wales S. Nov. 7, 1874 M. Aug. 4, 1877
201 Davey, George, Waitekauri Gold Mining Company, Waitekauri, Auckland, New Zealand June 10, 1893
202 Davey, Henry, 3, Princes Street, Westminster, London, S. W. Oct. 11, 1873
203 Davies, David, Cowell House, Llanelli, South Wales Dec. 9, 1899
204 Davies, Thomas George, Barrytown, New Zealand Aug. 5, 1899
Date of Election
and of Transfer.
205 Davis, Kenneth, Dudley Colliery, Northumberland April 13, 1889
206 Davison, J. Ford, Thorn Bank, Haydock, near St. Helen's, Lancashire
Oct. 13, 1894
207 Daw, Albert William, 11, Queen Victoria Street, London. E.C. June 12,
1897
208 Daw, John, Jun., Brooklands, Rosemont Road, Acton, London, W.
Dec. 14, 1895
209 Dees, J. Gibson, Floraville, Whitehaven Oct. 13, 1883
210 Dees, R. R., Newcastle-upon-Tyne Oct. 7, 1871
211 Delmas, Julian R., Success Villa, Assensole, Bengal, India Oct. 14, 1899
213 Denny, G. A., 43, Mansion House Chambers, Adderley Street, Cape Town, South Africa Dec. 8, 1894
215 Dewhurst, John Hubert, Grove House, Walton-le-Dale, Preston, Lancashire April 2, 1898
216 Dickinson, Arthur, Warham Road, South Croydon, Surrey April 14, 1894
217 Dietzsch, Ferdinand, 13, Austin Friars, London, E.C. Aug. 5, 1899
219 Dixon, John, Merewether, Newcastle, New South Wales Feb. 12, 1898
221* Dixon, James S., Fairleigh, Bothwell, N.B. Aug. 3, 1878
222 Dixon, R., Sankey Wire Mills and Ropeworks, Warrington June 5, 1875
223 Dixon, William, Cleator, Cumberland April 10, 1897
224 Dobb, T. G., Brick House, West Leigh, near Manchester Dec. 8, 1894
225 Dobbs, Joseph, Jarrow Colliery, Castlecomer, Co. Kilkenny April 14, 1894
226 Dodd, Benjamin, Bearpark Colliery, near Durham S. May 3, 1868
M. Aug. 1, 1868
227 Dodd, M., Lemington Hall, Lemington-upon-Tyne S. Dec. 4, 1875
A. M. Aug. 7, 1880
M. June 8, 1889
228 Dodd, Thomas Robert, Woodford Grange, Thrapston June 13, 1896
229* Donkin, W., Witbank Colliery, Per Special Post Bag, via Pretoria, South Africa S. Sept. 2, 1876
A. M. Aug. 1, 1885
M. June 8, 1889
230* Douglas, C. P., Thornbeck Hill, Carmel Road, Darlington March 6, 1869
231 Douglas, James, 99, John Street, New York City, U.S.A. Oct. 14, 1899
M. Aug. 3, 1885
233 Douglas, T., The Garth, Darlington (Past-President, Member of Council) Aug. 21, 1852
234 Dowdeswell, H., Grosvenor Gardens, Newcastle, Staffordshire S. April 5, 1873
M. Aug. 7, 1875
235 Doyle, Patrick, Indian Engineering, 7, Government Place, Calcutta, India. Transactions sent to c/o F. E. Robertson, 8, Great George Street, Westminster, London, S. W. A.M. March 1, 1879
M. Aug. 3, 1889
236 Draper, David, P.O. Box 3517, Johannesburg, Transvaal Feb. 15, 1896
238 Dumat, Alfred, Pietermaritzburg, Natal, South Africa April 8, 1893
239 Dyson, T. Ingleby Feb. 9, 1895
240 Eastlake, Arthur W., Caenwood House, Grove Road, Clapham Park, London, S.W. June 11, 1892
241 Ede, Francis J., Silchar, Cachar, India Aug 1., 1896
242 Ede, Henry Edward, 251, School Road, Crookes, Sheffield July 14, 1896
243 Eden, C. H., c/o Vivian and Sons. Swansea June 14., 1890
244 Edge, J. H., Coalport Wire Rope and Chain Works, Shifnal, Salop A.M. Sept. 7, 1878
M. Aug. 3, 1889
245 Edgecombe, Alfred S., Rossland, British Columbia Dec. 10, 1898
246 Edwards, Edward, Maindy Pit, Ocean Coal Company, Ton Pentre, South Wales Feb. 9, 1895

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Date of Election and of Transfer.
247 Edwards, Telford, Tati, Matabeleland, South Africa ; and 1, Bradenham Place, Penarth, South Wales Dec. 12, 1896
248 Eissler, M., 46, Rue Vital, Passy, Paris Feb. 15, 1896
249 Ellis, W. R., Wigan June 1, 1878
250 Elwen, Thomas Lee, Brandon Colliery, Durham Oct. 13, 1888
251 Embleton, H. C. Central Bank Chambers, Leeds April 14, 1894
252 Embleton, T. W., The Cedars, Methley, Leeds S. Sept. 2, 1865
M. Aug. 1, 1868
253 Engel, Konrad Ernst Richard, Linden Allee, 67, Essen (Ruhr), Germany April 28, 1900
254 English, John, Garesfield Colliery, High Spen, Lintz Green, R.S.O., Co. Durham Dec. 9, 1899
256 Esuman-Gwira, John Buckman, Cape Coast Castle, West Africa April 2, 1898
257 Etherington, J., 39a, King William Street, London Bridge, London, E.C. Dec. 9, 1893
258 Evans, Lewis, Castle Hotel, Howick, Natal, South Africa Oct. 14, 1893
Everard, J. B., 6, Millstone Lane, Leicester    March 6, 1869
Fairley, James, Craghead and Holmside Colliery, Chester-le-Street  A.M. Aug. 7, 1880
M. Aug. 3, 1889
Fenwick, Barnabas, 37, Osborne Road, Newcastle-upon-Tyne  Aug. 2, 1866
Fergie, Charles, Drummond Colliery, Westville, Nova Scotia  Dec. 9, 1893
Ferguson, C, Walbottle Colliery, Scotswood-upon-Tyne  Feb. 12, 1898
Ferguson, D., c/o James Ferguson, 140, Hyndland Drive, Kelvinside, Glasgow  A.M. Dec. 8, 1883
M. Aug. 3, 1889
Ferguson, James, P.O. Box 253, Johannesburg, Transvaal Dec. 12, 1896
Fernau, John JamesConstant, Nenthead House, by Alston, Cumberland  Dec. 10, 1898
Figari, Alberto, Apartado, 405, Lima, Peru  April 25, 1896
Fisher, Edward R., Blaina Lodge, Llandebie, R.S.O., Carmarthenshire  A.M. Aug. 2, 1884
M. Aug. 3, 1889
Fletcher, James, Whickham and Bullock Island Coal Company, Limited, Carrington, New South Wales  Dec. 9, 1893
Fletcher. Lancelot, Brigham Hill, Cockermouth A.M. April 14, 1888
M. June 8, 1889
Fletcher, Leonard Ralph, The Hindles, Atherton, near Manchester  Aug. 5, 1899
Fletcher, Walter, The Hollins, Bolton, Lancashire  Dec. 14, 1895
Flint, John, Broomhill Colliery, Acklington, Northumberland  Jan. 19, 1895
Ford, Mark, Bedlington Colliery, Bedlington, R.S.O., Northumberland  Aug. 3, 1895
Ford, Stanley H., P.O. Box 38, Krugersdorp, South African Republic  June 10, 1893
Forrest, J. C, Holly Bank Colliery, Essington, Wolverhampton  April 12, 1884
Forster, G. B., 3, Eldon Square, Newcastle-upon-Tyne. Transactions sent to Farnley Hill, Corbridge-upon-Tyne (Past-President, Member of Council)  Feb. 5, 1857
Forster, John Henry Bacon, Cramlington Colliery, Northumberland  S. Nov. 24, 1894
A. Aug. 7, 1897
M. Feb. 10, 1900
Forster, Thomas E., 3, Eldon Square, Newcastle-upon-Tyne  (Member of Council)  S. Oct. 7, 1876
A.M. Aug. 1, 1885
M. June 8, 1889

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Date of Election
and of Transfer.
282 Fowler, R., Washington Colliery, Washington Station, R.S.O., Co. Durham  
Nov. 24, 1894

283 Frecheville, William, North Breach Manor, Ewhurst Surrey  
Feb. 15, 1896
284 Frossard, J. D., Orthes, Basses Pyrenees, France  
Dec. 14, 1895
285 Fryar, John William, Job's Hill, Crook, via Darlington  
A. June 14, 1890  
M. June 12, 1897
286 Fryar, Mark, Denby Colliery, Derby  
S. Oct. 7, 1876  
A.M. Aug. 4, 1883  
M. June 8, 1889
287 Fryar, William, Inspector of Mines, Brisbane, Queensland, Australia  
April 10, 1897
288 Galloway, T. Lindsay, 43, Mair Street, Plantation, Glasgow  
Sept. 2, 1876
289 Galloway, William, Cardiff  
April 23, 1887
S. Oct. 2, 1880  
M. Oct. 10, 1891
291 Gardiner, E. T., 8, South View Terrace, Bishop Auckland  
Dec. 8, 1894
292 Geddes, George H., 21, Young Street, Edinburgh  
Oct. 1, 1881
293 Gerrard, James, 9, Meek Buildings, Wigan  
S. March 1, 1873  
A.M. Aug. 2, 1879  
M. June 8, 1889
294 Gerrard, John, H.M. Inspector of Mines, Worsley, Manchester  
S. March 5, 1870  
M. Aug. 1, 1874
295 Gifford, Henry J., Minas de Passagem, Ouro Preto, Brazil  
Oct. 14, 1893
296 Gilchrist, J. R., Garesfield Colliery, Lintz Green. Newcastle-upon-Tyne  
S. Feb. 3, 1877  
A.M. Aug. 1, 1885
297 Gill, Hugh Llewellyn, c/o Bennie, Teare and Company, Woodward Street,  
Coolgardie, Western Australia  
April 8, 1899
298 Gillman, F., Gartenstrasse, 1, Freiburg im B, Baden, Germany  
A.M. Dec. 8, 1894
M. June 8, 1895
299 Gipps, F. G. de Visme, Pirie Buildings, Broken Hill, New South Wales  
April 25, 1896
300*Gledhill, Edward, Altona, Parkwood Road, Pokesdown, Bournemouth  
Dec. 9, 1893
301 Goerz, A., Manor House, St. John's Wood Park, London, N.W.  
April 14, 1894
302 Goldsworthy, Arthur, Linares, Provincia de Jaen, Spain  
Aug. 3, 1895
303 Goldsworthy, Christopher, Almodovar del Rio, Provincia de Cordoba, Spain  
June 12, 1897
304 Goodwin, William Lawton, School of Mining, Kingston, Ontario, Canada  
Feb. 11, 1899
305 Golden, Walter T., c/o Easton, Anderson and Golden, Limited, 2, St. Nicholas' Buildings, Newcastle-upon-Tyne  
Aug. 6, 1892
306 Gore, Henry, Victorian Gold Estates, Limited, 395, Collins Street, Melbourne, Victoria, Australia  
April 28, 1900
307 Gouldie, Joseph, The Gill, Bromfield, Brayton, S.O., Cumberland  
Aug. 5, 1893
308 Graham, Edward, Jun., Bebside, Northumberland  
Aug. 1, 1896
309 Greaves, J. O., Westgate, Wakefield  
Aug. 7, 1862
310  Greener, George Alfred, Netherton Hall Colliery, Newcastle-upon-Tyne  
    Feb. 10, 1900
311  Greener, Henry, South Pontop Colliery, Annfield Plain, R.S.O., Co. Durham  
    A.M. Dec. 9, 1882
    M. Aug. 3, 1889
312  Greener, T. ST., West Lodge, Crook, Darlington  S. July 2, 1872
    M. June 8, 1889
313  Greenwell, G. C, Jun., Poynton, near Stockport  S. March 6, 1869
    M. Aug. 3, 1872
314  Gregorie, Charles, Aberdare, South Wales  Oct. 9, 1897
315  Gregson G. Ernest, 11, Chapel Street, Preston, Lancashire  A.M. Dec. 8, 1894
    M. Feb. 9, 1895

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    Date of Election
and of Transfer.
    M. Aug. 3, 1889
317  Grey, C. G., Ballycourcy, Enniscorthy, Co. Wexford  May 4, 1872
318  Grey, Frederick William, Dashwood House, 9, New  
    Broad Street, London, E.C.  July 14, 1896
319  Griffith, N. Maurice, c/o The Broughton and Plas Power Coal Company, Limited,  
    near Wrexham  S. Nov. 24, 1894
    M. Feb. 11, 1899
320  Griffith, N. R., Plasnewydd, Ruabon, North Wales  Aug. 1, 1867
321  Griffith, William, Waterloo House, Aberystwyth, South Wales  Dec. 9, 1893
322  Grimshaw, E. J., 23, Hardshaw Street, St. Helen's, Lancashire  Sept. 5, 1868
323  Grundy, James, 27, Chowringhee Road, Calcutta, India  June 13, 1896
324  Guthrie, James K., 21, Cleveland Road, North Shields  Aug. 3, 1889
325  Haddock, W. T., Sutherland Reef, Limited, Leydsdorp,  
    Zoutpansberg, South African Republic  S. Oct. 7, 1876
    A.M. Aug. 1, 1885
    M. June 8, 1889
326  Haehner, Paul, Bilbao, Spain  April 28, 1900
327  Haggie, D. H, Wearmouth Patent Rope Works, Sunderland  March 4, 1876
328  Haggie, Peter Sinclair, Gateshead-upon-Tyne  A.M. April 14, 1883
    M. Aug. 3, 1889
329  Hague, Ernest. Castle Dyke, Sheffield  S. March 2, 1878
    M. Aug. 3, 1878
330  Hair, Thomas Chicken, Bede House, Hebburn-upon-Tyne  Dec. 9, 1899
331  Halbaum, Henry Wallace Gregory, 12, Kelvin Grove, Gateshead-upon-Tyne  
    April 8, 1899
332  Halder, Albert H., 1500, Robson Street, Vancouver, British Columbia  
    April 8, 1893
333  Hall, Frederick, Fernleigh, Highfield, Workington  Oct. 14, 1893
334  Hall, Fred. W., Tamworth Colliery, Alvecote, near Tamworth  S. June 8, 1889
    M. Feb. 10, 1894
335  Hall, George William, Coolgardie, Western Australia  Dec. 12, 1896
336  Hall John Charles, Pegswood Colliery, near Morpeth  A. Dec. 14, 1889
M. Aug. 3, 1895
337 Hall, M., Lofthouse Station Collieries, near Wakefield Sept. 5, 1868
338 Hall, M. S., 8, Victoria Street, Bishop Auckland Feb. 14, 1874
339 Hall, William F., Haswell Colliery, Easwell, via Sunderland May 13, 1858
340 Hallas, G. H., Huyton, near Liverpool S. Oct. 7, 1876
A.M. Aug. 4, 1883
M. June 8, 1889
341 Hallimond, William Tasker, c/o Mrs. Hallimond, Oakdene, Seapoint, Cape Town, South Africa Dec. 14, 1889
342 Halse, Edward, c/o Senores Marcelino Restrepo y Cia, Medellin, Republic of Colombia, South America A.M. June 13, 1885
M. Aug. 3, 1889
343 Hamilton, E., Rig Wood, Saltburn-by-the-Sea S. Nov. 1, 1873
A.M. Aug. 2, 1879
M. June 8, 1889
344 Hancock, H. Lipson, Moonta Mines, South Australia Dec. 14, 1895
345 Hancock, H. R., Ivymeade, Burnside, South Australia A.M. Aug. 4, 1894
M. Nov. 24, 1894
346 Hann, Robert, Jun., 42, Eglinton Street, Sunderland Oct. 14, 1899
347 Hannah, David, Brynderwen, Ferndale, South Wales Feb. 9, 1895
348 Hare, Samuel, Bedlington Collieries, Bedlington, R.S.O., Northumberland S. Aug. 2, 1879
M. Aug. 1, 1891
349 Harle, Peter, Page Bank Colliery, Co. Durham Oct. 8, 1892
350 Harle, Richard, Browney Colliery, Durham April 7, 1877
351 Harris, G. E., Margherita, Debrugarh, Upper Assam Feb. 10, 1894
352 Harris, Howard, P.O. Box 16, Dundee, Natal, South Africa Aug. 7, 1897
353 Harris, W. S., Kibblesworth, Gateshead-upon-Tyne S. Feb. 14, 1874
A.M. Aug. 7, 1880
M. June 8, 1889
354 Harrison, C. A., North Eastern Railway, Newcastle-upon-Tyne June 21, 1894

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Date of Election and of Transfer.
355 Harrison, G. B., Swinton, near Manchester Aug. 6, 1892
356 Harrison, Jonathan, Kimihia, Auckland, New Zealand June 8, 1895
357 Harrison, W. B., Brownhills Collieries, near Walsall April 6, 1867
358 Harvey, James Andrew, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne June 11, 1898
359 Haselden, Arthur, Linares, Provincia de Jaen, Spain A.M. Dec. 11, 1897
M. April 2, 1898
360 Haselden, Eugene Kinnaird, Jardines No. 3, La Carolina, Provincia de Jaen, Spain A.M. Dec. 11, 1897
M. June 11, 1898
361 Hawker, Edward William, 8, Alma Chambers, Off Grenfell Street, Adelaide, South Australia Oct. 12, 1895
362 Hay, J., Jun., Widdrington Colliery, Acklington S. Sept. 4, 1869
M. Aug. 4, 1874
363 Hedley, J. L., H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne (Vice-President, Member of Council) S. Feb. 5, 1870
M. Aug. 2, 1873
364 Hedley, Septimus H, Langholme, Roker, Sunderland S. Feb. 15, 1876
A.M. Aug. 1, 1885
M. Aug. 3, 1889
365 Hedley, William, Ouston House, Chester-le-Street Feb. 13, 1897
366 Heinez, F. A., Trail, British Columbia Dec. 11, 1897
367 Henderson, Charles, Cowpen Colliery, Blyth, Northumberland Dec. 9, 1899
368 Henderson, Joseph J., P.O. Box 28, Brooklyn, New York, U.S.A. June 13, 1891
370 Hepburn, Wheldon, Littletown Colliery, near Durham Aug. 3, 1895
371 Heppell, T., Leafield House, Birtley, Chester-le-Street Aug. 6, 1863
373 Heslop, C, Woodside, Marske Mill Lane, Saltburn-by-the-Sea S. Feb. 1, 1868
M. Aug. 2, 1873
374 Heslop, Grainger, Deptford Hall, Sunderland Oct. 5, 1872
375 Heslop, Michael, Rough Lea Colliery, Willington, Co. Durham A. Feb. 10, 1894
M. June 21, 1894
376 Heslop, Septimus, New Beerbroom Coal Company, Limited, Asansol, Bengal, India Oct. 12, 1895
377 Heslop, Thomas, Randolph Colliery, Evenwood, Bishop Auckland S. Oct. 2, 1880
A.M. Aug. 4, 1888
M. Aug. 3, 1889
378 Heslop, William Taylor, South African Collieries, Dundee, Natal, South Africa Aug. 3, 1895
379 Hewitson, Thomas, Ivanhoe Gold Corporation, Limited, Boulder, Western Australia Dec. 9, 1899
380* Hewitt, G. C., Serridge House, Coalpit Heath, near Bristol June 3, 1871
381 Hewlett, A., Haseley Manor, Warwick March 7, 1861
383 Higson, Jacob, 18, Booth Street, Manchester Aug. 7, 1862
M. Dec. 12, 1896
385 Hill, William, 40, Wellington Road, Edgbaston, Birmingham A.M. June 9, 1883
M. Aug. 3, 1889
386* Hilton, J., Woodcock Hall, Newburgh, near Southport S. Dec. 7, 1867
M. Aug. 6, 1870
387 Hilton, Robert Stuart, Thorn Lea, St. Ann's, St. Helen's, Lancashire April 28, 1900
390 Hodge, Francis, Coromandel, near Auckland, New Zealand April 14, 1894
391 Hodgson, Jacob, Cornsay Colliery, Co. Durham June 8, 1895
392 Hoffman, Charles, Per Private Bag, P.O. Box 1022, Johannesburg, Transvaal June 13, 1896
Date of Election
and of Transfer.
394  Holberton, Walter Twining, Copiapo, Chile       June  9, 1900
395  Holliday, Martin F., Langley Grove, Durham      May  1,1875
396  Hollings, James Spencer, Brymbo, near Wrexham    Oct.  14, 1899
397  Holms, Henry William, Fairfield, Darlington     June  8,1889
398  Holman, Frederick John, The Grove, Walton-le-Dale, Preston, Lancashire Dec. 9, 1899
399  Holt, John, Jun., Exchange Buildings, 6, St. Mary's Gate, Manchester Aug.  5, 1893
400  Homersham, Thomas H. C, Vulcan Iron Works, Thornton Road, Bradford Aug.  6,1898
401  Hood, A., 6, Bute Crescent. Cardiff             May  2,1861
402  Hooper, Edward, c/o Bewick, Mooreing and Company, Broad Street House, New Broad Street, London, E.C. A.M. June  4, 1881
        M. April 14, 1894
403  Hooper, G. C, P.O. Box 38, Klerksdorp, South African Republic A.M. Aug.  4, 1894
        M. Oct.  13, 1894
404  Hope, Edmund Louis, Dandot, Ichelum, Punjaub, India Oct.  9, 1897
406  Hopkins, Gerald, British Columbia Bullion Extracting Company, Silica, Rossland, British Columbia Feb. 10, 1900
407  Horswill, Frederick J., 1218, Chesnut Street, Oakland, California, U.S A. Oct. 14, 1899
408  Hoskold, Carlos A. Lynes, First Engineer, Inspector of the National Department of Mines and Geology, Calle Charcas, 1222, Buenos Aires, Argentine Republic June  8, 1895
409  Hoskold, H. D., Inspector General of Mines of the Argentine Republic, and Director of the National Department of Mines and Geology, Buenos Aires, Argentine Republic April 1, 1871
411  Howes, Frank T., Singareni Collieries, Hyderabad Deccan Company, Limited, Secunderabad, India A. Dec. 10, 1892
        M. Oct.  14, 1893
412  Hudson, James O., Menzies, Western Australia April  2, 1898
414  Hurst, George, 9, Framlington Place, Newcastle-upon-Tyne S. April 14, 1883
        M. Aug.  1, 1891
415  Hutchinson, John William, Willow Lodge, Abram, near Wigan, Lancashire Oct. 14, 1899
416  Hutchinson, R. L., c/o W. Hutchinson and Company, 3, Queen Street, Newcastle-upon-Tyne June 13, 1896
417  Jackson, W. G., High Prestwick, Chiddingfold, Surrey June  7, 1873
418  Jaffrey, Thomas, John Bull Gold Mine, Limited, Ravenswood, Queensland, Australia Dec. 10, 1898
419  Jaffrey, William, 3, Victoria Street, London, S.W. Feb. 13, 1897
420  James, John, The Crown Point Gold Mines, Limited, MacMahon's Reef, New South Wales June 12, 1897
422 Jeffcock, T. W., 18, Bank Street, Sheffield Sept. 4, 1869
423 Jefferson, Frederick, Whitburn Colliery, South Shields Dec. 11, 1897
424 Jenkins, Charles Warren Bowen, Keirawarra, Chatswood, North Sydney, New South Wales Oct. 9, 1897
425 Jenkins, W Ocean Collieries, Treorchy, Glamorganshire Dec. 6, 1897
426 Jeppson, H., 39, North Bailey, Durham S. July 2, 1872
A.M. Aug. 2, 1879
M. June 8, 1889
427 Jobling, John William, Clifton Cottage, Burnley, Lancashire June 13, 1896
428* Jobling, Thomas E., Bebside, Northumberland (Member of Council) S. Oct. 7, 1876
A.M. Aug. 4, 1883
M. June 8, 1889
429* Johns, J. Harry, c/o H. Eckstein and Company, 5, Standard Bank Buildings, Cape Town, South Africa June 21, 1894

Date of Election and of Transfer.
430 Johnson, Algernon Edward, Egerton Street, Wrexham April 25, 1896
431 Johnson, J., York Terrace, Doncaster Road, Stairfoot, near Barnsley March 7, 1874
432 Johnson, W., Hall Garth, Carnforth, Lancashire S. Feb. 14, 1874
A.M. Aug. 2, 1879
M. June 8, 1889
433 Johnston, Duncan Stuart, P.O. Box 116, Johannesburg, Transvaal Feb. 15, 1896
434 Johnston, J. Howard, c/o Backus and Johnston, Lima, Peru, South America Feb. 10, 1894
435 Joicey, W. J., Sunningdale Park, Berkshire March 6, 1869
436 Jones, John Arthur, Gijon, Asturias, Spain April 8, 1893
437 Jones, Jacob Carlos, Bellambi, New South Wales Aug. 6, 1892
438 Jones, Thomas, 1, Princes Street, Great George Street, London, S.W. June 12, 1897
439 Judd, Henry Alexander, Lake View South Gold Mine, Kalgoorlie, Western Australia Oct. 8, 1898
440 Kanda, Reiji, Shikaibetsu Silver and Lead Mines, Yoichi, Hokkaido, Japan A. M. Aug. 4, 1894
M. Nov. 24, 1894
441 Kay, Robert, South Tanfield Colliery, Stanley, R.S.O., Co. Durham Aug. 4, 1894
442 Kayll, A. C, Gosforth, Newcastle-upon-Tyne (Member of Council) S. Oct. 7, 1876
M. Aug. 3, 1889
443 Kayser, H. W. Ferdinand, Launceston, Tasmania Nov. 24, 1894
445 Kellett, Matthew H., St. Helen's Colliery, Bishop Auckland S. April 11, 1891
M. Aug. 3, 1895
446 Kellett, William, Portland Bank, Southport June 1, 1878
447 Kennedy, Prof. George Thomas, King's College, Windsor, Hants County, Nova Scotia A. M. Oct. 10, 1896
M. April 2, 1898
448 Kidd, Thomas, Jun., Linares, Provincia de Jaen, Spain. Transactions sent to c/o Thomas Kidd, 104 Balham Park Road, Balham, London, S.W. Aug. 3, 1895
449 Kirkby, J. W., Kirkland, Leven, Fife Feb. 1, 1873
450 Kirkegaard, Peter, Canadian Goldfields, Limited, Deloro, Hastings County, Ontario, Canada April 28, 1900

451 Kirkup, Austin, Newbottle Colliery, Bunker Hill, Fence Houses S. April 9, 1892
M. June 12, 1897
452 Kirkup, J. P., Burnhope, Manchester April 11, 1891
453 Kirkup, Philip, Leafield House, near Chester de-Street (Member of Council) S. March 2, 1878
A.M. Aug. 7, 1886
M. Aug. 3, 1889
454 Kirton, Hugh, Kimblesworth Colliery, Chester-le-Street S. April 7, 1877
A. M. Aug. 1, 1885
M. June 8, 1889
455 Klauke, Josef, High Green, Tankersley, near Barnsley Feb. 13, 1897
456 Knowles, Robert, Ednaston Lodge, Derby April 10, 1886
457 Kondo, R., 7, Setomoncho, Nihonbashi, Tokio, Japan June 21, 1894
458 Kwang, Kwong Yung, Chinese Engineering and Mining Company, Lin Si Colliery, Tientsin, North China June 8, 1895
459 Lamb, R. O., West Denton, Newcastle-upon-Tyne Aug. 2, 1866
460 Lambert, Farquhar, Apartado, 2025, City of Mexico, Mexico Dec. 9, 1899
461 Lancaster, John, Ashlawn, Rugby March 2, 1865
462 Lancaster, John, Auchenheath, R.S.O., N.B. Sept. 7, 1878
463 Landale, A., Comely Park Place, Dunfermline Dec. 2, 1858
464 Landero, Carlos F. de, c/o Real del Monte Company, P.O. Box 1, Pachuca, Mexico Feb. 15, 1898
465* Laporte, H., 57, Rue de la Concorde, Brussels May 5, 1877
466 Laverick, John Wales, Thornley House, Thornley, R.S.O., Co. Durham A.M. Dec. 9, 1882
M. Aug. 3, 1889

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Date of Election
and of Transfer.
467 Lawn, James Gunson, South African School of Mines, Kimberley, South Africa July 14, 1896
468 Lawrence, H., 7 and 8, Post Office Chambers, Newcastle-upon-Tyne (Member of Council) Aug. 1, 1868
469 Lawrence, H. L., 19, Walpole Terrace, Brighton April 8, 1893
470 Laws, W. G., Town Hall, Newcastle-upon-Tyne Oct. 2, 1880
471 Leach, C. C, Seghill Colliery, Northumberland (Member of Council) S. March 7, 1874
A. M. Aug. 6, 1881
M. Aug. 4, 1883

473 Leck, William, H.M. Inspector of Mines, Cleator Moor, Cumberland Nov. 24, 1894
475 Lewis, H. R., Finsbury Circus Buildings, London, E.C. April 14, 1894
476 Lewis, John Dyer, H.M. Inspector of Mines, 183, Richmond Road, Roath, Cardiff Oct. 9, 1897
477 Lewis, Sir William Thomas, Bart., Mardy, Aberdare Sept. 3, 1864
479 Liddell, J. M., 3, Victoria Villas, Newcastle-upon-Tyne S. March 6, 1875 A.M Aug. 6, 1881 M. June 8, 1889
480 Lindsay, George, Blackett Colliery, Haltwhistle June 10, 1893
481 Lindop, A. B., Westport Coal Company, Limited, Denniston, Westport, New Zealand Dec. 9, 1893
482 Lishman, R. R., Bretby Colliery, Burton-upon-Trent S. June 9, 1883 M. Aug. 1, 1891
484 Lishman, William, Holly House, Witton-le-Wear April 1, 1858
485 Lishman, W. Ernest, Rothbury House, Gosforth, Newcastle-upon-Tyne June 10, 1893
486 Lisle, J., El Bote Mine, Zacatecas, Mexico S. July 2, 1872 A.M. Aug. 3, 1878 M. June 8, 1889
487 Little, Gilbert, Transport Appliance Works, Smethwick, Birmingham April 27, 1895
490 Llewellyn, David Morgan, Glanwern Offices, Pontypool May 14, 1881
492 Lloyd, Herbert, P.O. Box 484, Bulawayo, Rhodesia, South Africa A.M. April 2, 1898 M. Aug. 6, 1898
493 Lockwood, Alfred Andrew, 48, East Street, Faversham, Kent June 12, 1897
494 Logan, William, Langley Park Colliery, Durham Oct. 5, 1867
495 Longridge, Captain Cecil Clement, Swan House, Great Swan Alley, Copthall Avenue, London, E.C. Aug. 1, 1896
496 Longridge, Jethro, Burradon and Hazelrigg Collieries, South Gosforth, Newcastle-upon-Tyne Dec. 14, 1889.
497 Lord, Edward Iveagh, Greymouth, Westland, New Zealand Dec. 12, 1896
499 Louis, Henry, 9, Summerhill Terrace, Newcastle-upon-Tyne (Member of Council) Feb. 15, 1896


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Date of Election
and of Transfer.
501 Lowdon, Thomas, Hamsteels, near Durham Dec. 14, 1889
502 Litpton, Arnold, 6, De Grey Road, Leeds Nov. 6, 1869
503 MacArthur, John S., 45, Renfield Street. Glasgow April 8, 1893
504 MacCabe, H. O., c/o N. K. Ewing, Perth, Western Australia S. Sept. 7,1878
 A.M. Aug. 7,1880
 M. Aug. 3, 1889
505 McCarthy, E. T., c/o Colonel Pigott, Archer Lodge, Charles Road, St. Leonards-on-the-Sea A.M. Oct. 8,1887
 M. Aug. 3,1889
506 McCreath, J., 208, St. Vincent Street, Glasgow March 5,1870
507 Macfarlane, George, Edmonton, Alta, Canada Oct. 14,1899
508 McGeachie, Duncan, West Wallsend, New South Wales Nov. 24,1894
509 Mackintosh, James, Lamancha P.O., Peeblesshire Oct. 12,1895
510 Maclaren, James Malcolm, Assistant Government Geologist, Brisbane, Queensland April 28,1900
511 McMurtrie, George Edwin James, Radstock, near Bath A.M. Aug. 2, 1884
 M. Dec. 12,1891
512 McMurtrie, J., Radstock Colliery, Bath Nov. 7, 1863
513 McNeill, Bedford, 25a, Old Broad Street, London, E.C. Dec. 11,1897
514 Maddison, Thomas R., Dirtcar House, near Wakefield S. March 3,1877
 A.M. Aug. 6,1881
 M. June 8,1889
515 Maddison, W. H. F., The Lindens, Darlington June 14,1890
516 Maling, C. T., Ellison Place, Newcastle-upon-Tyne Oct. 5,1872
517 Mammutt, J. E., 1, Albion Place, Leeds Aug. 3,1865
518 Manning, Arthur Hope, P.O. Box 88, Heidelberg, Transvaal Dec. 11, 1897
519 Markham, G. E., Coundon, Bishop Auckland S. Dec. 4,1875
 A.M. Aug. 7,1880
 M. June 8,1889
520 Marley, J. W., Thornfield, Darlington S. Aug. 1, 1868
 M. Aug. 2,1873
522 Marten, E. B., Pedmore, near Stourbridge July 2,1872
523 Martin, C. W., Newbottle Colliery Offices, Fence Houses Aug. 6, 1892
524 Martin, Henry W., Trewern, Dowlais, Glamorganshire Oct. 9, 1897
525 Mascall, William Henry, Meadow View, Etherley Lane, Bishop Auckland S. Nov. 5, 1892
A. Aug. 7, 1897
M. Feb. 10, 1900
526 Mason, Francis Herbert, Queen Building, Hollis Street, Halifax, Nova Scotia
June 8, 1895
527 Mathieson, Alexander, Hetton Colliery, Carrington, near Newcastle, New South Wales
Nov. 5, 1892
528 Matthews, D. H. F., H.M. Inspector of Mines, Hoole, Chester Nov. 24, 1894
529 Matthews, J., c/o R. and W. Hawthorn, Newcastle-upon-Tyne
A.M. April 11, 1885
M. Aug. 3, 1889
530 Matthews, R. F., Harehope Hall, Alnwick March 5, 1857
531 Mawson, R. Bryham, Bickershaw House, Bickershaw, near
Wigan June 11, 1892
532 May, George, The Harton Collieries, South Shields (Past-President,
Member of Council) March 6, 1862
533 Mein, Henry Johnson, Carterthorne Colliery, Toft Hill, Bishop Auckland
Dec. 9, 1899
534 Meldrum, J. J., Atlantic Works, City Road, Manchester Nov. 24, 1894
535 Mellon, Henry, Brook Lea, Askam-in-Furness April 25, 1896
536 Mellors, Paul, The New Rio Tinto Copper Company, Limited, La Majada,
Campofrio, Huelva, Spain April 8, 1899
537 Menzies, Arthur William, Menai Bank, Carnarvon Aug. 6, 1898
538 Merivale, J. H., Togston Hall, Acklington, Northumberland (Vice-President,
Member of Council) May 5, 1877
539* Merivale, W., Agent and Engineer, South Western of Venezuela Railway, c'o Messrs. Bolton, Puerto Cabello, Venezuela
A.M. March 5, 1881
M. Aug. 3, 1889

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Date of Election
and of Transfer.
540 Merritt, W. Hamilton, 90, Bloor Street East, Toronto, Ontario, Canada
Oct. 14, 1893
541 Metcalfe, A. T., Joe's Reef United (Sheba), Limited, Eureka City, De
Kaap, South African Republic June 21, 1894
542 Mefsey-Thompson, A. H., Sun Foundry, Leeds A.M. April 3, 1889
M. Aug. 3, 1889
543 Middleton, Robert, Sheep Scar Foundry, Leeds Aug. 1, 1891
544 Miller, George Appleby Bartram, Barnsley House, Leighton Road,
Southville, Bristol June 13, 1896
545 Miller, James, Minas de Sao Bento, Santa Barbara de Matto Dentro, Minas
Geraes, Brazil Aug. 4, 1894
546 Miller, J. P. K., H. C. Frick Coke Company, Scottdale, Pennsylvania, U.S.A.
Dec. 14, 1895
547 Mitchinson, R., Pontop Colliery, Annfield Plain, R.S.O., Co. Durham
Feb. 4, 1865
548 Mole, William Frederick de, P.O., Box 217, Coolgardie, Western Australia
Dec. 12, 1896
549 Monckton, G. F., School of Mines, Vancouver, British Columbia A.M. July
14, 1896
M. Dec. 10, 1898
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<tr>
<th>No.</th>
<th>Name 1</th>
<th>Address 1</th>
<th>Address 2</th>
<th>Date 1</th>
<th>Date 2</th>
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<tr>
<td>551</td>
<td>Moody, Thomas Pearson, Hikurangi, via Auckland, New Zealand</td>
<td>Moody, Thomas Pearson, Hikurangi, via Auckland, New Zealand</td>
<td>Dec. 11, 1897</td>
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<td>552</td>
<td>Moore, R. T., 156, St. Vincent Street, Glasgow</td>
<td>Moore, R. T., 156, St. Vincent Street, Glasgow</td>
<td>Oct. 8, 1892</td>
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<td>553</td>
<td>Moore, R. W., Somerset House, Whitehaven</td>
<td>Moore, R. W., Somerset House, Whitehaven</td>
<td>S. Nov. 5, 1870</td>
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<td>555</td>
<td>Moreing, C. A.</td>
<td>Moreing, C. A., Broad Street House, Old Broad Street, London, E.C.</td>
<td>Nov. 7, 1874</td>
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<td>556</td>
<td>Morgan, John, Norseman Gold Mining Company, Limited, Norseman, Western Australia</td>
<td>Morgan, John, Norseman Gold Mining Company, Limited, Norseman, Western Australia</td>
<td>Aug. 7, 1897</td>
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<td>557</td>
<td>Morison, John, Cramlington House, Northumberland</td>
<td>Morison, John, Cramlington House, Northumberland</td>
<td>A. M. Dec. 4, 1880</td>
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<td>558</td>
<td>Morland-Johnson, Edward Thomas, Dol Gam, Newmarket Square, Blaenau Festiniog, North Wales</td>
<td>Morland-Johnson, Edward Thomas, Dol Gam, Newmarket Square, Blaenau Festiniog, North Wales</td>
<td>April 10, 1897</td>
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<td>560</td>
<td>Morse, Willard S., Apartado A., Aguascalientes, Mexico</td>
<td>Morse, Willard S., Apartado A., Aguascalientes, Mexico</td>
<td>June 13, 1896</td>
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<td>563</td>
<td>Mountain, William C, Forth Banks, Newcastle-upon-Tyne</td>
<td>Mountain, William C, Forth Banks, Newcastle-upon-Tyne</td>
<td>April 9, 1892</td>
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<td>564</td>
<td>Muir, John James, Mount Lyell Comstock Mine, North Lyell P.O., Tasmania</td>
<td>Muir, John James, Mount Lyell Comstock Mine, North Lyell P.O., Tasmania</td>
<td>Aug. 5, 1899</td>
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<td>565</td>
<td>Mundle, Arthur, Bank Chambers, 24, Grainger Street West, Newcastle-upon-Tyne</td>
<td>Mundle, Arthur, Bank Chambers, 24, Grainger Street West, Newcastle-upon-Tyne</td>
<td>S. June 5, 1875</td>
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<td>567</td>
<td>Ness, William Waters van, Bulawayo, Matabeleland, South Africa</td>
<td>Ness, William Waters van, Bulawayo, Matabeleland, South Africa</td>
<td>A.M. Aug. 7, 1897</td>
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<td>568</td>
<td>Nevin, John, Littlemoor, Mirfield, Normanton</td>
<td>Nevin, John, Littlemoor, Mirfield, Normanton</td>
<td>S. May 2, 1868</td>
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<td>570</td>
<td>Newton, James, 2, Randolph Gardens, Dover</td>
<td>Newton, James, 2, Randolph Gardens, Dover</td>
<td>Nov. 5, 1892</td>
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<td>572</td>
<td>Nicholson, J. Cook, Collingwood Street, Newcastle-upon-Tyne</td>
<td>Nicholson, J. Cook, Collingwood Street, Newcastle-upon-Tyne</td>
<td>Feb. 10, 1894</td>
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Date of Election
and of Transfer.
573  Nicholson, J. H., Cowpen Colliery Office, Blyth  S. Oct.  1  1881
A. Aug.  3, 1889
M. April  8, 1893
574  Nicholson, Marshall, Middleton Hall, Leeds  Nov.  7  1863
575  Noble, Thomas George, Sacriston Colliery, Durham  A. Feb.  13, 1892
M. June  8, 1895
576  Nomi, Aitaro, Namazuta Colliery, Province of Chikuzen, Japan  Aug.  5, 1899
577  North, F. W., 18, St. Swithin's Lane, London, E.C.  Oct.  6, 1864
578  Oates, Robert J. W., Rewah State Collieries, Umaria, C. India, Bengal Nagpur Railway  S. Feb.  10, 1883 A.M. Aug.  1, 1891
M. Dec.  12, 1891
579  O'Donahue, Thomas Aloysius, 35, Princess Street, Wigan  A.M. Dec.  14, 1895
M. Oct.  9, 1897
580  Oldham, George, 25, Western Hill, Durham  Nov.  5,1892
581  Orchard, Albert John Alfred, The White House, Nailstone Colliery, near Leicester  Feb.  12, 1898
582  Oshima, Rokuro, Hokkaido Colliery and R. R. Company, Sapporo, Japan  April 10, 1897
583  Ornsby, Robert Embleton, Seaton Delaval Colliery, Northumberland  June 11, 1898
584  Palmer, Claude B., Wardley Hall, near Newcastle-upon-Tyne  A.M. Nov.  5, 1892
M. June  8, 1895
585  Palmer, Henry, Medomsley, R.S.O., Co. Durham  S. Nov.  2, 1878
A.M. Aug.  4, 1883
M. Aug.  3, 1889
586  Pamely, C, Wye Cliffe House, Welsh Street, Chepstow  S. Sept.  5, 1868
M. Aug.  5, 1877
587  Panton, F. S., 54 Leazes Terrace, Newcastle-upon-Tyne  S. Oct.  5, 1867
M. Aug.  4, 1874
588  Parker, Thomas, Wellington Pit, Whitehaven  June 10, 1899
589  Parish, Charles Edward, Ouston Villa, Chester-le-Street, Co. Durham  Feb.  10, 1900
590  Parrington, M. W., Wearmouth Colliery, Sunderland (Vice-President, Member of Council)  S. Dec.  1, 1864
M. Aug.  6, 1870
591  Parsons, Hon. Charles Algernon, Heaton Works, Newcastle-upon-Tyne  A.M. June 12, 1886
M. Aug.  3, 1889
592  Pascoe, Thomas, New Options, Limited, Harraughtville, Victoria, Australia  A.M. April 10, 1897
M. June 12, 1897
593  Paterson, Andrew James, 31, Oxford Street, Lutton Place, Edinburgh. Transactions sent to P.O. Box 20, Maryborough, Queensland, Australia  June 11, 1898
594  Peake, R. C, Cumberland House, Redbourn, Herts.  S. Feb.  7, 1880
A.M. Aug.  7, 1886
M. Aug.  3, 1889
595  Pearse, John Walter, 56, Rue de l'Aqueduc, Paris-Nord, France  June 10, 1899
596  Pease, Sir J. W., Bart., Hutton Hall, Guisborough, Yorkshire  March 5, 1857
597  Peel, Robert, New Brancepeth Colliery. Durham  Aug.  6, 1892
<table>
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<th>Date</th>
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<th>Location</th>
<th>Notes</th>
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<tr>
<td>M. Aug. 6, 1870</td>
<td>Pengilly, Frederick Cardell, St. Day, Scorrier, Cornwall</td>
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<td>Feb. 10, 1900</td>
<td>Percy, C. M., King Street, Wigan</td>
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<td>Dec. 14, 1895</td>
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<td>Dec. 14, 1895</td>
<td>Pernolet, Arthur, 87, Rue Lafayette, Paris, France</td>
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<td>June 12, 1897</td>
<td>Phillips, William Battle, 59, Ninth Street, Pittsburg, Pennsylvania, U.S.A.</td>
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<td>Aug. 7, 1897</td>
<td>Pile, William, c/o King and Sons, Durban, Natal, South Africa</td>
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<td>A.M. June 11, 1898</td>
<td>Pingstone, George Arthur, P.O. Box 212, Bulawayo, Rhodesia, South Africa</td>
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<td>Dec. 14, 1895</td>
<td>Pernolet, Arthur, 87, Rue Lafayette, Paris, France</td>
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<td>June 12, 1897</td>
<td>Phillips, William Battle, 59, Ninth Street, Pittsburg, Pennsylvania, U.S.A.</td>
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<td>Date of Election</td>
<td>and of Transfer.</td>
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[xxxiv]
M. Feb. 12, 1898
626 Reid, A. H., 20, South African Chambers, St. George's Street, Cape Town
June 21, 1894
627 Reid, Francis, 13, Railway Arches, Westgate Road, Newcastle-upon-Tyne
April 9, 1892
628 Renwick, T. C, Lumley Thicks, Fence Houses April 14, 1894
629 Rhodes, C. E., Car House, Rotherham Aug. 4, 1883
630 Rhodes, F. B. F., National Smelting and Refining Company, South Chicago,
Illinois, U.S.A. Feb. 10, 1894
631 Rich, Francis Arthur, Karangahake, Auckland, New Zealand Aug. 5, 1899
632 Rich, William, 1, Heauton Villas, Redruth, Cornwall A.M. June 9, 1888
M. Aug. 3, 1889
633 Richard, George Anderson, Mount Morgan, Queensland, Australia June 11, 1898
634 Richards, T. J., Kingfield House, Ebbwvale, Monmouthshire Oct. 10, 1896
635 Richardson H., Backworth Colliery, Newcastle-upon-Tyne March 2, 1865
636 Richardson, Robert, Blaydon Main Colliery, Blaydon-upon-Tyne
A. M. Feb. 8, 1890
M. Aug. 3, 1895
637 Ridley, N. B., 2, Collingwood Street, Newcastle-upon-Tyne June 8, 1895
638 Ridley, William, Gilpin House, Houghton-le-Spring April 10, 1897
639 Ridyard, J., Hilton Bank, Little Hulton, Bolton-le-Moors, Lancashire Nov. 7, 1874
640 Ritson, U. A., 15, Queen Street, Newcastle-upon-Tyne Oct. 7, 1871
641 Robert, Philip Rhinelander, Greenland, Ontonagon County, Michigan,
U.S.A. Feb. 10, 1900

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Date of Election
and of Transfer.
642 Roberts, James, Jun., Perran House, Perranporth, R.S.O., Cornwall Dec. 14, 1895
643 Roberts, Robert, Oakley Slate Quarries Company Limited, Blaenau
Festiniog, North Wales Oct. 12, 1895
644 Roberts, Stephen, Penlan, Trefriw, R.S.O., North Wales April 28, 1900
645 Robertson, Andrew, 49, Mining Exchange, Ballarat, Victoria, Australia
Aug. 7, 1897
646 Robertson, D. A. W., Metropolitan Colliery, Helensburgh, near Sydney, New
South Wales Aug. 6, 1892
647*Robertson, J. R. M., Linton, Milson's Point, Sydney, New South Wales
Aug. 2, 1890
648 Robertson, W., 141, St. Vincent Street, Glasgow March 5, 1870
649 Robeson, Anthony Maurice, Alaska Mexican Company, Douglas Island, Alaska,
U.S.A June 13, 1896
650*Robins, Samuel M., Nanaimo, British Columbia Oct. 12, 1895
651 Robinson, C. Dec. 9, 1893
652 Robinson, George, Boldon Colliery, R.S.O., Co. Durham. June 10, 1899
Robinson, G. C, Brereton and Hayes Colliery, Rugeley, Staffordshire
Nov. 5, 1870

Robinson, John, The Grange, Haydock, near St. Helen's, Lancashire
Aug. 1, 1896

Robinson, J. B., Colliery Offices, Tow Law, R.S.O., Co. Durham
Aug. 5, 1893

Robinson, John Thomas, South Medomsley Colliery, Dighton, R.S.O.
Feb. 13, 1892

Robinson, R., Howlish Hall, near Bishop Auckland Feb. 1, 1868

Robson, J. S., Butterknowle Colliery, via Darlington May 15, 1862

Robson, T. O., Chowdene Cottage, Low Fell, Gateshead-upon-Tyne (Member
of Council) S. Sept. 11, 1875
A.M. Aug. 2, 1884
M. June 8, 1889

Rolker, Charles M., Leadenhall Buildings, 1 Leadenhall Street, London, E.C.
June 8, 1895

Ronaldson, J. H, 76, Pitt Street, Sydney, New South Wales Aug. 6,
1892

Roscamp, J., Shilbottle Colliery, Lesbury, E.S.O., Northumberland Feb. 2,
1867

Ross, Hugh, Croxdale Colliery Office, Durham Aug. 6, 1892

Ross, J. A. G., 19, Croft Terrace, Jarrow-upon-Tyne July 2, 1872

Rothwell, R. P., 253, Broadway (P.O. Box 1833), NewYork, U.S.A.
March 5, 1870

Rothwell, Samuel, 21, ChorleyNew Road, Bolton, Lancashire Dec. 9,
1899

Routledge, W. H., Woodfield Park, Blackwood, Monmouthshire
S. Oct. 7, 1876
A.M. Aug. 1, 1885
M. June 8, 1889

Rowe, William Henry, 9, Earl Terrace, Douglas Isle of Man June 13, 1896

Rowley, Walter, 20, Park Row, Leeds Aug. 5, 1893

Russell, Robert, Coltness Iron Works, Newmains, N.B. Aug. 3, 1878

Rutherford, W., South Derwent Colliery, Annfield Plain, Lintz Green Oct. 3,
1874

Saint, William, H.M. Inspector of Mines, Kersal Bank, Higher Broughton,
Manchester Oct. 10, 1896

Satse, Walter, Giridih, E.I.R., Bengal, India A.M. Nov. 3, 1877
M. Aug. 3, 1889

Sam, T. B. F., c/o F. and A. Swanzy, Cape Coast Castle, West Africa
Aug. 5, 1893

Samborne, John Stukely Palmer, Timsbury House, Bath Aug. 1, 1891

Sandeman, John J., Allan House, Rossland, British Columbia
Feb. 12, 1898

Satterthwaite, John, Garbham Mines, Garividi, E.C.R., Vizagapatam District,
India Dec. 10, 1898

Saunders, David William Alban, Worcester Chambers, Swansea A.M. Feb
12, 1898
M. June 11, 1898

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Date of Election
and of Transfer.
679 Saunders, William Thomas, Ivydene, West Cross, R.S.O., near Swansea.  
June 12, 1897
680* Sawyer, A. R., c/o Fletcher's Wholesale, Cape Town, South Africa; and 
Hilhouse, Woking, Surrey  S. Dec. 6, 1873
A.M. Aug 2, 1879
M. June 8, 1889
681 Schmitz-Dumont, G., Inspector of Mines, Barberton, Transvaal  Dec. 11, 
1897
682 Schroller, William, c/o Simon-Carves Bye-Product Coke Oven Construction and 
Working Company, Limited, 20, Mount Street, Manchester  Aug. 4, 1894
683 Scott, C. P., Grove Cottage, Leadgate, Co. Durham  S. April 11, 1874
M. Aug. 4, 1877
684 Scott, Elgin, Ropienka Oil Wells, Ropienka, Galicia, Austria  Aug. 4, 
1894
685 Scott, Ernest, Close Works, Newcastle-upon-Tyne  April 9, 1892
686 Scott, Edward Carlton, 20, Henrietta Street, Swansea  A. Oct. 8, 1892
M. Feb. 11, 1899
687 Scott, F. Bowes, 2 and 3, Birch Lane, London, E.C.  Dec. 14, 1895
688 Scott, Joseph, Ngahire, via Greymouth, New Zealand  Aug. 5, 1893
689 Scott, Joseph S., Trimdon Hall, Trimdon Grange, R.S.O., Co. Durham  S. 
Nov. 19 1881
M. April 9, 1892
690 Scoular, G., St. Bees, Cumberland  July 2, 1872
691 Selby, John Baseley, Leigh, Lancashire  April 25, 1896
692 Selkirk, John G., Dalton-in-Furness  April 8, 1893
693 Settle, Joseph Burton, The Bartissol Gold Mining Company, Limited, Umtali, 
Rhodesia, South Africa  Dec. 11, 1897
694 Sharp, Jacob, Burnmoor Colliery, Fence Houses  June 11, 1898
695 Shaw, F. George  June 10, 1893
696* Shaw, James, Stanley House, Kent Town, Adelaide, South Australia  
Dec. 12,1896
697 Shaw, J. Leslie, Somerset House, Whitehaven  Oct. 8, 1892
698 Sheafer, A. Whitcomb, Pottsville, Pennsylvania, U.S.A.  Aug. 4, 1894
699 Shiel, John, Framwellgate Colliery, Co. Durham  May 6, 1871
700 Shipley, T. B.  Transactions sent to c/o Andrew Reid 
and Company, Limited, Newcastle-upon-Tyne  A.M. Aug. 2, 1884
M. Aug. 3, 1889
701 Shute, C. A., 7, Dixon Terrace, Darlington  April 11, 1874
702 Sibold, C. W., Public Works Department, Soane Circle, Arrah, Bengal, India  
Dec. 9, 1893
703 Simon, Frank, c/o The African Banking Corporation, Limited, Durban, 
Natal, South Africa  Dec. 14,1895
704 Simpson, C. L., Engine Works, Grosvenor Road, Pimlico, London  April 8, 
1893
13, 1884
M. Aug. 3, 1889
706 Simpson, F. R., Hedgefield House, Blaydon-upon-Tyne  (Member of 
Council)  S. Aug. 4, 1883
M. Aug. 1,1891
707 Simpson, Gilbert Pitcairn, 3, Cornwall Terrace, Regent's Park, London, N.W. 
Oct. 10, 1896
708 Simpson, J., Heworth Colliery, Felling, R.S.O., Co. Durham  (Member of 
Council)  S. Dec. 6, 1866
M. Aug. 1,1868
709 Simpson, J. B., Bradley Hall, Wylam-upon-Tyne (Past-President, Member of Council) Oct. 4, 1860
710 Sladden, Harry, P.O. Box 2844, 6, Barnato Buildings, Johannesburg, Transvaal Nov. 24, 1894
711 Slinn, T., 40, Park Avenue, Whitley Bay, Northumberland July 2, 1872
712 Slooten, William van, 52, Sidney Place, Brooklyn, New York, U.S.A. Feb. 13, 1897
713 Smailes, Jno., Hebburn Colliery, Newcastle-upon-Tyne June 8, 1895
714 Smart, A., c/o Frazer and Chalmers, Limited, Erith, Kent Feb. 10, 1894
715 Smith, Alfred Godden, Golden Valley Ochre and Oxide Company, Wick, Bristol Dec. 10, 1898
716 Smith, David Curle, Little Sylvester Street, Coolgardie, Western Australia Feb. 12, 1898

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Date of Election and of Transfer.
717 Smith, Eustace, Newcastle-upon-Tyne A.M. June 11, 1887
M. Aug. 3, 1889
718* Smith, R. Clifford, Ashford Hall, Bakewell Dec. 5, 1874
719 Snyder, Frederick T., 400, Monon Building, Chicago, Illinois, U.S.A April 8, 1899
720 Sopwith, A., Cannock Chase Collieries, near Walsall Aug. 6, 1863
721 Southern, E. O., Ashington Colliery, near Morpeth S. Dec. 5, 1874
A.M. Aug. 1, 1885
M. June 8, 1889
722 Southern, John, Heworth Colliery, Felling, R.S.O., Co. Durham A. Dec. 14, 1889
M. April 8, 1899
723 Southern, R., Burleigh House, The Parade, Tredegarville, Cardiff Aug. 3, 1865
724 Southworth, Thomas, Hindley Green Collieries, near Wigan May 2, 1874
725 Sparkes, J. S., 55, Richmond Road, Cardiff April 9, 1892
726 Spence, R. F., Backworth, R.S.O., Northumberland S. Nov. 2, 1878
A.M. Aug. 2, 1884
M. Aug. 4, 1889
727 Spencer, Francis H, Bonanza Gold Mining Company, P.O. Box 149, Johannesburg, Transvaal Dec. 13, 1890
728 Spencer, John, Westgate Road, Newcastle-upon-Tyne Dec. 4, 1869
729 Spencer, John W., Newburn, near Newcastle-upon-Tyne May 4, 1878
730 Spencer, T., Ryton, near Newcastle-upon-Tyne Dec. 6, 1866
731 Squire, J. B., Thrale Hall, Streatham, Surrey June 8, 1895
732 Stanley, James, 3, Chancery Chambers, Coolgardie, Western Australia Dec. 12, 1896
M. Aug. 3, 1889
734 Stanton, John, 11 and 13, William Street, New York, U.S.A. June 8, 1895
735 Steavenson, A. L., Durham (Past-President, Member of Council) Dec. 6, 1855
736 Steavenson, C. H, Redheugh Colliery, Gateshead-upon-Tyne S. April 14, 1883
A. Aug. 1, 1891
M. Aug. 3, 1895
<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Address</th>
<th>Date</th>
<th>Type of Election</th>
</tr>
</thead>
<tbody>
<tr>
<td>737</td>
<td>Stevens, A. J.</td>
<td>Uskside Iron Works, Newport, Monmouthshire</td>
<td>April 8, 1893</td>
<td></td>
</tr>
<tr>
<td>738</td>
<td>Stevens, James</td>
<td>9, Fenchurch Avenue, London, E.C.</td>
<td>Feb. 14, 1885</td>
<td></td>
</tr>
<tr>
<td>739</td>
<td>Stewart, William</td>
<td>Tillery Collieries, Abertillery, Monmouthshire</td>
<td>June 8, 1895</td>
<td></td>
</tr>
<tr>
<td>740</td>
<td>Stobart, F.</td>
<td>Biddick Hall, Fence Houses</td>
<td>S. Aug. 2, 1873</td>
<td></td>
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<tr>
<td></td>
<td>A.M. Aug. 5, 1882</td>
<td></td>
<td>M. June 8, 1889</td>
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<tr>
<td>741</td>
<td>Stobart, H. T.</td>
<td>Wearmouth Colliery, Sunderland</td>
<td>S. Oct. 2, 1880</td>
<td></td>
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<td></td>
<td>A.M. Aug. 4, 1888</td>
<td></td>
<td>M. Aug. 3, 1889</td>
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<tr>
<td>742</td>
<td>Stobart, W.</td>
<td>Pepper Arden, Northallerton</td>
<td>July 12, 1872</td>
<td></td>
</tr>
<tr>
<td>743</td>
<td>Stobart, William</td>
<td>Etherley Lodge, Darlington</td>
<td>Oct. 11, 1890</td>
<td></td>
</tr>
<tr>
<td>745</td>
<td>Stoker, Arthur P.</td>
<td>Birtley, near Chester-le-Street</td>
<td>S. Oct. 6, 1877</td>
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<tr>
<td></td>
<td>A.M. Aug. 1, 1885</td>
<td></td>
<td>M. Aug. 3, 1889</td>
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<tr>
<td>746</td>
<td>Stone, Arthur</td>
<td>Heath Villas, Hindley, Wigan</td>
<td>June 13, 1896</td>
<td></td>
</tr>
<tr>
<td>747</td>
<td>Straker, J. H.</td>
<td>Howden Dene, Corbridge-upon-Tyne</td>
<td>Oct. 3, 1874</td>
<td></td>
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<tr>
<td>748</td>
<td>Streatfield, Hugh S.</td>
<td>Ryhope, near Sunderland</td>
<td>A.M. June 8, 1889</td>
<td></td>
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<tr>
<td></td>
<td>M. Aug. 3, 1889</td>
<td></td>
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<tr>
<td>749</td>
<td>Stuart, Donald M. D.</td>
<td>Redland, Bristol</td>
<td>June 8, 1895</td>
<td></td>
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<tr>
<td>750</td>
<td>Sulman, Henry</td>
<td>Livingstone, 60, Gracechurch Street, London, E.C.</td>
<td>Feb. 11, 1899</td>
<td></td>
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<td></td>
<td>M. Aug. 3, 1889</td>
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<tr>
<td>751</td>
<td>Swallow, J.</td>
<td>Catchgate, Annfield Plain, R.S.O., Co. Durham</td>
<td>May 2, 1874</td>
<td></td>
</tr>
<tr>
<td>752</td>
<td>Swallow, R. T.</td>
<td>Simonside House, Simonside, South Shields</td>
<td>Feb. 5, 1863</td>
<td></td>
</tr>
<tr>
<td>753</td>
<td>Swan, H. F.</td>
<td>North Jesmond, Newcastle-upon-Tyne</td>
<td>Sept. 2, 1871</td>
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</tr>
</tbody>
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Date of Election and of Transfer.

704 Swan, J. G., Upsall Hall, near Middlesbrough | Sept. 2, 1871
705 Swinney, Alfred John George, Lome Villa, Elm Road, Sidcup, Kent | June 11, 1898
706 Symons, Francis, Ulverston, Lancashire | Feb. 11, 1899
707 Tate, Simon, Trimdon Grange Colliery, Co. Durham | Sept. 11, 1875
709 Tatum, Lawrence W., Dolores Hidalgo, Guanajuato, Mexico | A.M. Aug. 7, 1897
800 M. Dec. 11, 1897
760 Taylor, Hugh, East Holywell Office, Quay, Newcastle-upon-Tyne | Sept. 5, 1856
761 Taylor, T., Quay, Newcastle-upon-Tyne | July 2, 1872
762 Teasdale, Thomas, Middridge, via Heighington, R.S.O. | April 9, 1892
764 Tennent, Robert, H.M. Inspector of Mines, Westport, New Zealand | Oct. 8, 1898
765 Thackthwaite, Thomas Michael Oct. 10, 1896
766 Thomas, Arthur, 115, Trelowarren Street, Camborne, Cornwall Aug. 7, 1897
767 Thomas, Ernest Henry, Oakhill, Gadlys, Aberdare, South Wales Feb. 10, 1900
768 Thomas, Iltyd Edward, Glanymor, Swansea Feb. 10, 1900
769 Thomas, J. J., Hawthorn Villa, Kendal June 21, 1894
770 Thomas, Richard, Brown's Duckenfield Collieries, Minmi, Newcastle, New South Wales Feb. 11, 1899
771 Thomas, Trevor Falconer, Llandaff Place, Cardiff A.M. Feb. 12, 1898
M. Aug. 6, 1898
772 Thomlinson, William, Seaton Carew, R.S.O. April 25, 1896
773 Thompson, Charles Lacy, Farlam Hall, Brampton Junction, Cumberland A.M. Feb. 10, 1883
M. Aug. 3, 1889
774 Thompson, Francis William, 15, Wood Street, Bolton, Lancashire June 8, 1895
775 Thompson, John G., Bank House, Collins Green, Earlestown June 8, 1895
776 Thompson, John William, Greenfield House, Crook, R.S.O., Co. Durham A. June 10, 1893
M. Feb. 10, 1900
777 Thompson, W., 58, New Broad Street, London, E.C. Aug. 4, 1888
778 Thomson, John, Eston Mines, by Middlesbrough April 7, 1877
779 Thomson, Joseph F., Manvers Main Colliery, Rotherham Feb. 6, 1875
780 Todd, John T., Blackwell Collieries, Alfreton S. Nov. 4, 1876
A.M. Aug. 1, 1885
M. June 8, 1889
781 Tonkin, J. J., Linares, Provincia de Jaen, Spain Oct. 14, 1893
782 Touzeau, E. M 30 and 31, St. Swithin's Lane, London, E.C. Aug. 6, 1892
783 Treadwell, G. A., Phoenix, Arizona, U.S.A. Aug. 3, 1895
784 Trelease, W. Henwood, Pesterena United Gold Mining Company, Limited, Pesterena, Vail Anzasca, Novara, Italy April 8, 1893
785 Trevail-Williams, T., Johannesburg Consolidated Investment Company, Limited, Atkinson's Buildings, St. George's Street, Cape Town, South Africa Dec. 10, 1898
786 Tulip, Samuel, Bunker Hill, Fence Houses June 12, 1897
787 Turnbull, John James, East Indian Coal Company, Limited, Jherria P.O., District Manbhum, Bengal, India Feb. 12, 1898
788*Tyers, John E., c/o The Hyderabad Deccan Company, Limited, Secunderabad, Deccan, East India A.M. Dec. 10, 1877
M. Aug. 3, 1889
789 Tyzack, David, Bellingham, Northumberland Feb. 14, 1874
790 Upton, Prescott, P.O. Box 1026, Johannesburg, Transvaal June 12, 1897
791 Varty, Thomas, Skelton Park Mines, Skelton, R.S.O., Cleveland Feb. 12, 1887

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Date of Election
and of Transfer.
792 Vaughan, Cedric, Hodbarrow Iron Ore Mines, Millom, Cumberland Dec. 10, 1892
793 Vaughan, John. Balaclava House, Dowlais, Glamorganshire Feb. 12 1898
795 Veasy, Harvey C., Burrakur Coal Company, Limited, Barakar, Bengal, India  June 21, 1894
796 Verney, George, Doubouvaïs, Balka Krivoï, Russia  Oct. 8, 1898
797 Verschoyle, William Denham, Alpha Gold Mining Company, Westland, New Zealand  Dec. 11, 1897
798 Vezin, Henry A., P.O. Box 256, Denver, Colorado, U.S.A.  June 21, 1894
799 Vitanoff, George N., Sophia, Bulgaria  A. M. April 22, 1882
800 Vivian, John, Vivian's Boring and Exploration Company, Limited, 42, Lowther Street, Whitehaven  March 3, 1877
801 Waddle, Hugh, Llanmore Iron Works, Llanelly, South Wales  Dec. 13, 1890
802 Wadham, E., Millwood, Dalton-in-Furness  Dec. 7, 1867
803 Wales, H. T., Western Mail Chambers, Cardiff  Feb. 11, 1893
804 Walker, Henry Blair, Die Rietfontein Colliery, Springs, Johannesburg, Transvaal  Oct. 9, 1897
805 Walker, James Howard, Bank Chambers, Wigan  Dec. 9, 1899
806 Walker, J. S., Pagefield Iron Works, Wigan, Lancashire  Dec. 4, 1869
808 Walker, Thomas A., Pagefield Iron Works, Wigan, Lancashire  June 8, 1895
810 Walker, William Edward, Lowther Street, Whitehaven  Nov. 19, 1881
811 Wall, Henry, Rowbottom Square, Wallgate, Wigan  June 8, 1895
812 Wallace, Henry, Trench Hall, Gateshead-upon-Tyne  Nov. 2, 1872
813 Wallwork, Jesse, Bolton Road, Atherton, Lancashire  Feb. 9, 1895
814 Walsh, G. Paton, 564, Heirengracht, Amsterdam, Holland  Nov. 24, 1894
815 Walton, J. Coulthard, Wrinthlington Colliery, Radstock, via Bath  S. Nov. 7, 1874
816 Walton, Thomas, Habergham Colliery, Burnley  Aug. 3, 1895
817 Ward, A. H., Sitarampur, E.I.R., Bengal, India  April 14, 1894
818 Ward, H., Rodbaston Hall, near Penkridge, Stafford  March 6, 1862
820 Watkyn-Thomas, W., Workington  A. M. Feb. 10, 1883
821 Watson, Edward, South Pelaw Colliery, Chester-le-Street  S. Feb. 13, 1892
822 Watson, Thomas, Trimdon Colliery, Trimdon Grange  Oct. 11, 1890
823 Watts, J. Whidbourne, United Ivy Gold Mining Company, Limited, Barberton, Transvaal  Dec. 12, 1896
824 Watts, William, Sheffield Corporation Water Department, Little Don Valley Works, Engineer's Office, Langsett, near Penistone  June 13, 1896
825 Webster, Alfred Edward, Manton, Worksop, Notts  June 12, 1897
826 Webster, H. Ingham, Mainsforth Hall, Ferryhill, S.O., Co. Durham A. M. April 14, 1883
M. Aug. 3, 1889
827 Weeks, J. G., Bedlington, R.S.O., Northumberland (President, Member of Council) Feb. 4, 1865
828 Weeks, R. L., Willington, Co. Durham A. M. June 10, 1882
M. Aug. 3, 1889
829 Wehner, Frederick Carl, 5, Alexandra Terrace, Stanley Road, Wallington, Surrey A.M. Feb. 13, 1897
M. June 9, 1900
M. Oct. 8, 1898
831 Wells, Joseph Fleetwood, Kamloops, British Columbia Aug. 5, 1899

Date of Election and of Transfer.
832 Western, C. R., Queen Anne's Mansions, Westminster, London, S W. June 10, 1893
833 Westmacott, P. G. B., Rose Mount, Sunninghill, Berks. June 2, 1866
834 Whalley, Frederick Herbert, Queen Street, Auckland, New Zealand Oct. 9, 1897
835 White, C. E., Wellington Terrace, South Shields S. Nov. 4, 1876
A.M. Aug. 1, 1885
M. Aug. 3, 1889
836 White, Frederick Napier, H.M. Inspector of Mines, 9, Mirador Crescent. Swansea June 11, 1898
837 White, H., Walker Colliery, Newcastle-upon-Tyne S. March 2, 1867
M. Aug. 5, 1871
838 White, J. F., 15, Wentworth Street, Wakefield S. July 2, 1872
M. Aug. 2, 1873
839 Whitelaw, John, 31, Albany Street, Edinburgh Feb. 5, 1870
840 Widdas, C, North Bitchburn Colliery, Howden, Darlington Dec. 5, 1868
841 Wight, Edward S., Taupiri Coal Mines, Limited, Mine Manager's Office, Huntly, near Auckland, New Zealand A.M. Dec. 12, 1885
M. Aug. 3, 1889
842 Wight, W. H., Cowpen Colliery, Blyth Feb. 3, 1877
843 Wilcox, Henry, Miners' Safety Explosive Works, Stanford-le-Hope, Essex June 8, 1895
844 Wilkins, William Glyde, Westinghouse Building, Pittsburg, Pennsylvania, U.S.A. Dec. 11, 1897
846 Williams, Ernest, c/o Bewick, Moreing and Company, Hooper Chambers, Macdonald Street, Kalgoorlie, Western Australia Oct. 10, 1891
848 Williams, H. J. Carnegie Oct. 12, 1895
849 Williams, Luke, Mount Reid Mining Company, Limited, Mount Read, Tasmania April 10, 1897
M. Aug. 1, 1896
851 Williams, Robert, 30, Clements Lane, Lombard Street, London, E.C. June 13, 1896
852 Williams, Samuel Herbert, Newfoundland Iron Ore Company, Workington, Lower Island Cove, Newfoundland July 14, 1896
853 Wilson, Archibald Laurence, The New Ravenswood, Limited, Ravenswood, Queensland, Australia A.M. June 12, 1897
M. April 2, 1898
M. June 10, 1899
855 Wilson, J. B., The Rowans, Ashley Road, Epsom Nov. 5, 1852
857 Wilson, Lloyd, Flimby Colliery, Maryport Jan. 19, 1895
858 Wilson, P. O. Dec. 9, 1893
859 Wilson, W. B., Hawthorn Rectory, Sunderland S. Feb. 6, 1869
M. Aug. 2, 1873
861 Wilson-Moore, Cuninghame, Steynsprod, Transvaal Feb. 10, 1900
862 Winchell, Horace V., Butte, Montana, U.S.A. Nov. 24, 1894
863 Winstanley, Robert, 42, Deansgate, Manchester Sept. 7, 1878
864 Wood, C. L., Freeland, Forandenny, Perthshire Aug. 3, 1854
865 Wood, Ernest Seymour, c/o The Bengal Coal Company, Limited, 5 Fairlie Place, Calcutta, India Oct. 10, 1891
866 Wood, John, Coxhoe Hall, Coxhoe, R.S.O., Co. Durham S. June 8, 1889
A. Aug. 4, 1894
M. Aug. 3, 1895
867 Wood, Sir Lindsay, Bart., The Hermitage, Chester-le-Street (Past-President, Member of Council) Oct. 1, 1857

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Date of Election
and of Transfer.
868 Wood, Robert Arna, c/o Harrison, Barber and Company, Limited, 18, Queen Victoria Street, London, E.C. April 10, 1897
M. Aug. 5, 1871
870 Wood, W. H., Coxhoe Hall, Coxhoe, R.S.O Co. Durham Aug. 6, 1857
871 Wood, W. O., South Hetton, Sunderland (Vice-President, Member of Council) Nov. 7, 1863

872 Woodburne, T. J., De Beers Consolidated Mining Company, Limited, Kimberley, South Africa Feb. 10, 1894
873 Woodcock, J. H., 49, Lowther Street, Whitehaven June 10, 1893
874 Wormald, C. F., Mayfield Villa, Saltwell, Gateshead-upon-Tyne A.M. Dec. 8, 1883
M. Aug. 3, 1889
875 Worsdell, Wilson, North Eastern Railway Company, Gateshead-upon-Tyne Oct. 14, 1899
876 Wright, Sidney Bkistow, Canadian Goldfields, Limited, Deloro, Hastings County, Ontario, Canada  
April 28, 1900
877 Wrightson, Sir Thomas, Bart., Stockton-upon-Tees  
Sept. 13, 1873
878 Wynne, T. Trafford, c/o W. Watkyn Wynne, c/o T. Sherratt and Nelson, Solicitors, Kidsgrove, Staffordshire  
Oct. 12, 1895

879 Young, Henry William, Greymouth, New Zealand  
Dec. 12, 1896
880 Young, James, 4, Granville Road, Jesmond, Newcastle-upon-Tyne  
Oct. 9, 1897
881 Young, John A., 3, Fountain Avenue, Gateshead-upon-Tyne  
A.M. Dec. 10, 1887
M.Aug. 3, 1889
882 Young, John Huntley, Wearmouth Colliery, Sunderland  
June 21, 1894
883 Zumbuloglon, G. C, Mahmoudie-Han, Stamboul, Turkey  
S. Feb. 14, 1891
A. Aug. 4, 1894
M. Aug. 3, 1895

ASSOCIATE MEMBERS.
Marked * have paid life composition.

Date of Election
and of Transfer.

1 Ahier, Philippe Davidson, 3, Alder Street, Seaforth, Liverpool  
Oct. 14, 1899
2 Ainsworth, H. S., "Belvedere," Marine Terrace, Geraldton, Western Australia  
Feb. 15, 1896
3 Archibald, John Wilson, Coolgardie, Western Australia  
Feb. 15, 1896
4 Armstrong, J. H., St. Nicholas’Chambers, Newcastle-upon-Tyne  
Aug. 1, 1885
5 Armstrong, T. J., Hawthorn Terrace, Newcastle-upon-Tyne  
Feb. 10, 1883
6 Atkinson, G. B., Prudential Assurance Buildings, Mosley Street, Newcastle-upon-Tyne  
Nov. 5, 1892
7 Baker, Max, Effingham House, Arundel Street, Strand, London, W.C.  
April 2, 1898
8 Banks, Charles John, Westwood, Washington, R.S.O., Co. Durham  
Feb. 12, 1898
9 Barrett, William Scott, Abbotsgate, Huyton, Liverpool  
Oct 14, 1899
10 Bell, Hugh, Middlesbrough-upon-Tees  
Dec. 9, 1882
Aug. 1, 1891
12 Blow, A. A., The Sheba Gold Mining Company, Limited, Eureka City, Barberton, South African Republic  
Dec. 10, 1898
13 Blue, Archibald, Bureau of Mines, Toronto, Ontario, Canada  
Feb. 10, 1894
14 Boyle, A. R., Melbourne and Metropolitan Board of Works, "Rialto," 501, Collins Street, Melbourne, Australia  
Dec. 10, 1898
15 Broadbent, Denis Ripley, 26, Great Russell Street, Russell Square, London, W.C.  
Oct. 14, 1899

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Date of Election
and of Transfer.
16 Burdon, A. E., Hartford, Bedlington, R.S.O., Northumberland  Feb. 10, 1883
17 Burn, Charles William, 28, Fawcett Street, Sunderland   June 11, 1898
18 Capell, Rev. G. M., Passenham Rectory, Stony Stratford   Oct. 8, 1892
19* Carr, William Cochran, 91, Jesmond Road, Newcastle-upon-Tyne  Oct. 11, 1890
20 Chaffey, John Robert, 338, Collins Street, Melbourne, Australia April 2, 1898
21 Chaplin, George P., Mina Grande Mining Company, Pinal de Amoles, Estado Queretaro, Mexico  S. Feb. 15, 1896
22 A.M.   Oct. 9, 1897
23 Chewings, Dr. Charles, Albany, Western Australia   April 25, 1896
24 Cleland, E. Davenport, Bayley Street, Coolgardie, Western Australia June 13, 1896
25 Collopy, Lieut. Charles J., C Squadron, Bethune's Mounted Infantry, Tugela Ferry, Natal, South Africa Dec. 10, 1898
26 Cooper, R. W., Newcastle-upon-Tyne   Sept. 4, 1890
27 Cory, Clifford J., c/o Cory Brothers and Company, Limited, Cardiff Dec. 11, 1897
28 Crosby, A. Aug. 7, 1897
29 Davidson, Louis, 8, Burdon Terrace, Newcastle-upon-Tyne   Oct. 14, 1899
30 Duncan, G. T., 96, Brighton Grove, Newcastle-upon-Tyne Aug. 5, 1893
31 Eccles, Edward, King Street, Newcastle-upon-Tyne   Oct. 13, 1894
32 Edwards, F. H., Forth House, Bewick Street, Newcastle-upon-Tyne June 11, 1887
33 Ellam, Albert Spencer, c/o Shanghai Race Club, Shanghai, China April 25, 1896
34 Elliot, Sir George, Bart., 16, Great George Street, Westminster, London, S.W. April 2, 1898
35 Fairless, Joseph, Mineral Traffic Manager, North Eastern Railway Company, Newcastle-upon-Tyne June 10, 1899
36 Ferguson, C. A., 41, Lovaine Place, Newcastle-upon-Tyne July 14, 1896
37 Foster, T. J., Coal Exchange, Scranton, Pennsylvania, U.S.A Dec. 12, 1891
38 Gibbon, James, c/o W. T. Sampson, Beaufort Street, Grahamstown, Cape Colony Dec. 9, 1899
39 Gilbert, William J., Monarch Gold Mining Company, Gullewa, via Yalgoo, Murchison, Western Australia Dec. 10, 1898
40 Graham, John, Findon Cottage, Sacriston, Durham Oct. 9, 1897
41* Gregson, Jesse, Australian Agricultural Company, Newcastle, New South Wales Aug. 6, 1898
42 Griffin, Noel, Geelong Gold Mines, Gwanda, Matabeleland, South Africa Feb. 13, 1897
43 Gue, T. R., P.O. Box 520, Halifax, Nova Scotia Feb. 15, 1896
44 Gummerson, James M., 29, Luther Strasse, Berlin, W., Germany June 10, 1899
45 Guthrie, Reginald, Neville Hall, Newcastle-upon-Tyne (Treasurer, Member of Council) Aug. 4, 1888
46 Hailes, Alfred G., Sejooah Colliery, Katras, District Manbhoom, Bengal, India Aug. 5, 1899
48 Harris, William Pollard, The Yellow Astor Gold Mine, Touranna, near Roeburne, Western Australia Dec. 11, 1897
50 Hedley, J. Hunt, John Street, Sunderland June 13, 1891
51 Heeley, George, 61, Kyle Park, Uddingston, near Glasgow Dec. 14, 1895
52 Henderson, C. W. C, The Riding, Hexham Dec. 9, 1882

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Date of Election
and of Transfer.
53 Henzell, Robert, Prudential Buildings, Mosley Street, Newcastle-upon-Tyne April 11, 1891
54 Hill, Albert J., New Westminster, British Columbia Dec. 10, 1898
55 Hodgetts, Arthur, c/o A. H. Thornton, 82, Station Road, Handsworth, Birmingham Oct. 9, 1897
56 Hodgson, Albert, Santa Francisca Gold Mines, Limited, Leon, Nicaragua, Central America Feb. 13, 1897
57 Holland, Williamson, 36, Orchard Terrace, Rochdale Road, Heywood, Lancashire Feb. 13, 1897
58 Holliday, Henry, Consett Iron Company, Limited, Blackhill, Co. Durham Feb. 12, 1898
59 Hopper, J. I., Wire Rope Works, Thornaby-upon-Tees Dec. 8, 1888
60 Humphreys-Davies, G., 8, Laurence Pountney Hill, Cannon Street, London, E.C Oct. 8, 1892
61 Hunter, C. E., Selaby Park, Darlington April 27, 1895
62 Innes, Thomas Snowball, Crown Chambers, Side, Newcastle-upon-Tyne Dec. 10, 1898
63 James, Henry M., Colliery Office, Whitehaven June 10, 1893
65 Jeffrey, Joseph Andrew, c/o The Jeffrey Manufacturing Company, Columbus, Ohio, U.S.A Dec. 11, 1897
66 Jeffries, Joshua, Greta Collieries, Greta, New South Wales Dec. 10, 1898
67 Jobson, Edward, 5, Bath Terrace, Tynemouth Oct. 9, 1897
69 Kalb, Courtenay De, School of Mining, Kingston, Ontario, Canada Oct. 8, 1898
70 Kidson, Arthur, Argyle House, Sunderland April 8, 1899
71 Kirkby, William, c/o H. C. Embleton, Central Bank Chambers, Leeds April 2, 1898
72 Kirkup, Frederic O., Langley Park, Durham April 9, 1898
73 A.M. April 25, 1896
75 Lamb, Edmund George, Borden Wood, Liphook, Hants. Feb. 12, 1898
76 Larsen, A., 128, Cambridge Street, London, S.W. April 27, 1895
77 Lawrance, David H., British Columbia Chamber of Mines, P.O. Box 325, Vancouver, British Columbia Feb. 12, 1898
78 Loevy, J., P.O. Box 778, Johannesburg, Transvaal June 13, 1896
79 Lumsden, John Alder December 11, 1897
80 Marshall, P., College and Grammar School, Auckland, New Zealand June 12, 1897
81 Meiklejohn, J., Oriental Hotel, Water Street, Vancouver, British Columbia Aug. 6, 1898
82 Minard, Frederick Horace, 409, Equitable Building, Denver, Colorado, U.S.A. Dec. 11, 1887
83 Newbery, Frederick, 230, Camden Road, London, N.W. April 2, 1898
84 Palmer, A. M., 1, Jesmond High Terrace, Newcastle-upon-Tyne. Transactions sent to the Anglo-American Club, Freiburg, Saxony, Germany Nov. 24, 1894
85 Perkins, Charles, Middleton Hall, Belford, Northumberland Aug. 6, 1892
86*Pickup, P. W. D., Rishton Colliery, Rishton, near Blackburn Feb. 12, 1898
87 Pringle, John, c/o Russo-Chinese Bank, Newchwang, China Feb. 13, 1897

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Date of Election and of Transfer
88*Proctor, John H., 22, Hawthorn Terrace, Newcastle-upon-Tyne June 8, 1889
89 Richter, F., Osborne Villas, Newcastle-upon-Tyne Oct. 10 1891
90 Ridley, J. Cartmell, 1, Bentinck Terrace, Newcastle-upon-Tyne Feb. 11, 1893
91 Ridley, Sir Matthew W., Bart., Blagdon, Northumberland Feb. 10, 1883
92 Ritson, J. Ridley, Burnhope Colliery, Lanchester S. April 11, 1891 A.M. Aug. 3, 1895
93 Roberts, William Murray, P.O. Box 413, Johannesburg, Transvaal Oct. 9, 1897
94 Robinson, John Walton, 6, Gladstone Terrace, Gateshead -upon-Tyne Dec. 12, 1896
95 Robinson, Walter Francis, Greymouth, New Zealand April 2, 1898
96 Robson, Henry Naunton, Walkeringham, Gainsborough Dec. 12, 1890
97 Rogerson, John E., Oswald House, Durham June 8, 1895
98 Rosen, John, P.O. Box 1647, Johannesburg, Transvaal Dec. 10, 1898
99 Saunders, G. B., Saunders, Todd and Company, Maritime Buildings, King Street, Newcastle-upon-Tyne Jan. 19, 1895
100 Scott, John Henry, 1157, Burnaby Street, Vancouver, British Columbia Aug. 5, 1899
101 Scott, John Oliver, The Glebe, Riding Mill-upon-Tyne Dec. 11, 1897
102 Searle, John Thomas Luxton, The Cottage, Eden, Minster, Thanet Feb. 11, 1899
103 Shaw, Saville, Durham College of Science, Newcastle-upon-Tyne April 13, 1899
104 Sherlaw, James Linn, 17, Ellerker Gardens, Richmond, Surrey Aug. 1, 1896
105 Sjogren, Hj., Osmo-Nynas, Sweden April 25, 1896
106 Smith, C. A., 23, Rectory Terrace, Gosforth, Newcastle-upon-Tyne Dec. 8, 1894
107 Snowball, Francis John, Seaton Burn House, Dudley, Northumberland Dec. 12, 1891
109 Stewart, Samuel, 16, Great George Street, Westminster, London, S. W. ; and Parkhurst, Park Road, Wallington, Surrey Feb. 12, 1898
110 Stokes, H. G., Silver Spur Silver Mines, Texas, via Stanthorpe, Queensland, Australia Dec. 11, 1897
111 Stowell, William, 3, Akenside Hill, Newcastle-upon-Tyne June 11, 1898
112 Strange, Harold Fairbrother. Johannesburg Consolidated Investment Company, Limited, P.O. Box 590, Johannesburg, Transvaal Dec. 11, 1897
113 Swinburne, U. P., c/o R. Chamberlain, 39, Cadogan Square, London, S.W. Aug. 4, 1894
114 Tattley, Ernest William, Taupiri Extended Coal Mining Company, Limited, Mine Manager's Office, Waikato, Auckland, New Zealand June 12, 1897
115 Thiis, Erling Einar, Prindsens Gd. No. 4, Christiania, Norway Aug. 6, 1898
116 Thompson, Oswald, Hendon Lodge, Sunderland June 10, 1899
117 Todd, James, West View House, Durham Aug. 6, 1892
118 Tunnington, Albert, Mawsons Reward Company, Dundas, Western Australia Oct. 9, 1897
119 Turner, Basil William, 40, Collins Street, Annandale, Sydney, New South Wales Feb. 13, 1897
121 Wall, G. Young, Halmote Court Office, New Exchequer Building, Durham Nov. 24, 1894

ASSOCIATES.

1 Allport, E. A., 89, Dodworth Road, Barnsley, Yorkshire S. April 14, 1894 A. Aug. 4, 1900
2 Archer, M. W., High Priestfield, Lintz Green, Co. Durham S. June 8, 1895 A. Aug. 4, 1900
3 Barker, John Dunn, John Street, Meadowfield, Durham Aug. 5, 1899
4 Barrass, M., Hedley Hill Colliery, WTaterhouses, Co. Durham S. Feb. 9, 1894 A. Aug. 1, 1891
5 Battey, Thomas, Percy Terrace, Backworth Colliery Oct. 13, 1894
6 Beckett, James, 57, Pine Street, Teams. Gateshead-upon-Tyne Oct. 8, 1898
7 Bell, John, Wardley Colliery, Newcastle-upon-Tyne Feb. 8, 1890
8 Bell, Thomas, White Lea Colliery, Crook, R.S.O., Co. Durham Aug. 6, 1898
9 Bell, W. Ralph, Wearmouth Colliery, Sunderland  Oct. 13, 1894
10 Berry, Thomas, 1, Middleton, Swalwell, R.S.O.  Nov. 5, 1892
11 Bewick, George, Dudley Colliery, Northumberland  April 10, 1897
12 Booth, F. L., Ashington Colliery, Morpeth  S. Feb. 10, 1894
A. Aug. 4, 1900
13 Bowes, Thomas, Pontop House, Annfield Plain, R.S.O. Feb. 13, 1892
14 Bowman, Frank, Trimdon Grange Colliery, Co. Durham June 8, 1895
15 Brown, Robert O., Throckley Colliery, near Newcastle-upon-Tyne  S. Oct. 8, 1892
A. Aug. 3, 1895
16 Calland, Robert, East Hedley Hope Colliery, Tow Law, R.S.O., Co. Durham June 11, 1898
17 Carroll, John, Newfield House, Newfield, Willington, Co. Durham Feb. 12, 1898
18 Clark, Thomas, Dipton Colliery, Lintz Green Station Oct. 11, 1890
19 Clifford, E. Herbert  S. Oct. 13, 1894
A. Aug. 6, 1898
20 Clough, John, 1, Melton Terrace, Seaton Delaval Colliery, R.S.O., Northumberland Feb. 13, 1897
21 Cockburn, Edmund, High Street, Boosbeck, Skelton-in-Cleveland, Yorkshire Dec. 11, 1897
22 Cookburn, Evan, Page Bank Colliery, via Spennymoor, Co. Durham Aug. 5, 1893
23 Corbett, Vincent, 2, Grey Terrace, Ryhope, via Sunderland  June 11, 1898
24 Cowx, H. F., Thornley Collieries, via Trimdon Grange, R.S.O. April 14, 1894
25 Crown, William, 39, Fifth Row, Ashington, Morpeth  April 14, 1894
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Date of Election and Transfer.

26 Dakers, John, 32, South Street, Brandon Colliery, Durham  Aug. 5, 1899
27 Danskin, Thomas, Springwell Colliery, Gateshead-upon-Tyne Dec. 10, 1898
28 Davis, James E., South Medomsley Colliery, Dipton, R.S.O., Co. Durham Feb. 12, 1898
29 Davison, Francis, 37, Hedley Hill Terrace, Waterhouses, Co. Durham Feb. 12, 1898
30 Davison, Mathew, Hedley Hill Colliery, Waterhouses, Co. Durham Feb. 12, 1898
31 Daykin, George, 116, High Gurney Villa, near Bishop Auckland July 14, 1896
32 Denton, John, Montgomery Chambers, Hartshead, Sheffield  S. June 21, 1894
A. Aug. 4, 1900
33 Ditmas, Francis Ivan Leslie, Ferryhill, Co. Durham June 11, 1898
34 Dormand, R. B., Waldridge Colliery, Chester-le-Street Dec. 9, 1893
35 Draper, William, New Seaham Colliery, Sunderland Dec. 14, 1889
36 Dunnett, Samuel, 20, Hambledon Street, Blyth, Northumberland
37 Eltringham, G., Eltringham Colliery, Prudhoe-upon-Tyne, R.S.O.  Dec. 8, 1894
June 8, 1895
38 Elves, Edward, Middridge Colliery, Heighington, R.S.O., Co. Durham June 13, 1896
39 Emmerson, George, Brandon Colliery, near Durham Oct. 8, 1898
40 Falcon, Michael, 33, Bute Street, Treorchy, South Wales S. Oct. 13, 1894
A. Aug. 4, 1900
41 Fawcett, Edward, Middle Street, Walker-upon-Tyne June 11, 1892
42 Fewster, John, 4, Belgrave Terrace, Felling, R.S.O., Co. Durham Feb. 13, 1897
43 Finney, Joseph, Elswick Collieries, Newcastle-upon-Tyne Aug. 6, 1898
44 Gordon, George Stoker, Louisa Terrace, West Stanley Feb. 15, 1896
45 Hampson, Alexander, St. Helen's Colliery, Bishop Auckland Feb. 12, 1898
46 Handyside, William, Jun., 4, Brandling Terrace, Felling-upon-Tyne June 12, 1897
47 Hare, George, Seghill Colliery, Northumberland Feb. 12, 1898
48 Harle, R. A., Wallsend Colliery, Wallsend-upon-Tyne April 14, 1894
49 Hedley, A. M., Medomsley, R.S.O., Co. Durham Nov. 24, 1894
50 Henderson, William, Wheatley Hill Colliery, via Trimdon Grange Aug. 5, 1893
51 Herron, Edward, Holly Terrace, Stanley, R.S.O. Feb. 15, 1896
52 Heslop, William, Hunwick, Willington, Co. Durham Oct. 8, 1898
53 Hindmarch, John, Isabella Pit, Newsham, Blyth Aug. 3, 1895
54 Hobson, Moses, Shildon, via Darlington Aug. 5, 1893
55 Hornsby, Demster, Herrington Pit, New Herrington, Fence Houses. Feb. 12, 1898
56 Howe, James, Jun., East Cross Street, Langley Park, Durham Feb. 11, 1899
57 Hughes, James Nicholson, Hedley Hill Colliery, Waterhouses, Co. Durham Feb. 12, 1898
58 Hunter, A., 193, Stephenson Street, South Shields Feb. 13, 1897
59 Hunter, Christopher, Cowpen Colliery Office, Blyth, Northumberland Dec. 10, 1892
60 James, Alexander A., Croxdale, near Durham June 10, 1893
61 Johnson, James, 4, Oswald Terrace, Castletown, Sunderland Aug. 6, 1898
62 Johnson, William, Framwellgate Moor, Durham Aug. 6, 1892
63 Kearton, Christopher, Rose Cottage, Keekle, Hensingham, Cumberland Aug. 5, 1899

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Date of Election
and of Transfer.
64 Kellett, Robert, Copley Lane, Butterknowle, R.S.O., Co. Durham Feb. 12, 1898
65 King, Fred., 1, Shankhouse Row, Shankhouse, near Cramlington, Northumberland S. Oct. 8, 1892
A. Aug. 4, 1900
66 Lightley, John, Front Street, Sherburn Colliery, Durham April 25, 1896
67 Lindsay, Robert, 3, Sebastopol Terrace, Seaham Harbour Dec. 8, 1894
68 Lishman, T. A., Harton Colliery, Tyne Dock, South Shields S. Nov. 24, 1894
A. Aug. 7, 1897
69 MacKinlay, Edward, 20, Fourth Street, Heworth Village, Felling, R.S.O., Co. Durham June 11, 1892
70 Manderson, John Tom, c/o Mrs. T. E. Hall, Dene Crescent. Walker-upon-Tyne  
Feb. 13, 1897

71 Marr, James Heppell, Ravensworth Colliery, near Lamesley, Co.  
Durham  Feb. 13, 1897

72 Marshall, John, 124, Manchester Road, E., Little Hulton, near Bolton, Lancashire  
Feb. 12, 1898

73 Mason, Benjamin, Burnopfield Colliery, Burnopfield, R.S.O., Co. Durham  
April 11, 1891

74 Milburn, William, Birtley White House, near Chester-le-Street  June 8, 1895
75 Miller, J. H., South Hetton, Sunderland  Dec. 8, 1894
76 Minto, George William, Perkins Ville, Chester-le-Street Oct. 10, 1891
77 Morland, Thomas, 24, Langley Street, Langley Park, Durham  Feb. 11, 1899
78 Naisbit, John, No. 48, Tudhoe Colliery, Spennymoor  April 27, 1895
79 Owen, William Rowland, 32, Duke Street, Millom, Cumberland  
Feb. 12, 1898

80 Parkinson, W., 6, Ivy Terrace, South Moor, Chester-le-Street  June 13, 1891
81 Pedelty, Simon, Littletown Colliery, Durham  Dec. 10, 1892
82 Peel, J. W., Orchard House, Escombe, Bishop Auckland  S. Aug. 4, 1894
A. Aug. 4, 1900
83 Pratt, G. Ross, Springwell Colliery, Gateshead-upon-Tyne  April 27, 1895
84 Proctor, Thomas, Woodhorn Colliery, Morpeth  Dec. 10, 1892
85 Ramsay, John, Tursdale Colliery, Ferryhill  Aug. 5, 1899
86 Ramsay, J. G Page Bank Colliery, via Spennymoor, Co. Durham  Feb. 8, 1890

87 Raw, John, Hunwick, Willington, Co. Durham  Feb. 9, 1895
88 Ridley, George D., Tudhoe Colliery, Spennymoor  S. June 11, 1892
A. Aug. 3, 1895
89 Rivers, John, Bow Street, Thornley Colliery, Durham  Dec. 10, 1898
90 Robson, William, Jun., Byers Green Collieries, Bishop Auckland  S. Jan. 19, 1895
A. Aug. 4, 1900
91 Rochester, William, Jun., Emma Colliery, Ryton-upon-Tyne  June 8, 1895
92 Sample, J. B., Beamish Colliery, Pit Hill, R.S.O., Co. Durham  Oct. 13, 1894
93 Saner, Charles B., Rietfontein "A," Limited, per Private Bag, Johannesburg,  
Transvaal  April 10, 1897

94 Severs, Jonathan, Stanley, R.S.O., Newcastle-upon-Tyne  S. June 8, 1895
A. Aug. 4, 1900
95 Severs, William, Beamish View, via Chester-le-Street  Nov. 5, 1892
96 Simpson, Nelson Ashbridge, Bradley Hall, Wylam-upon-Tyne  S. Aug. 1, 1891
A. Aug. 7, 1897
97 Stokoe, James, Ravensworth Colliery, Low Fell, Gates-head-upon-Tyne  
Nov. 24, 1894
98 Stokoe, John George, Coalburn, Hepscott, Morpeth  Dec. 9, 1899
99 Swallow, F. C, 36, Manor Court Road, Nuneaton  April 14, 1894
100 Swallow, Ralph Storey, Langley Park Colliery, Durham  Dec. 9, 1899
Date of Election
and of Transfer.
101 Tarbuck, Harold, Ryhope Colliery, near Sunderland Feb. 15, 1896
102 Thompson, Joseph, North Biddick Colliery, Washington Station, Co. Durham April 8, 1893
103 Turner, George, Tindale Terrace, Roachburn Colliery, Brampton Junction, Carlisle June 8, 1895
104 Urwin, John, Inkerman House, Usworth Colliery Feb. 15, 1896
105 Wainwright, William, Heworth Colliery, Felling, R.S.O., Co. Durham April 2, 1898
106 Watson, Thomas, East Hedley Hope, Tow Law, R.S.O. Aug. 3, 1895
107 Willis, Henry Stevenson, Lead Company's Office, Middleton-in-Teesdale, by Darlington S. Feb. 13, 1892
A. Aug. 4, 1900
108 Wilson, R. G., Pelton Colliery, Chester-le-Street Aug. 6, 1892

STUDENTS.

Date of Election.
1 Armstrong, William, Jun., Cramlington Collieries, Northumberland June 11, 1898
2 Bayldon, Harold Cresswell, c/o Bechuanaland Exploration Company, Limited, Bulawayo, Rhodesia, South Africa April 2, 1898
3 Bell, William, Elswick Collieries, Newcastle-upon-Tyne Feb. 10, 1900
4 Borrow, Frank Kendall, 38, Nevern Square, London, S.W. Oct. 8, 1898
5 Burne, Cecil A., Copiapo Mining Company, Copiapo, Chile, South America Aug. 4, 1894
6 Clive, Robert, Langley Park Colliery, near Durham Feb. 10, 1900
7 Coxon, William B., Langley Park Colliery, Durham Feb. 12, 1898
8 Crofton, Charles Arthur, 2, South View, St. Helen's, Bishop Auckland Dec. 10, 1898
9 Dixon, George, East Hetton Colliery Office, Coxhoe Bridge, Co. Durham June 13, 1896
10 Eddowes, Hugh M., College Court, Shrewsbury Oct. 8, 1898
11 Glass, Robert William, Axwell Park Colliery, Swalwell, R.S.O., Co. Durham June 10, 1899
13 Greenwell, Alan Leonard Stapyton, South Durham Colliery, Eldon, Bishop Auckland Oct. 8, 1898
14 Hall, Joseph Percival, Edmondsley Colliery, Chester-le-Street Oct. 9, 1897
15 Harbit, William Denham, 32, High Street, Wallsend-upon-Tyne Dec. 10, 1898
16 Heaps, Christopher, 12, Richmond Terrace, Gateshead-upon-Tyne. Feb. 10, 1910
17 Holliday, Norman Stanley, Langley Grove, Durham April 10, 1897
18 Jaeger, Bernard, Anglo-American Club, Freiburg in Sachsen, Germany June 12, 1897
19 Jones, William, Hamsteels Colliery, near Durham Aug. 4, 1894
20 Latimer, Hugh, South Durham Colliery, Eldon, Bishop Auckland Feb. 15, 1896
21 Leathart, W. B. S., Bracken Dene, Gateshead-upon-Tyne June 11, 1898
22 McGowan, Ernest, c/o Griffith and Company, 14, Royal Arcade, Newcastle-upon-Tyne Oct. 13, 1894
24 Marley, Frederick Thomas, Hebburn Colliery, Newcastle-upon-Tyne Oct. 8, 1898

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Date of Election.

25 Middleton, H. W., Trimdon Grange Colliery, Trimdon Grange, R.S.O., Co. Durham Aug. 4, 1894
26 Milburn, Edwin Walter, Link View, Blyth, Northumberland Feb. 10, 1900
27 Milburne, John Etherington, Collingwood Street, Coundon, Bishop Auckland Oct. 14, 1899
28 Minns, Thomas Tate, Jun., No. 4 Herrington Pit, New Herrington, Fence Houses April 10, 1897
29*Mitchell-Withers, William Charles, School of Mines, Camborne, Cornwall April 28, 1900
30 Murray, Frank Douglas, 9, Stratton Street, Piccadilly, London, W. Aug. 7, 1897
31 Musgrove, William, Throckley Colliery Office, Throckley Colliery, near Newcastle-upon-Tyne June 8, 1895
32 Nesbit, John Straker, Cramlington Collieries, Northumberland Oct. 9, 1897
33 Nisbet, Norman, Harraton Colliery, Washington Station, R.S.O., Co. Durham Nov. 24, 1894
34 Parrington, T. E., Hill House, Monkwearmouth Aug. 3, 1895
35 Pearson, Richard Nash Dec. 10, 1898
36 Peterkin, John Alexander, 13, Swinley Road, Wigan, Lancashire June 12, 1897
38 Ramsey, Robert, Felling Colliery, Newcastle-upon-Tyne Oct. 8, 1898
39 Richardson, Nicholas, South Ashfield, Newcastle-upon-Tyne Dec. 12, 1896
40 Richardson, Sydney, South Pelaw Colliery, Chester-le-Street Oct. 9, 1897
41 Robinson, George Henry, Jun., Holm Lea, Sunderland Dec. 9, 1899
42 Robinson, John Walton, Jun., 6, Gladstone Terrace, Gateshead-upon-Tyne April 2, 1898
43 Rogers, John, Coanwood, near Carlisle April 8, 1899
44 Roose, Hubert F. G., 45, Hill Street, Berkeley Square, London Dec. 9, 1899
45 Routledge, Robert, Jun., Colliery House, Garforth, near Leeds Feb. 13, 1897
46 Rutherford, Thomas Easton, South Derwent Colliery, Annfield Plain, Co. Durham June 10, 1899
47 Simpson, R. R., 11, Haldane Terrace, Jesmond, Newcastle-upon-Tyne Aug. 3, 1895
49 Snowdon, Thomas, Jun., Oakwood, Cockfield, R.S.O., Co. Durham June 12, 1897
50 Southern, Stephen, Heworth Colliery, Felling, R.S.O., Co. Durham Dec. 14, 1895
51 Stewart, William, Milnthorp House, Sandal, Wakefield Oct. 8, 1898
52 Stratton, H. S., 15, Portland Terrace, Newcastle-upon-Tyne Feb. 9, 1895
53 Swallow, W. A., Tanfield Lea, Tantobie, R.S.O., Co. Durham Dec. 9, 1893
54 Tate, W. O., Trimdon Grange, Co. Durham Oct. 12, 1895
55 Thornton, Norman, Pelton Colliery, Chester-le-Street April 27, 1895
56  Tweddell, John Smith, Seaton Delaval Colliery, Northumberland  Feb. 13, 1897
57  Walton, Arthur John, Seghill Colliery, Northumberland  Feb. 12, 1898
58  Welsh, Arthur, 3, Model Street, New Seaham Colliery, Sunderland  Aug. 1, 1896
59  Wilbraham, Arthur G. B., Mina de S. Domingos, Mertola Portugal  Dec. 11, 1897

SUBSCRIBERS.

1  Owners of Ashington Colliery, Newcastle-upon-Tyne.
2  Birtley Iron Company (3), Birtley.
3  Bridgewater Trustees (2), Bridgewater Offices, Walkden, Bolton-le-Moors, Lancashire.
4  Marquess of Bute, Bute Estate Offices, Aberdare, South Wales.
5  Butterknowle Colliery Company, Darlington.
6  Cowpen Coal Company, Limited (2), F, King Street, Newcastle-upon-Tyne.
7  Earl of Durham (2), Lambton Offices, Fence Houses.
8  Elswick Coal Company, Limited, Newcastle-upon-Tyne.
9  Harton Colliery Company, Limited (3), Harton Collieries, South Shields.
10  Hetton Coal Company (5), Fence Houses.
11  Joicey, James, and Company, Limited (2), Newcastle-upon-Tyne.
12  Lambton Collieries, Limited (2), E, Queen Street, Newcastle-upon-Tyne.
13  Marquis of Londonderry (5), c/o V. W. Corbett, Londonderry Offices, Seaham Harbour.
15  Owners of North Hetton Colliery (3), Fence Houses.
16  Ryhope Coal Company (2), Ryhope Colliery, near Sunderland.
17  Owners of Seghill Colliery, Seghill, Northumberland.
18  Owners of Soth Hetton and Murton Collieries (2), 50, John Street, Sunderland.
19  Owners of Stella Colliery, Hedgefield, Blaydon-upon-Tyne.
20  Owners of Throckley Colliery, Newcastle-upon-Tyne.
22  Owners of Wearmouth Colliery (2), Sunderland.
23  Westport Coal Company, Limited (2), Manager, Dunedin, New Zealand.

ENUMERATION.

August 4, 1900
Honorary Members 30
Members 883
Associate Members 132
Associates 108
Students 59
Subscribers 23
Honorary Members 30

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Total 1,235

Members are desired to communicate all changes of address, or any corrections or omissions in the list of names, to the Secretary.
MEMOIR OF SAMUEL BAILEY.

Samuel Bailey, mining engineer of Birmingham, F.G.S. (1865), born 16th April, 1825, came of a mining family, his grandfather, Samuel Bailey, a mining engineer, in the early years of the nineteenth century, being connected with the collieries of Earl Fitzwilliam near Sheffield, and afterwards at those of the Earl of Lichfield, near Walsall. His father was mining engineer in 1836 to Messrs. John Bagnall & Sons, one of the largest firms of ironmasters in South Staffordshire and of railmakers in the time of the railway mania about 1840. He was trained at these extensive collieries, and became a practical mining engineer, of singular uprightness and indefatigable industry. He eventually became mining adviser to the Earl of Dartmouth, Lord Hatherton, Mr. John Percy, F.R.S., Mr. H. C. Vernon and many others, and retained his connexion with their successors until his death on November, 19th, 1899. He was among the foremost in the Midland counties to introduce, at an early date, underground hauling machinery in lieu of horse draft, and also in the search for and development of the coal-seams lying under the Permians outside of the Old South Staffordshire coal-field, rightly named in those years, "the Black Country." About 30 years ago he was joined in partnership under the name of Messrs. S. & J. Bailey, by his brother, and subsequently by his sons, Mr. T. H. Bailey and Mr. E. J. Bailey, and in conjunction with them was engaged until the time of his death in important developments of coal-areas between the Staffordshire and Shropshire coal-fields, and in the oulying and until then unproved coal-field of Warwickshire.

He had been a member of the North of England Institute of Mining and Mechanical Engineers since June 2nd, 1859. In 1861, at the meeting in Birmingham, he contributed an excellent paper, containing many valuable suggestions, "On the Advantage and Necessity of the Introduction of Steam-power for the Purpose of Underground Conveyance in the Coal- and Ironstone-mines of South Staffordshire."*


BRIEF SYLLABUS
OF THE
THREE YEARS' COURSE OF LECTURES
FOR
COLLIERY ENGINEERS, ENGINEWRIGHTS,
APPRENTICE MECHANICS, AND OTHERS.

The Council of the North of England Institute of Mining and Mechanical Engineers, in collaboration with the Council of The Durham College of Science, have arranged a course of Lectures for Colliery Engineers, Enginewrights, Apprentice Mechanics, and others, to be delivered at The Durham College of Science, Newcastle-upon-Tyne.

The course will extend over three winter sessions, and involves attendance for 24 Saturday afternoons, from 3 p.m. to 5 p.m. during each session. Students can enter any of the courses, each series of Lectures being, as far as possible, entirely independent of the others, and constituting a complete course upon its own subject.

It is desirable that Students should not be less than 17 years of age.

The delivery of the next course of Lectures will commence on October 6th, 1900. The fee for the series of four courses given during each session is £1 10s.

Examinations will be held at the end of each course in the respective subjects. Certificates will be granted to those Students who attend satisfactorily and pass the
Examinations throughout the three years’ course, and Prizes will be awarded annually to the two Students who do best in the aggregate Examinations of the year. Prof. Henry Louis reports that during the session 1899-1900, the following courses of lectures were delivered:—Iron and Steel, by Mr. Saville Shaw; Pumping and Ventilation, by Prof. Henry Louis; Transmission of Power, by Mr. R. M. Ferrier; and Mining Machinery, by Prof. Henry Louis. The two former lectures were attended by 89 students and the latter by 74. Out of these, 52 sat for Examination in the two first-named subjects, and 28 succeeded in passing; and the numbers were respectively 49 and 30 in the two latter subjects. Prizes were awarded to Messrs. James Wray and John Brass, who gained the highest aggregate number of marks during the session. The Students attended with commendable regularity, but the proportion who sent in home work was less than it should have been. The Council recommend that colliery owners and others, who send Students to these classes, should insist upon home work being done regularly.

Several colliery owners have agreed to pay the fees and (or) train fares of a number of Students whom they propose to send to the course of Lectures. Any further information will be supplied on application to Mr. F. H. Pruen, Secretary, Durham College of Science, Newcastle-upon-Tyne, or Mr. M. Walton Brown, Secretary, North of England Institute of Mining and Mechanical Engineers, Neville Hall, Newcastle-upon-Tyne.

1900 - 1.—MICHAELMAS TERM.
Mensuration.—3-4 p.m.
Lecturer—Principal H. P. Gurney, M.A., D.C.L., F.G.S.
Lengths, triangles, similar figures, chords, arcs and circumferences of circles. Areas of plane figures; rectangles, parallelograms, triangles and rectilinear figures; circles, sectors and segments of circles; Simpson’s rule; similar figures. Volumes of solid figures; parallelopiped, right prism, right circular cylinder, ring and pipe, right pyramid, right circular cone and sphere. Areas of surfaces of solids; plane surfaces, right circular cylinder, right circular cone and sphere. Mechanical mensuration.
The Chemistry of Fuel.—4-5 p.m.
Lecturer—Mr. Saville Shaw, M.Sc., F.C.S.

1900 - 1.—EPIPHANY TERM.
Strength of Materials (with Experimental Illustrations).—3-4 p.m.
Lecturer—Mr. R. M. Ferrier, M.Sc., C.E.
Materials used in construction:—Cast-iron, wrought-iron, steel, brass, brick, stress and strain. Strength under tension, compression, shearing, and bending. Breaking and working strengths; factors of safety; the effect of live loads; extension and compression under load; behaviour of material under stress; effect of length of specimens.
The Lectures will be illustrated by actual experiments on the 100 tons testing-machine in the Engineering Laboratory.

Experimental Mechanics.—4-5 p.m.
Lecturer—Mr. R. J. Patterson, M.Sc.
Introductory definitions, with illustrations; force and work, and their measurement; power; horsepower; principle of the conservation of energy. Machines for changing the magnitude and the direction of force;
workshop appliances, lever, single and double purchase winches, pulleys, inclined plane and screw, screwjack; friction, efficiency of machines. Graphical representation of forces. Specific gravity and its determination by the hydrostatic balance. The atmosphere and the pressure it exerts; the barometer; lifting and forcing pumps.

1901 - 2.—MICHAELMAS TERM.  
Theoretical Electricity.  
Lecturer—Mr. R. J. Patterson, M.Sc.  
Magnetism; lines of magnetic force, magnetic field; distinctive magnetic properties of iron and steel. Electricity; production of an electric current; magnetic, chemical and heating effects of the current; measurement of current strength, electro-motive force and resistance; practical electrical units, the ampere, volt and ohm; Ohm's Law. The principle of the dynamo; dynamo construction; various types of dynamos. The electric motor, its principle and use in workshops, mines, etc.

Electrical Engineering.  
Lecturer—Mr. W. M. Thornton, M.Sc.  

1901 - 2.—EPIPHANY TERM.  
The Steam-engine.  
Lecturer—Mr. R. M. Ferrier, M.Sc., C.E.  
Heat, its measurement and transfer; saturated steam; pressure and temperature of steam; expansion of steam; the indicator and indicator-diagrams; horsepower, indicated and effective; simple forms of the steam-engine, valves and the distribution of steam, governors; compound and triple-expansion engines; efficiency of the steam-engine; steam-boilers, combustion and draught; evaporative power of coal.

Haulage and Winding.  
Lecturer—Prof. H. Louis M.A., A.R.S.M.  
Main haulage-roads, animal traction, self-acting inclines, engine-planes, main-and-tail-rope haulage, endless-rope or endless-chain haulage; haulage-engines, plant and appliances, underground haulage-engines; electric, hydraulic and pneumatic engines; secondary haulage. Onsetting and banking out. Winding-engines, cages, ropes, safety appliances, pulley-irames, heapsteads, surface arrangements.

1902- 3.—MICHAELMAS TERM.  
Transmission of Power.  
Lecturer—Mr. R. M. Ferrier, M.Sc., C.E.  
Work and power; different forms of energy, its storage, transformation and transmission; simple machines, friction and lost work, efficiency of machinery; methods of transmitting power, shafting and bearings, spur-and-bevel wheels, rope gearing, hydraulic transmission, compressed-air transmission; the steam-engine and boiler; comparison of different methods.
Pumping and Ventilation.
Lecturer—Prop. H. Louis, M.A., A.R.S.M.
Elementary notions of drainage, dams, reservoirs; syphons; baling; arrangement of pumps, driving, starting and working pumps; pipes; bucket-pumps; plunger-pumps; details, balance-bobs, angle-bobs, spears, catches, etc.; pump-valves; direct-acting pumps; electric, pneumatic and hydraulic pumps. Principles of ventilation; movement of air-currents; measurement of air-currents; anemometers, water-gauges; natural ventilation; ventilating appliances, fans, furnaces; distribution of air-currents, splitting currents, doors, stoppings, regulators; general considerations affecting ventilation.

1902 - 3.—EPIPHANY TERM.
Iron and Steel.
Lecturer—Mr. Savill Shaw, M.Sc., F.O.S.

Mining Machinery (mainly Machinery used Underground).
Lecturer—Prof. H. Louis, M.A., A.R.S.M.

LIST OF COMMITTEES, 1900-1901.

Finance Committee.
Mr. T. W. Benson.
Mr. W. Cochrane.
Mr. J. Daglish.
Mr. T. Douglas.
Mr. G. B. Forster.
Mr. J. L. Hedley.
Mr. George May.
Mr. J. B. Simpson.
Sir Lindsay Wood, Bart.

Library Committee.
Mr. G. B. Forster.
Mr. T. E. Forster.
Prof. H. Louis.
Mr. J. H. Merivale.
Mr. George May.
Mr. R. A S. Redmayne.
Mr. John Simpson.
Sir Lindsay Wood, Bart.

Prizes Committee
Mr. T. W. Benson.
Mr. W. Cochrane.
Mr. G. B. Forster.
Mr. T. E. Forster.
Mr. T. E. Jobling.
Mr. George May.
Mr. J. H. Merivale.
Mr. F. R. Simpson.
Mr. J. B. Simpson.

Arrears Committee.
Mr. R. Donald Bain.
Mr. G. F. Bell.
Mr. T. W. Benson.
Mr. H. F. Bulman.
Mr. W. Cochrane.
Mr. M. H. Douglas.
Mr. G. B. Forster.
Mr. J. L. Hedley.
Mr. A. C. Kayll.
Mr. John Simpson.
Mr. J. B. Simpson.

Reference Committee for Papers to Read.

(a) Coal Mining.
Mr. G. F. Bell.
Mr. W. C. Blackett
Mr. H. F. Bulman.
Mr. G. B. Forster.
Mr. George May.
Mr. R. A. S. Redmayne.
Mr. John Simpson
Mr. A. L. Steavenson.
Sir Lindsay Wood, Bart

(b) Metalliferous Mining.
Mr. R. Donald Bain.
Mr. T. W. Benson.
Mr. W. Cochrane.
Mr. J. L. Hedley.
Prof. H. Louis.
Mr. J. H. Merivale.
Mr. A. L. Steavenson.

(c) Geological.
Mr. R. Donald Bain.
Mr. J. L. Hedley.
Prof. H. Louis.
Mr. J. H. Merivale.
(d) Mechanical and Electrical Engineering
Mr. W. C. Blackett
Mr. W. Cochrane Mr. H. Lawrence
Mr. C. C. Leach
Mr. J. H. Merivale.
 Mr. R. A. S. Redmayne.
Mr. A. L. Steavenson.

(e) Civil Engineering.
Mr. T. E. Forster.
Prof. H. Louis.
 Mr. M. W. Parrington
Mr. J. B. Simpson.
 Mr. A. L. Steavenson.

(f) Chemical.
Sir Lowthian Bell, Bart. Mr. W. Cochrane
Prof. H. Louis. Mr. R. A. S. Redmayne.

N.B. - The President is ex officio on all Committees.

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LIST OF TRANSACTIONS AND JOURNALS OF SOCIETIES
Etc., IN THE LIBRARY.
* Exchanges. † Exchanges. †Presented.

*American Academy of Arts and Sciences, Boston. Memoirs, complete to vol. xii., parts 1 to 4, 1893. Proceedings, complete.
*American Institute of Mining Engineers, New York City. Transactions, complete from 1871.
†American Machinist, New York, 1894 to date. By the U.S.A. Consul.
*American Society of Civil Engineers, New York City. Proceedings, complete from 1872. Transactions, complete from 1872.
*American Society of Mechanical Engineers, New York City. Transactions, complete from 1880.
†Annales des Mines de Belgique, Brussels. Memoires, complete.
*Annales des Ponts et Chaussees, Paris. Memoires et Documents, complete from series G. Lois, Decrets, etc., complete from series 6. Personnel, complete from 1881.

Board of Trade Journal, London. Complete from 1886.


British Association for the Advancement of Science. Complete from 1831. By the Association.


British Society of Mining Students, Cinderford. Journal, complete.

Brown's Export List, Newcastle-upon-Tyne. Complete from 1853.

Bulletin Russe de Statistique Financiere et de Legislation, St. Petersbourg. Complete from 1895

California State Mining Bureau, Sacramento. Annual Reports of the State Mineralogist. 5th to 12th. By the State.

Canadian Institute, Toronto. Annual Reports, complete from 1887. Transactions complete, with the exception of vol. i., series i. (The Canadian Journal), parts 6, 7 and 10; vol. xv., series ii. (The Canadian Journal), parts 5 and 7; vol. i., series iii. (Proceedings of the Canadian Institute); vol. iii., series iii. (Proceedings of the Canadian Institute), parts 1, 3, and all after 4.

Canadian Mining Institute (late Federated Canadian Mining Institute), Ottawa. Journal, complete from vol. i., 1896.

Canadian Mining Review, Ottawa. Complete from vol. xi.


Chemical and Metallurgical Society of South Africa. Proceedings, complete from vol. i. Journal, complete from vol. i.

Chesterfield and Midland Counties Institution of Engineers, Chesterfield. Transactions, complete.

Cleveland Institution of Engineers, Middlesbro'. Proceedings, complete from 1869.

Coal and Iron, London, complete from vol. iii. By the Publishers.

Colegio de Ingenieros de Venezuela, Caracas. El Ingeniero, vol. i., no. 1, 1898.


Meteorological Returns and Reports, complete from 1868 to 1884, with the exception of those for 1873-74 and 1885-86. Miscellaneous Publications, complete with the exception of Nos. 1, 2, 12, 13, 16, 17, and 19 to 28.

Colonial Reports. Annual and Miscellaneous Series. Complete from commencement 1891.

*Compressed Air. Vol. i., nos. 2 and 3; vol. iv., nos. 2, 3, and 8 to 12; vol. v., nos. 1, 3, 5 and 6. By the Publishers.

*Connecticut Academy of Arts and Science, New Haven. Transactions, complete, except title-page and index to vol. iv.


‡De Beers Consolidated Mines, Limited, Kimberley. Annual Reports, complete from the first, 1889. By the Company.


†Durham University Calendar, Durham. Complete from 1873, except for the years 1881 and 1891. By the College.

*Engineering Association of New South Wales, Sydney. Minutes of Proceedings, complete from 1885 to vol. x. for 1894.


Explosives. Annual Reports of Her Majesty's Inspectors of Explosives. Complete from the first, 1875.

Fielden's Magazine. Complete from vol. i., 1899.

Foreign Office Reports, London. Complete from 1886.

†Franklin Institute of the State of Pennsylvania, Philadelphia. Journal, complete from vol. iv.

†General Mining Association of the Province of Quebec. Journal, complete to 1895.

*Geological Institution of the University of Upsala, Upsala. Bulletin, complete.


*Geological Survey of Iowa, Des Moines. Annual Reports, complete from vol. i.


*Geologiska Forening, Stockholm.  Forhandlingar, complete from 1872.
*Gluckauf, Essen.  Complete from 1883.

*Institut Geologique du Mexique, Mexico.  Boletin, complete from 1895.
*Institution of Engineers and Shipbuilders in Scotland, Glasgow.  Transactions, complete from 1857, except vol. ii.
*Institution of Civil Engineers, London.  Minutes of Proceedings, complete from 1837.
*Institution of Civil Engineers of Ireland, Dublin.  Transactions complete from 1845.
†Institution of Mechanical Engineers, London.  Proceedings, complete from 1847.
†Institution of Mining and Metallurgy, London.  Transactions, complete from vol. i.
†Institution of Mining Engineers, Newcastle-upon-Tyne.  Transactions, complete from vol. i., 1889.  By the Institution.
‡Inventors' Review and Scientific Record, London.  Complete from vol. iv., no. 4; except vol. v., nos. 7 and 12; vol. vi., nos. 4 and 8 to 12; vol. vii., nos. 1 to 3, 5, 6 and 9 to 12; and vol. viii., nos. 1 to 3.  By the Publishers.
*Iron and Steel Institute, London.  Journal, complete from 1871.

*Jaarboek van het Mijnwezen in Nederlandsch Oost-Indie, Amsterdam.  Complete from 1878.
*Jernkontorets Annaler.  Complete from 1900.

*Kaiserliche Akademie der Wissenschaften, Vienna.  Sitzungsberichte, complete from vol. xlix., except Mathematik, Physik, Chemie, etc., vols. lx. to lxiv.
*Kaiserlich-konigliche Geologische Reichsanstalt, Vienna.  Jahrbuch, complete from 1860.
*Kaiserlich-leopoldinisch-Carolinische Deutsche Akademie der Naturforscher, Halle.  Complete from vol. xxxvi.
*Königlich Preussischen Geologischen Landesanstalt und Bergakademie zu Berlin.  Annual volumes for 1880-81, 1892-95.

†Lake Superior Mining Institute.  Proceedings, complete from vol. i., 1893.
*Liverpool Engineering Society, Liverpool. Complete from 1881.
‡Liverpool Geological Association, Liverpool. Transactions, complete from 1880 to vol. x., 1890, except vols. iv. and viii.
*L’Union des Charbonnages, Mines et Usines Métallurgiques de la Province de Liège. Complete from 1872.

‡Machinery Market and Exporter. Complete from 1895. By the Publishers.
*Magyarhoni Foldtani Tarsulat, Budapest. Foldtani Kozlony, complete from 1871.
*Manchester Association of Engineers, Manchester. Transactions, complete from 1887.
†Manchester Geographical Society, Manchester. Journal, complete from vol. vi.
†Manchester Geological Society, Manchester. Transactions, complete from 1840, except vols. iii., vii. and ix.
*Manchester Literary and Philosophical Society, Manchester. Memoirs, complete except all volumes in first series. Proceedings, complete from 1887.

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†Massachusetts Institute of Technology, Society of Arts, Boston. Complete from vol. xi.
‡Mechanical Engineer. Complete. By the Publishers.
‡Mechanical Progress. Complete. By the Publishers.
*Midland Institute of Mining, Civil and Mechanical Engineers, Barnsley. Transactions, complete from 1869.
*Mining Association and Institute of Cornwall, Camborne. Transactions, complete to vol. iv., part 1, 1893.
‡Mining Engineering. Complete from vol. i., 1897. By the Publishers.
*Mining Institute of Scotland, Hamilton. Transactions, complete.
†Mining Society of Nova Scotia, Halifax. Transactions, complete.
‡Mount Bischoff Tin Mining Company, Tasmania. Half-yearly Reports, complete from the 46th, 1896. By Mr. H. W. Ferd. Kayser.

‡National Association of Colliery Managers. Transactions, complete. By the Association.
Natural History Society of Northumberland and Durham, Newcastle-upon-Tyne. Complete from 1838.
*Naturforschende Gesellschaft zu Freiburg im Breisgau, Freiburg. Transactions, complete from 1886.
*Neues Jahrbuch für Mineralogie, Geologie, und Paläontologie, Stuttgart. Complete from 1883, except Supplement, part 1.
†New South Wales, Annual Report of the Department of Mines. Complete from 1881.
*New York Academy of Sciences, New York. Transactions, complete from 1881, except vol. iii. Annals, complete from 1879.
*New Zealand Institute, Wellington. Transactions and Proceedings, complete, except vol. ii. (1869), vol. iii. (1870) and vol. iv. (1871).
†New Zealand Institute of Mining Engineers. Transactions, complete from vol. i., 1897.
*New Zealand Mines Department, Wellington. Reports, complete from 1879. New Zealand Mines Record. Complete from vol. i., 1897.
Norges geologiske undersogelse. Complete from No. 1, 1891.
*North-East Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne. Transactions, complete from vol. i., 1884.
*North Staffordshire Institute of Mining and Mechanical Engineers, Newcastle-under-Lyme. Transactions, complete from vol. i., 1873, except vol. ii., vol. xiii., parts 6 to 13, and vol. xiv., parts 1 to 4, 7, 9, and 10.
*Nova Scotia Department of Mines, Halifax. Reports, complete from 1862.
*Nova Scotian Institute of Natural Science, Halifax, N.S. Proceedings and Transactions, complete from vol. vi., 1883.

†Ontario Bureau of Mines, Reports. Complete from 1891. By the Bureau.
*Patents and Patentees of Victoria, Melbourne. Indexes, complete.
*Pennsylvania State College, Centre County, Pennsylvania. Mining Bulletin, complete from vol. i.
*Philosophical Society of Glasgow, Glasgow. Proceedings, complete from 1841.

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*Reale Comitato Geologico d'Italia, Roma. Bollettino, complete from 1870.
Reports to the Secretary of the Board of Trade upon the Working of the Boiler Explosions Acts, 1882 and 1890, London. Complete.
Revista Minera, Metalurgica, y de Ingenieria, Madrid. Complete from vol. xxxiv., 1883.
*Rochester Academy of Science, Rochester. Proceedings, complete from vol. i.
*Royal Cornwall Polytechnic Society, Falmouth. Annual Reports, complete from 1870.
*Royal Dublin Society, Dublin. Proceedings, complete from 1856. Transactions, complete from 1877.
*Royal Geological Society of Cornwall, Penzance. Transactions, complete from vol. v.
*Royal Institute of British Architects, London. Proceedings, complete from 1841, except vol. i., part 1, 1857 to 1862, 1867 to 1870, and 1873 to 1876. Journal of Proceedings, complete from 1881.
*Royal Institution of Cornwall, Truro. Journal, complete from 1856.
*Royal Society of Victoria, Melbourne. Transactions, complete, except vols. i. and vi.

*Sanitary Institute of Great Britain, London. Transactions, complete from 1880.
*Sociedad Nacional de Mineria, Santiago, Chile. Boletin, complete from vol. x., No. 18, 1898.
*Societe Belge de Geologie de Paleontologie et d'Hydrologie, Bruxelles. Bulletin, complete from vol. i., 1887.
*Societe des Ingenieurs des Mines, St. Petersbourg. Bulletin, complete from No. 12, 1897, except Nos. 1, and 3 to 5. 1898.
*Societe des Ingenieurs sortis de l'Ecole Provinciale d'Industrie et des Mines du Hainaut, Liege. Memoires, complete from 1850.
*Societe Geologique de Belgique, Liege. Annales, complete from 1874.
*Societe de l'Industrie Mine'rale, St. Etienne. Bulletin, complete from vol. vii., series 2, except vol. vii., 1893, part 4 ; and vol. viii., 1894, parts 1 and 2. Comptes-rendus,
complete from 1877, except 1894, January and March to November numbers. Atlases, complete from vol. vi., except 1893, part 4; and 1894, parts 1 and 2.


*Societe Scientifique Industrielle de Marseille, Marseille. Bulletin, complete.


*Society of Engineers, London. Transactions, complete from 1861.

*South African Association of Engineers and Architects, Johannesburg. Complete from vol. i.

†South African Republic. Reports of State Mining Engineer, complete from 1896.

*South Staffordshire Institute of Iron and Steel Works Managers, Stourbridge. Complete from vol. ii., 1881.

†South Wales Institute of Engineers, Cardiff. Transactions, complete from vol. i., 1857.

*Stahl und Eisen, Dusseldorf. Complete from vol. xiv.


‡Stevens' Indicator, Hoboken, New Jersey. Complete from vol. vi., 1889. By the Institute.

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Subject Matter Index of Technical and Scientific Periodicals. Compiled by Dr. R Rieth by the Order of The Imperial Patent Office, Berlin. Complete from 1892.

*Surveyors' Institution, London. Transactions, complete from 1868.

‡Tasmania. Annual Reports of the Secretary of Mines, from 1898-99. Annual Reports of the Surveyor-General and Secretary for Land, from 1898-99. The Progress of the Mineral Industry of Tasmania, from quarter commencing April 1, 1898.


*U.S. Naval Institute, Annapolis. Proceedings, complete from vol. viii., 1882.


*Vereins-Mittheilungen, Beilage zur Oesterreichischen Zeitschrift fur Berg-und Hutten wesen, Vienna. Complete from 1884.

*Victoria, Department of Mines, Melbourne. Reports, complete from 1874. Special Reports, complete from 1892. Gold-fields of Victoria, Mining Record, complete from 1897; Monthly Return, complete from 1898.


‡Western Australia, Department of Mines. Reports, complete from 1895. Gold Mines Statistics, complete from 1896. By the Government.

*Western Society of Engineers, Chicago. Journal, complete from vol. i.

*West of Scotland Iron and Steel Institute. Journal, complete from vol. iv.

*Wisconsin Academy of Sciences, Arts, and Letters, Madison. Transactions, complete to 1895.

CHARTER OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

FOUNDED 1852.
INTEGRATED NOVEMBER 28th, 1876.

VICTORIA, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, to all to whom these Presents shall Come, Greeting:

Whereas it has been represented to us that Nicholas Wood, of Hetton, in the County of Durham, Esquire (since deceased) ; Thomas Emerson Forster, of Newcastle-upon-Tyne, Esquire (since deceased); Sir George Elliot, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and Edward Fenwick Boyd, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty-two, form themselves into a Society, which is known by the name of The North of England Institute of Mining and Mechanical Engineers, having for its objects the Prevention of Accidents in Mines and the Advancement of the Sciences of Mining and Engineering generally, of which Society Lindsay Wood, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. And whereas it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property ; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community ; that the Society has since its establishment diligently pursued its aforesaid objects, and in so doing has made costly experiments and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions ; that the various modes of getting coal, whether by mechanical appliances or otherwise have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life ; that the Society has held meetings at stated
periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom; And whereas in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of our Kingdom, we have been besought to grant to the said Lindsay Wood, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. Now know ye that we, being desirous of encouraging a design so laudable and salutary, of our especial grace, certain knowledge, and mere motion, have willed, granted, and declared, and do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said Lindsay Wood, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "The North of England Institute of Mining and Mechanical Engineers," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of us, our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the statutes of mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectively at the rack rent which might have been had or gotten for the same respectively at the time of the purchase or acquisition thereof. And we do hereby grant our especial license and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments not exceeding charter.

with the lands, tenements or hereditaments so purchased or previously acquired such annual value as aforesaid, and also any moneys, stocks, securities, and other
personal estate to be laid out and disposed of in the purchase of any lands, tenements or hereditaments not exceeding the like annual value. And we further will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting, And our will and pleasure is, and we further grant and declare that for the better rule and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all ex-officio Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. And we do hereby further will and declare that the said Lindsay Wood shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectively shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. And we do hereby further will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. And we do further will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say : for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein ; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held.

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and for convening the same and regulating the proceedings thereat, and for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. And we do further will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these
presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, provided always that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. In witness whereof we have caused these our Letters to be made Patent.

Witness Ourself at our Palace, at Westminster, the 28th day of November, in the fortieth year of our reign.

[Great Seal of the United Kingdom] 

By Her Majesty's Command. 

CARDEW.

BYE-LAWS.

I.—Constitution.

1.—The North of England Institute of Mining and Mechanical Engineers shall consist of Members, Associate Members and Honorary Members. The Institute shall in addition comprise Associates and Students.

2.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Members and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council.

II.—Qualifications of Members, Associate Members, Honorary Members, Associates and Students.

3.—Members.—Every candidate for admission into the class of Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-three years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least two years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have been employed or have practised as an Engineer for at least five years. This class shall also comprise every person who was an Ordinary Member, Life Member, or Student on the first of August, 1877.

4.—Associate Members shall be persons connected with or interested in Mining or Engineering, and not practising as Mining or Mechanical Engineers, or in some other branch of Engineering.

5.—Honorary Members shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Associates shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines, or employed in analogous positions in other branches of Engineering.
7.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or other branch of Engineering, and such persons may continue Students until they attain the age of twenty-five years.

III.—Election and Expulsion of Members.
8.—Any person desirous of becoming a Member, an Associate Member, an Associate or a Student, shall be proposed according to the proper Form in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified. The Form must be signed by the proposer and at least two other Members or Associate Members, certifying a personal knowledge of the candidate, who shall himself sign the undertaking contained therein.

Any person qualified to become an Honorary Member shall be proposed according to the proper Form in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly stated. This Form must be signed by the proposer and at least five other Members or Associate Members, certifying a personal knowledge of the candidate, who shall himself sign the undertaking contained therein, and the Council shall have the power of defining the time during which, and the circumstances under which the candidate shall be an Honorary Member.

Any Associate or Student desirous of becoming a Member, shall be proposed and recommended according to the proper Form in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This Form must be signed by the proposer and at least two other Members or Associate Members, certifying a personal knowledge of the candidate, who shall himself sign the undertaking contained therein, and the proposal shall then be treated in the manner hereinafter described.

Every proposal shall be delivered to the Secretary, and by him submitted to the next meeting of the Council, who, on approving the qualifications, shall determine if the candidate is to be presented for ballot, and if it is so determined, the Chairman of the Council shall sign such proposal. The same shall be read at the next Ordinary General Meeting, and afterwards be exhibited in the Institute's Hall until the following Ordinary General Meeting, when the candidate shall be balloted for.

A Student may become an Associate at any time after attaining the age of twenty-one years.

9.—The balloting shall be conducted in the following manner:—Each Member or Associate Member attending the meeting, at which a ballot is to take place, shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the proper Form in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members and Associate Members voting.

10.—Notice of election shall be sent to every person within one week after his election, according to the proper Form in the Appendix, and the person elected shall send the amount of his annual subscription, or life composition, within four months from the date of such election, which otherwise shall become void.

11.—Every Member having signed a declaration according to the proper Form in the Appendix, and having likewise made the proper payment, shall receive a certificate of his election, according to the proper Form in the Appendix.

12.—Any Member, Associate Member, Associate or Student elected at any meeting between the Annual Meetings shall be entitled to all Transactions issued in the
Institute's year, so soon as he has signed and returned a declaration according to the proper Form in the Appendix, and paid his subscription.

13.—The Transactions of the Institute shall not be forwarded to those whose subscriptions are in arrear on the first of November in each year.

14.—Any person whose subscription is more than one year in arrear shall be reported to the Council, who shall direct application to be made for it, according to the proper Form in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter to his last recorded address in the books of the Society, according to the proper Form in the Appendix, of declaring that the defaulter has ceased to be a Member.

15.—In case the expulsion of any person shall be judged expedient by ten or more Members or Associate Members, and they think fit to draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the next meeting of the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half of the Members or Associate Members of the Institute; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the proper Form in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion; and if a majority of the Members and Associate Members present at such meeting (provided the number so present be not less than forty) vote that such person be expelled, the Chairman of that meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the proper Form in the Appendix.

IV.—Subscriptions.

16.—The annual subscription of each Member and Associate Member shall be £2 2s., of each Associate and Student £1 5s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

17.—Any Member, Associate Member, Associate or Student may, at any time, compound for all future subscriptions by a payment in accordance with the following scale:—

- Under 30 years of age, the sum of £31
- Over 30, £27
- 40, £24
- 50, £21
- 60, £17

or on such other conditions as the Council may, in writing, accept. Every person so compounding shall be a Member, Associate Member, Associate or Student for life, as the case may be. Any Associate Member, Associate or Student so compounding who may afterwards be qualified to become a Member, may do so, by election in the manner described in Bye-law 8. All compositions shall be deemed capital money of the Institute.

18.—In case any Member, Associate Member or Associate, who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed by them for that purpose, if they find good
reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a Member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the composition mentioned in Bye-law 17, and may thereupon release him from any or all future subscriptions, and permit him to resume his former rank in the Institute.

19.—Owners of Collieries, Engineers, Manufacturers, Railway Companies, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to tickets to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible; and each such subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Transactions of the Institute sent to him.

V.—Election of Officers.
20.—The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election to any office, with the exception of any President who may have held office for the two immediately preceding years, or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest

Council Meetings during the past year, and when any such attendances are equal, the Council shall decide between them; but any such Member or Associate Member shall be eligible for re-election after being one year out of office. Any Retiring Vice-President or Councillor who may be ineligible for re-election shall nevertheless be eligible to any other office.

21.—Each Member and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents, and Members of Council for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members and Associate Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the Ordinary General Meeting in June, and shall be the balloting list for the annual election in August. (See proper Form in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting to every Member and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other Member or Associate Member eligible for each respective office; but the number of names on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease, expulsion, or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to
the next Ordinary General Meeting a List of persons whom they nominate as suitable for the vacant office or offices, and a new Officer or Officers shall be elected at the first succeeding Ordinary General Meeting.

23.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

VI.—Duties of the Officers and Council.

24.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being ex-officio a member of all), and shall regulate and keep order in the proceedings.

25.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of

the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member or Associate Member present, to take the chair at the Meeting.

26.—At Meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members and Associate Members.

27.—The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

28.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating any specific subject connected with the objects of the Institute. Such Committees shall make a report to the Council, who shall act thereon, and make use thereof as they see occasion.

VII.—Communications and Memoirs.

29.—All papers shall be sent for the approval of the Council at least twenty-one days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and immediate notice shall be given to the writer whether it is to be printed or not.

30.—The copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

31.—Twenty copies of each paper printed by the Institute shall be presented to the author for private use.

32.—All proofs of reports of discussions, forwarded to any person for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

33.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

VIII.—Meetings of the Institute.

34.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council.
35.—All donations to the Institute shall be acknowledged in the Annual Report of the Council.

36.—A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members or Associate Members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

37.—The Members, Associate Members, Honorary Members, Associates, and Students, shall have notice of, and the privilege to attend, all Ordinary General Meetings and Special Meetings.

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38.—Every question, not otherwise provided for, which shall come before any meeting, shall be decided by the votes of the majority of the Members and Associate Members then present.

39.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote.

Any Member or Associate Member shall have power to introduce two strangers (see proper Form in the Appendix) to any General Meeting, but they shall not take part in the proceedings except by permission of the meeting.

IX.—Property of the Institute.

40.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

41.—The Institute Hall and Reading Room shall be open to the Members, Associate Members, Honorary Members, Associates and Students on every week day, from 10 a.m. to 5 p.m., except on such special day or days when the Council shall think it expedient to close the rooms and suspend the circulation of Books. Books shall be issued according to regulations from time to time approved by the Council.

42.—No duplicate copies of any portion of the Transactions shall be issued to any Member, Associate Member, Associate or Student, unless by order from the Council.

X.—Alteration of Bye-laws.

43.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

I hereby approve the foregoing Bye-laws.

M. W. RIDLEY,
One of Her Majesty’s Principal Secretaries of State.

Whitehall,
23rd September, 1898.

APPENDIX TO THE BYE-LAWS.

FORM A, Member or Honorary Member.
A. B. [Christian Name, Surname, Occupation, and Address in full], born on the ........day of....189 , being desirous of belonging to The North of England
Institute of Mining and Mechanical Engineers, I recommend him, from personal knowledge, as a person in every respect worthy of that distinction, because—[Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-laws 3 or 5.]

On the above grounds, I propose him to the Council as a proper person to belong to the Institute.

Signed ......................................................Member or Associate Member.

Dated this............................day of..............189

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We, the undersigned, concur in the above recommendation, from personal knowledge, being convinced that A. B. is in every respect a proper person to belong to the Institute.

......................................................Two Members or Associate

......................................................Members, or by Five Members

......................................................or Associate Members in the

......................................................case of the nomination

......................................................of an Honorary Member.

[Undertaking to be signed by the Candidate.]

I, the undersigned, do hereby promise that, in the event of my election, I will be governed by the Royal Charter and Bye-laws of the Institute for the time being, or as they may hereafter be altered, amended, or enlarged under the powers of the said Royal Charter; and that I will promote the objects of the Institute as far as may be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to belong to the Institute.

Signed

Dated this............................day of..................189

[To be filled up by the Council.]

The Council, having considered the above recommendation, present A. B. to be balloted for as a....................Member of The North of England Institute of Mining and Mechanical Engineers.

Signed.................Chairman.

Nominated at the Ordinary General Meeting ..................189

Passed by the Council :..................................................189

Elected at the Ordinary General Meeting.......................189

Age,............years,

FORM B, Associate Member, Associate or Student.

A. B. [Christian Name, Surname, Occupation, and Address in full], born on the........day of..................189, being desirous of belonging to The North of England Institute of Mining and Mechanical Engineers, I recommend him, from personal knowledge, as a person in every respect worthy of that distinction, and propose him to the Council as a proper person to belong to the Institute.

Signed..........................Member or Associate Member.

Dated this..............day of..................189

We, the undersigned, concur in the above recommendation, from personal knowledge, being convinced that A. B. is in every respect a proper person to belong to the Institute.

......................................................Two Members

or
[Undertaking to be signed by the Candidate.]

I, the undersigned, do hereby promise that, in the event of my election, I will be governed by the Royal Charter and Bye-laws of the Institute for the time being, or as they may hereafter be altered, amended, or enlarged under the powers of the said Royal Charter; and that I will promote the objects of the Institute as far as may be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to belong to the Institute.

Signed........................
Dated this............day of.................189.

[To be filled up by the Council.] The Council, having considered the above recommendation, present A. B. to be balloted for as a..................of The North of England Institute of Mining and Mechanical Engineers.
Signed.....................Chairman.
Nominated at the Ordinary General Meeting.................. 189
Passed by the Council .....................................................189
Elected at the Ordinary General Meeting ......................189. Age,.........years

FORM C, Transfer to Member or Associate Member.
A. B. [Christian Name, Surname, Occupation, and Address in full], born on the...........day of..........189 , at present a......................of The North of England Institute of Mining and Mechanical Engineers, being desirous of becoming a...........Member of the said Institute, I recommend him, from personal knowledge, as a person in every respect worthy of that distinction, because—
[Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-laws 3 and 4.]
On the above grounds, I propose him to the Council as a proper person to be admitted a...........Member.
Signed .....................Member or Associate Member.
Dated this ............day of.................189

We, the undersigned, concur in the above recommendation, from personal knowledge, being convinced that A. B. is in every respect a proper person to be admitted a...........Member.

............................Two Members
or
............................Associate Members.

[Undertaking to be signed by the Candidate.]

I, the undersigned, do hereby promise that, in the event of my election, I will be governed by the Royal Charter and Bye-laws of the Institute for the time being, or as they may hereafter be altered, amended, or enlarged under the powers of the said Royal Charter; and that I will promote the objects of the Institute as far may be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to belong to the Institute.

Signed.....................
Dated this........day of..................189
[To be filled up by the Council.]
The Council, having considered the above recommendation, present A. B. to be
balloted for as a......................Member of The North of England Institute of Mining and
Mechanical Engineers.
Signed.........................Chairman.
Nominated at the Ordinary General Meeting ............... 189
Passed by the Council ....................... 189
Elected at the Ordinary General Meeting.................189    . Age,........years

FORM D.
List of the names of persons to be balloted for at the Ordinary General Meeting
the.............day of.............189    .
Members :

....................................
Associate Members:—
....................................
Honorary Members :—
....................................

APPENDIX.—BYE-LAWS.
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Associates:—
....................................
Students :—
....................................

Strike out the names of such persons as you desire should not be elected, and hand
the list to the Chairman.

FORM E.
Sir,—I beg leave to inform you that on the........... day of..............................you were
elected a......................of The North of England Institute of Mining and Mechanical
Engineers. In conformity with its Bye-laws your election cannot be confirmed until
your first annual subscription be paid, the amount of which is £.........., or, at your
option, a life-composition in accordance with the following
scale:—

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Subscription</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 30</td>
<td>£31</td>
</tr>
<tr>
<td>31-40</td>
<td>£27</td>
</tr>
<tr>
<td>41-50</td>
<td>£24</td>
</tr>
<tr>
<td>51-60</td>
<td>£21</td>
</tr>
<tr>
<td>Over 60</td>
<td>£17</td>
</tr>
</tbody>
</table>

If the subscription is not received within four months from the present date, the
election will become void under Bye-law 10.
All annual subscriptions are due on the first Saturday in August of each year.
I am, sir, yours faithfully, Dated..............189    .....................Secretary.

FORM F.
The North of England Institute of Mining and Mechanical Engineers.
Founded 1852. Incorporated by Royal Charter, A.D.. 1876.
These are to certify that A. B. [Christian Name, Surname, Occupation, and Address
in full] was elected a Member of The North of England Institute of Mining and
Mechanical Engineers, at an Ordinary General Meeting held on the........day
of..........189
Witness our hands and seal this........day of..........189
...........................................President.
FORM G.
Sir,—I am directed by the Council of The North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 14, and to remind you that the sum of £........ of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, sir, yours faithfully,
................................Secretary.
Dated.........................189.

FORM H.
SIR,—I am directed by the Council of The North of England Institute of Mining and Mechanical Engineers to inform you that, in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 14, the Council have determined that unless payment of the amount £........ is made previous to the.....day of............next, they will proceed to declare that you have ceased to be a Member of the Institute.
But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.
I am, sir, yours faithfully,
................................Secretary.
Dated.........................189

FORM I.
Sir,—I am directed by the Council of The North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 15.
I am, sir, yours faithfully,
................................Secretary.
Dated.........................189

FORM J.
Sir,—It is my duty to inform you that, under a resolution passed at a Special GeneralMeeting of The North of England Institute of Mining and MechanicalEngineers, held on the........day of..........189 , according to the provisions of Bye-law 15, you have ceased to be of the Institute.
I am, sir, yours faithfully,
................................Secretary.
Dated.........................189

FORM K, Balloting List.
Ballot to take place at the Annual Meeting on..............189...at Two o'clock, p.m.
The names of persons for whom the voter does not vote must be erased, and the names of other persons eligible for re-election may be inserted in their place, provided the number remaining on the list does not exceed the number of persons to be elected.
President—Not more than One Name to be returned, or the vote will be lost.
.........................President for the current year eligible for re-election*
.........................}—New Nominations.*

Vice-Presidents—Not more than Six Names to be returned, or the vote will be lost.
The Votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter.

..................... Vice-President* for the current year eligible for re-election.
.........................
.........................New Nominations.

Council—Not more than Eighteen Names to be returned, or the vote will be lost.
1 Members of the Council for the current year eligible for re-election.
.........................
.........................
.........................}—New Nominations.

* To be inserted when necessary.

[Ixxvii]

Ex-Officio Members of the Council for the ensuing year:—
.........................Past-Presidents.
.........................
.........................Retiring Vice-Presidents.
.........................

Bye-law 21.
Each Member and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents and Members of Council for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election and of such other Members and Associate Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the ordinary General Meeting in June, and shall be the balloting list for the annual election in August. [See proper Form in the Appendix.] A copy of this list shall be posted at least seven days previous to the Annual Meeting to every Member and Associate Member who may erase any name or names from the list, and substitute the name or names of any other Member or Associate Member eligible for each respective office; but the number of names on the list after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.
Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

The following Members are ineligible from causes specified in Bye-law 20:—
As President........................
As Vice-Presidents...................
As Councillors......................

Form L
Admit. ....................
of..............................
to the Ordinary General Meeting on Saturday, the....................
(Signature of Member, Associate Member, Associate or Student),
The Chair to be taken at Two o'clock p.m.
I undertake to abide by the Bye-Laws of The North of England Institute of Mining, and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.
(Signature of Visitor)....................
Not transferable.