ADVERTISEMENT.

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.

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THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.
ANNUAL GENERAL MEETING,
Held in the Wood Memorial Hall, Newcastle-upon-Tyne,
August 7th, 1909.

Mr. JOHN H. MERIVALE, Past-President, in the Chair.


The Scrutineers afterwards reported the result of the ballot, as follows: —

President:
Mr. T. E. Forster.

Vice-Presidents:
Mr. J. B. Atkinson.
Mr. W. C. Blackett.
Mr. T. Y. Greener.
Mr. Henry Palmer.
Mr. M. W. Parrington.
Mr. John Simpson.

Councillors:
Mr. R. S. Anderson.
Mr. Sidney Bates.
Mr. C. S. Carnes.
Mr. Frank Coulson.
Mr. Benjamin Dodd.
Mr. Mark Ford.
Mr. A. M. Hedley.
Mr. T. E. Jorling.
Mr. J. P. Kirkup.
Mr. C. C. Leach.
Prof. Henry Louis.
Mr. A. D. Nicholson.
Mr. J. H. Nicholson.
Mr. F. R. Simpson.
Mr. Simon Tate.
Mr. R. I. Weeks.

The Secretary read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on June 26th, July 24th, and that day, and of the Council of The Institution of Mining Engineers on May 27th.

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

The Council regret to have to refer to the great loss that the Institute has sustained through the death of Mr. Henry Lawrence, who had been a member for over 40 years, and who had served on the Council, with hardly a break, since the year 1882. They also have to deplore the death of Mr. Bennett Hooper Brough, who had been associated with the Institute since the year 1887, and who had for a number of years acted as one of its representatives on the Council of The Institution of Mining Engineers.
The following table shows the progress of the membership during recent years: —

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<th>1903</th>
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<td>931</td>
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The members are to be congratulated that the membership roll has been maintained at its present high figure.

There were ten deaths, forty-five resignations, and the names of twenty-eight gentlemen were removed from the Register during the year, making a grand total of eighty-three.

The Library has been maintained in an efficient condition during the year; the additions, by donation, exchange, and purchase, include 287 bound volumes and 16 pamphlets, reports, etc.; and the Library now contains about 11,837 volumes and 396 unbound pamphlets. A card-catalogue of the books, etc., contained in the Library renders them easily available for reference.

The Most Honourable the Marquess of Londonderry has presented to the Institute some old wooden pumps found in the workings of Rainton Colliery, which, after being exhibited for some time in the Wood Memorial Hall, have been loaned to Armstrong College.

An exchange of Transactions has been arranged, during the year, with The North-West Mining News.

The courses of lectures for colliery engineers, enginewrights and apprentice mechanics have been continued at Armstrong College, Newcastle-upon-Tyne. The lectures are delivered on Saturday afternoons, and the three years' course embraces the following subjects:


Several colliery-owners have paid the fees (£1 10s. per annum) and railway expenses of pupils attending the classes from their collieries. During the past year, the lectures of the Michaelmas Term on the Transmission of Power and on Pumping and Ventilation were attended by 30 students, 24 of whom sat for examination and 17 passed; and during the Epiphany Term, the lectures on the Metallurgy of Iron and Steel and on Mining Machinery were attended by 31 students, 22 of whom sat for examination and 16 passed. Certificates have been awarded to the following students, who have completed the three years' course: Messrs. J. A. Lee, G. Malone, and J. G. Reavely. The first and second prizes for the Session 1908-1909 have been awarded to Messrs. P. Bateson and J. A. Lee respectively.
Mr. Thomas Douglas continues to represent the Institute as a Governor of Armstrong College, and Mr. John H. Merivale, in conjunction with the President (Mr. T. E. Forster), represents the Institute on the Council of the College.

Mr. George May continues to represent the Institute upon the Board of Directors of the Institute and Coal Trade Chambers Company, Limited.

The Rev. G. M. Capell will represent the Institute at the Conference of the Delegates of the Corresponding Societies of the British Association for the Advancement of Science, to be held in London on October 25th and 26th, 1909.

The constitution of the University of Durham College of Medicine has recently been amended, and under the new Articles of Association the President of the Institute will be a Representative Governor upon the Court of Governors during his term of office.

Under the will of the late Mr. John Daglish, funds have been placed at the disposal of Armstrong College for founding a Travelling Fellowship, to be called the "Daglish" Fellowship, candidates for which must be nominated by the Institute. Mr. Henry Moore Hudspeth was in January, 1909, awarded the Fellowship, and suitable arrangements for his gaining knowledge and experience abroad have been made.

G. C. Greenwell gold, silver and bronze medals may be awarded annually for approved papers "recording the results of experience of interest in mining, and especially where deductions and practical suggestions are made by the writer for the avoidance of accidents in mines."

Prizes for books have been awarded to the writers of the following papers, communicated to the members during the year 1907-1908:—

"The Occurrence and Commercial Uses of Fluorspar." By Mr. William Morley Egglestone.
"The Strength of Cast-iron Tubbing for Deep Shafts." By Dr. John Morrow.

The papers printed in the Transactions during the year are as follows:—

"The Working of the Inclined Seams in the St. Etienne Coal-field, at the Montrambert and La Beraudiere Collieries." By Mr. Hugh Clarkson Annett, Assoc. I.M.E.
"Hydraulic Stowing of Gob at Shamrock I. and II. Colliery, Heme, Westphalia, Germany." By Mr. Hugh Clarkson Annett, Assoc. I.M.E.
"Repairing Leaky Seams." By Mr. Ego Bagnoli, M.I.M.E.
"Notes on a Small Contrivance to More Easily Detect Fire-damp." By Mr. W. C. Blackett, M.I.M.E.

"Report of Delegate to the Jubilee Meeting of the Societe de l'Industrie Minerale, 1908." By Mr. A. M. Hedley, M.I.M.E.
"A Short Description of the Various Types of Coal Cargo-steamers and of Doxford's New Self-discharging Steamer." By Mr. John Kirnopp, Jun., M.I.M.E.
"Memoir of Henry Lawrence." By Mr. John H. Merivale, M.I.M.E.
"Note on the Effect of an Igneous Dyke on a Natal Coal-seam." By Mr. G. H. Stanley, M.I.M.E.
"Note on a Deposit of Sulphur in a Colliery Water." By Mr. G. H. Stanley, M.I.M.E.
"The 'Bold' Box-controller and Box-switch." By Mr. J. G. Thompson.
"Coal-mining on the Kirghese Steppe, in the Akmolinsk District of Southwestern Siberia." By Mr. Edward Watson, M.I.M.E.

In connection with the Annual General Meeting held upon August 1st, 1908, a visit was paid to the Hancock Museum of the Natural History Society of Northumberland, Durham and Newcastle-upon-Tyne, and the Loan Exhibition of Forestry. The exhibits were described by Mr. John F. Annand, Lecturer in Forestry at Armstrong College.

Another maintenance-grant of £50 towards the cost of conducting further experiments on the Inflammability of Mixtures of Coal-dust and Air, together with £10 for additional apparatus, has been made to Dr. P. Phillips Bedson.

A Committee has been appointed, with Mr. Stanley Smith as Secretary, to report upon the Carboniferous Limestone Formation of the North of England, with Special Reference to its Coal Resources.

The collection of safety-lamps was loaned to the Franco-British Exhibition, and the Council have pleasure in announcing that they have been granted a Diploma for the same.

A number of Silesian mining engineers visited Newcastle-upon-Tyne on July 22nd and 23rd, 1909, and visits to collieries, works, etc., were arranged for their entertainment. The thanks of the Institute have been sent to the owners of the collieries, works, etc., visited.

During the past year the old office and the stock-room of the institute have been decorated and furnished as two reading, writing, and smoke-rooms, with an entrance by spiral staircase from the Library, and it is hoped that they will prove a convenience, and also add to the comfort of the members using the rooms of the Institute.

The Institution of Mining Engineers is now in the twenty-first year of its existence, and the members are to be congratulated

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upon its continued success, and the ever increasing membership of the associated Institutes. During the course of the year it was considered that the best interests of the Institution would be served by placing the guidance of its affairs in the hands of an Honorary and an Assistant Secretary, Prof. L. T. O'Shea kindly undertaking the former, while Mr. Percy Strzelecki was appointed to the latter position. The headquarters of the Institution have been removed to London, chambers having been taken in Albany Buildings, 39, Victoria Street, Westminster, S.W., where a reading-and-writing room has been furnished for the convenience of members. Meetings were held in Edinburgh in September, 1908, and in London in May, 1909, the attendance in each case being of a satisfactory nature.

The Twentieth Annual General Meeting of The Institution of Mining Engineers will be held in Newcastle-upon-Tyne upon September 10th, 16th, and 17th, 1909, and a committee has been appointed to make the necessary arrangements.

The Chairman (Mr. John H. Merivale) moved the adoption of the Report.

Mr. C. H. Steavenson seconded the resolution, which was adopted.

The Annual Report of the Finance Committee was read as follows: —

ANNUAL REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts for the twelve months ending June 30th, 1909, duly audited.

The total receipts were £2,920 7s. 2d. Of this amount, £32 6s. represents subscriptions paid in advance, leaving £2,888 1s. 2d. as the ordinary income of the year, compared with £2,805
8s. in the previous year. The amount received for ordinary current-year subscriptions was £2,287 7s., and arrears £222 8s., as against £2,218 10s. and £239 18s. respectively in the year 1907-1908. Transactions sold realised £21 14s. 1d., as

compared with £11 5s. 8d. in the earlier period; the sum received for interest on investments was £356 12s. 1d., the amount in the former year being £335 14s. 4d. The expenditure was £2,994 18s. 3d., that for the previous year being £2,627 2s. 3d. The principal items making up the increase comprise the furnishing of the new offices and smoke-rooms, the contribution towards the maintenance of the offices of The Institution of Mining Engineers in London, the grant for further experiments on the inflammability of mixtures of coal-dust and air, the expenses of the Committee to Report upon the Carboniferous Limestone Formation of the North of England, with Special Reference to its Coal Resources, travelling expenses, and law-charges; the latter being for services extending over a period of 13 years.

It will be seen from the above figures that the expenditure exceeded the income by £74 11s. 1d., and deducting this amount from the balance of £504 15s. 3d. brought forward from the previous year, the sum of £430 4s. 2d. is left to carry forward.

The names of thirty-three persons have been struck off the membership list in consequence of non-payment of subscriptions. The amount of subscriptions written off was £151 10s., of which £78 18s. was for sums due for the year 1908-1909, and £72 12s. for arrears. It is probable that a considerable proportion of these amounts will be recovered and credited in future years. Of the amounts previously written off, £29 8s. was recovered during the past year.

John H. Merivale, Past-President. August 7th, 1909.

The Chairman (Mr. John H. Merivale), in moving the adoption of the Annual Report of the Finance Committee, said that at first sight it did not look very satisfactory, seeing that the expenditure exceeded the income by £74 11s. 1d.; but when the fact that there were some items charged to revenue which might be considered as capital, such as furniture for the new offices and rooms and accumulated law-charges (£92 7s. 6d) for several years, was taken into consideration, he thought that they would agree with him that the report was satisfactory.

Mr. J. P. Kirkup seconded the resolution, which was adopted.

Dr.

The Treasurer in Account with The North of England Institute of Mining and Mechanical Engineers for the Year ending June 30th. 1909.

<p>|</p>
<table>
<thead>
<tr>
<th>June 30th. 1908.</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>To balance of account at bankers</td>
<td>424</td>
<td>16</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot; in Treasurer's bands</td>
<td>77</td>
<td>12</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot; outstanding accounts due from authors for excerpts</td>
<td>2</td>
<td>6</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>June 30th. 1909.</td>
<td></td>
<td></td>
<td></td>
<td>504</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>To dividend of 7½ per cent, on 179 shares of £20 each in the Institute &amp; Coal-trade Chambers Company, Limited, for the year ending June 30th, 1909</td>
<td>268</td>
<td>10</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\text{&quot; interest on mortgage of } £1,400 \text{ with the Institute } &amp; \text{ Coal-trade Chambers Company, Limited })</td>
<td>49</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\text{&quot; dividend on } £340 \text{ consolidated 5 per cent, preference stock of the })</td>
<td>16</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Newcastle & Gateshead Water Company

.. dividend on £450 ordinary stock of the Newcastle & Gateshead Gas Company

.. interest on deposit account

-------------------
356 12 1

To sales of Transactions

To Subscriptions for 1908-1909. as follows:—

760 members @ £2 2s. 1,596 0 0
3 associate members @ £2 2s. 171 6 0
187 associates @ £1 5s. 233 15 0
41 students @ £1 5s. 51 5 0
50 new members @ £2 2s. 105 0 0
8 new associate members @ £2 2s. 16 16 0
10 new associates @ £1 5s. 12 10 0
15 new students @ £1 5s. 18 15 0

2,208 7 0
32 subscribing firms 115 10 0
1 new subscribing firm 2 2 0

Less, subscriptions for current year paid in advance at end of last year 38 12 0

Add, subscriptions paid in advance during current year 32 6 0

-------------------
2,542 1 0

-------------------
£3,425 2 5

[9]

Cr.

June 30th, 1909

By salaries and wages. 498 8 6
.. insurance 13 5 9
" rent, rates and taxes 31 9 3
" heating, lighting, etc. 51 18 9
furniture and repairs 234 13 4
" bankers'charges. 21 0 0
Wood Memorial Hall 34 7 2
" Library 21 2 1
" printing, stationery, etc. 114 9 5
" postages, etc. 63 16 11
" incidental expenses 69 3 2
" travelling expenses .......... 46 2 8
" prizes for papers ............ 13 13 0
" Subject-matter Index of Mining, Mechanical, and Metallurgical Literature 2 16 0

Law-charges. 96 7 2
" reporting of general meetings 10 10 0
" Library catalogue 75 0 0
" grant for further experiments on the inflammability of mixtures of coal-dust and air 60 0 0
" Committee to report upon the Carboniferous Limestone Formation of the North of England, with Special Reference to its Coal Resources... 20 8 9

-------------------
1,481 11 11

By The Institution of Mining Engineers : Calls, etc. £1,306 0 6
.. Guarantee Fund 210 3 10

-------------------
1,516 4 4

Less, amounts paid by authors for excerpts ...... 2 18 0

-------------------
1,513 6 4
By balance of account at bankers:

<table>
<thead>
<tr>
<th>Account Type</th>
<th>Dr. Balance</th>
<th>Cr. Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deposit account</td>
<td>125 0 0</td>
<td></td>
</tr>
<tr>
<td>Current account</td>
<td>222 12 3</td>
<td></td>
</tr>
<tr>
<td>&quot; in Treasurer's hands</td>
<td>80 19 9</td>
<td></td>
</tr>
<tr>
<td>&quot; outstanding accounts due from authors for excerpts</td>
<td>112 2</td>
<td>430 4 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>£3,425 2 5</td>
</tr>
</tbody>
</table>

The Treasurer of The North of England Institute of Mining Mechanical Engineers in Account with Subscriptions, 1908-1909.

Dr.

<table>
<thead>
<tr>
<th>Category</th>
<th>Dr. Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>To 942 members, 52 of whom have paid life-compositions</td>
<td>£1,869 0 0</td>
</tr>
<tr>
<td>To 105 associate members, 9 of whom have paid life-compositions</td>
<td>£201 12 0</td>
</tr>
<tr>
<td>To 209 associates, 1 of whom has paid a life-composition</td>
<td>£260 0 0</td>
</tr>
<tr>
<td>To 48 students</td>
<td>£60 0 0</td>
</tr>
<tr>
<td>To 33 subscribing firms</td>
<td>£117 12 0</td>
</tr>
<tr>
<td>To 50 new members</td>
<td>£105 0 0</td>
</tr>
<tr>
<td>To 8 new associate members</td>
<td>£16 16 0</td>
</tr>
<tr>
<td>To 10 new associates</td>
<td>£12 10 0</td>
</tr>
<tr>
<td>To 15 new students</td>
<td>£18 15 0</td>
</tr>
<tr>
<td>To 1 new subscribing firm</td>
<td>£2 2 0</td>
</tr>
<tr>
<td>To arrears, as per balance sheet, 1907-1908</td>
<td>£280 0 0</td>
</tr>
<tr>
<td>Add, arrears considered irrecoverable, but since paid</td>
<td>£29 8 0</td>
</tr>
<tr>
<td>To subscriptions paid in advance</td>
<td>£309 14 0</td>
</tr>
</tbody>
</table>

Cr.

<table>
<thead>
<tr>
<th>Category</th>
<th>Cr. Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>By 760 members, paid</td>
<td>£1,596 0 0</td>
</tr>
<tr>
<td>99 , unpaid</td>
<td>£207 18 0</td>
</tr>
<tr>
<td>2 , excused payment</td>
<td>£4 4 0</td>
</tr>
<tr>
<td>4 , dead *</td>
<td>£8 8 0</td>
</tr>
<tr>
<td>25 , struck off list</td>
<td>£52 10 0</td>
</tr>
<tr>
<td>890 By 83 associate members, paid</td>
<td>£174 6 0</td>
</tr>
<tr>
<td>10 , , unpaid</td>
<td>£21 0 0</td>
</tr>
<tr>
<td>1 , dead</td>
<td>£2 2 0</td>
</tr>
<tr>
<td>2 , , struck off list</td>
<td>£.4 4 0</td>
</tr>
<tr>
<td>96 By 187 associates, paid</td>
<td>£233 15 0</td>
</tr>
<tr>
<td>16 , , unpaid</td>
<td>£20 0 0</td>
</tr>
</tbody>
</table>
The North of England Institute of Mining and Mechanical Engineers: General Statement, June 30th, 1909.

**Liabilities.**

<table>
<thead>
<tr>
<th>Description</th>
<th>£</th>
<th>s</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subscriptions paid in advance during the current year</td>
<td>34</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>The George Clementson Greenwell prize fund</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Less, paid for medals</td>
<td>70</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital</td>
<td>.12,593</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Liabilities</strong></td>
<td>£12,657</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

**Assets.**

<table>
<thead>
<tr>
<th>Description</th>
<th>£</th>
<th>s</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance of account at bankers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deposit account.</td>
<td>125</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Current &quot;</td>
<td>222</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.. in Treasurer's hands</td>
<td>80</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td>Outstanding- accounts due from authors for excerpts</td>
<td>12</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrears of subscriptions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>179 shares in the Institute &amp; Coal-trade Chambers Company, Limited (at cost)</td>
<td>4,100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Institute &amp; Coal-trade Chambers Company, Limited (mortgage)</td>
<td>.1,400</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>£340 consolidated 5 per cent, preference stock of the Newcastle &amp; Gateshead Water Company (at cost)</td>
<td>499</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>£450 ordinary stock of the Newcastle &amp; Gateshead Gas Company (at cost)</td>
<td>487</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Of the above amount, £1,659 is due to life-subscriptions account.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of Transactions and other publications, as per stock account</td>
<td>316</td>
<td>10</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></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td>5,466</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>
We have examined the above balance-sheet with the books, vouchers, and securities relating thereto, and certify that, in our opinion, it is correct. We have accepted the assets, books, pictures, maps, etc., and Transactions and other publications, as valued by your officials.

JOHN C. BENSON AND SONS,
Chartered Accountants.

Newcastle-upon-Tyne,
July 31st, 1909.

[13]


The Chairman (Mr. John H. Merivale) moved, and Mr. J. P. Kirkup seconded, a resolution that the following gentlemen be elected as the representatives of the Institute on the Council of The Institution of Mining Engineers for the year 1909-1910: —

Mr. R. S. Anderson. Mr. W. Galloway. Mr. George May.
Mr. W. Armstrong. Mr. Reginald Guthrie. Mr. J. H. Merivale.
Mr. R. C. Aubrey. Mr. Samuel Hare. Mr. J. J. Prest.
Mr. W. C. Blackett. Mr. A. M. Hedley. Mr. F. R. Simpson.
Mr. A. G. Charleton. Mr. T. E. Jobling. Mr. J. B. Simpson.
Mr. Benjamin Dodd. Mr. J. P. Kirkup. Mr. C. H. Steavenson.
Mr. T. E. Forster. Mr. Philip Kirkup. Mr. J. G. Weeks.
Mr. J. W. Fryar. Mr. C. C. Leach. Mr. R. L. Weeks.

Prof. Henry Louis.

The resolution was agreed to.

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

Members —
Mr. Edward Barrs, Electrical and Mechanical Engineer, Cathedral Buildings, Newcastle-upon-Tyne.
Mr. William John Charlton, Jun., H.M. Inspector of Mines, 32, Western Hill, Durham.
Mr. William Henderson, Colliery Engineer, Alston House, Littleton, Durham.
Mr. George Weymouth Hutchinson, Mining Engineer, Greensburg, Westmoreland County, Pennsylvania, United States of America.
Mr. Joseph Henry Ivey, Mining Engineer, Stray Park House, Camborne.
Mr. James McGeachie, Colliery Manager, Charlestown, via Newcastle, New South Wales, Australia.
Mr. William Rostern Morton, Electrical Engineer, 57, Sanders Road, Newcastle-upon-Tyne.
Mr. Arthur Stanley Murdoch, Engineer, Largiemore, Camborne.
Mr. Henry Mason Parrington, Colliery Manager, Hill House, Monkwearmouth, Sunderland.
Mr. Robert William Taylor, Jun., Civil and Mining Engineer, 15, East Broad Street, Hazleton, Pennsylvania, United States of America.

Associate Member —
Mr. Frederic George Moore, Neath and Brecon Railway Company, Neath.
Associates —
Mr. James Bowman, Enginewright, 1, Front Street, East Stanley, Stanley, S.O., County Durham.

Mr. Edwin Carr Dixon, Back-overman, Hallgarth, Lanchester, Durham.
Mr. Frederick John Flint, Overman, Lady Ann Pit, Fence Houses.
Mr. Cyril Thompson, Mining Surveyor, 10 West Street, Fletchertown, Mealagagate, S.O. Cumberland.

Students —
Mr. William Henry Atkinson, Mining Student, Dans Castle, Tow Law, S.O. County Durham.
Mr. Henry Edward English, Mining Student, 12, Success Terrace, Bunker Hill, Fence Houses.
Mr. Charles Sharpe Magee, Mining Student, Colliery Offices, Lumley Thicks, Fence Houses.

DISCUSSION OF MR. JOHN KIRSOPP, JUN.'S, PAPER ENTITLED "A SHORT DESCRIPTION OF THE VARIOUS TYPES OF COAL CARGO-STEAMERS AND OF DOXFORD'S NEW SELF-DISCHARGING STEAMER."*

Mr. A. E. Doxford (Sunderland) wrote that Mr. H. M. Wilson in his remarks referred to the question of the life of the belt, stating that, with average use, they could not last more than 6 months. In contradiction to this, he (Mr. Doxford) might state that he had personally seen a belt 18 inches in width, and of lighter construction than those to be used in the new vessel, which had carried coal continuously for 5 years, and was almost as good as it was on the day when it started. Another belt of the same dimensions and of the same age, carrying limestone rock, was also in a perfectly good condition, although it showed wear and cuts due to the nature of the material which it had been carrying. Taking 300 working days in the year, averaging 9 hours per day, in 5 years there would be 13,500 working hours for those particular belts.

If that experience were applied to a steamer -which was discharged each voyage in 6 hours, 2,250 voyages would be required to complete the same amount of work; and, assuming that the vessel was so fortunate as to run in a trade in which, say, eighty voyages could be made in the year, this would give the belts a life of 28 years. It was, therefore, quite certain that the belts would not be worn out by wear-and-tear; but they would no doubt succumb to the natural deterioration of material. The possibility of coal falling over the side of the belt, to which Mr. Wilson had referred, had been provided for; and there would also

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be no difficulty in providing shields to prevent any material, tools, etc., which might be left on the return-belt, from passing under the end drum.

Mr. C. King (Newcastle-upon-Tyne) wrote that, in his opinion, the cantilever-framed type of vessel was, without doubt, the best both for trimming and discharging, and also for safety, loaded or light. The two top-side water-ballast tanks were a capital counterbalance for the deadweight in the bottom ballast-tanks, and would, no doubt, make a very easy, light ship in a heavy sea. With regard to vessels arranged to unload by belt-mechanism, he would like to know the estimated cost of the upkeep of the belts and other gear after, say, 2 or 3
years' use, assuming the life of the belt, etc., would be 2 years or so. Judging from the position of the waterline in Fig. 15,* the cargo was carried much too high up in the vessel, and in his opinion the empty space below the cargo, when all the ballast-tanks were empty, would make such vessels unsafe.

Mr. Rowland Hodge (Howdon-on-Tyne) wrote that, with regard to the cantilever-framed type of vessel, he would like to draw attention to the fact that the first of these vessels, which was an improved steamer named the "Mercedes," was designed and built in the year 1902 by the Northumberland Shipbuilding Company Limited, to carry out an Admiralty contract for coaling the China Fleet at sea. The vessel, which carried more than 7,000 tons deadweight, had her engines right aft, and the large hatchways were so arranged that four torpedo-boats could lie on each side of the vessel, the whole eight being, if necessary, coaled together by long derricks and Temperley transporters. The coal for the purpose was brought from Australia and New Zealand, and the deep cellular double bottom was arranged for water ballast, together with forward and aft peak tanks and continuous side-tanks, in order to give the vessel stability and sufficient immersion for the long sea voyage when light. The sloping side-tanks made the vessel a self-trimming collier. A 5-year Admiralty charter was carried out, which was afterwards renewed for a further period, and the vessel was eventually purchased by the Admiralty.


[16]

The Chairman (Mr. John H. Merivale) moved a vote of thanks to the Scrutineers for their services.

Mr. C. H. Steavenson seconded the resolution, which was cordially adopted.

Mr. C. H. Steavenson proposed a vote of thanks to the President, Vice-Presidents, Councillors, and Officers for their services during the past year.

Mr. T. R. Lonsdale seconded the motion, which was heartily adopted.

Mr. T. R. Lonsdale moved a vote of thanks to the representatives of the Institute on the Council of The Institution of Mining-Engineers for their services during the past year.

The Chairman (Mr. John H. Merivale) seconded the proposal, which was cordially adopted.

[17]

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
Held in the Wood Memorial Hall, Newcastle-upon-Tyne,
October 9th, 1909.

Mr. T. E. FORSTER, 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 August 21st, September 25th, and that day.

The following gentlemen were elected, having been previously nominated:—
Members—
Mr. James Barnes, Colliery Manager, Heddon Greta, via West Maitland, New South Wales, Australia.
Mr. Joseph Percival Hall, Colliery Manager, Talbot House, Birtley, S.O., County Durham.
Mr. Montagu Jacobs, Mining Engineer, 18, Greville Road, London, N. W.
Mr. George Sherwin Langford, Mine Surveyor, Taupiri Coal-mines, Limited, Huntly, New Zealand.
Mr. Ernest Hunter Oliver, Colliery Manager, Ravensworth Colliery, Low Fell, Gateshead-upon-Tyne.
Mr. William Sampson, Mine Manager, 33, Queen Street, Singapore.

Associate Member—
Mr. Arthur Geoffrey Harold Cook, North Biddick Hall, Washington Station, S.O., County Durham.

Associates—
Mr. Charles Percy Almond, Mining Engineer, Coalside, Southwick, Sunderland.
Mr. Charles Dawson, Electrical Engineer, Bettisfield Colliery, Bagillt, S.O., Flintshire.
Mr. George Edward Geary, Overman, Osmond Croft, Winston, Darlington.
Mr. George Heslop, Overman and Surveyor, St. George's Colliery, Hatting Spruit, Natal, South Africa.
Mr. Thomas McKie, Electrical Engineer, Ashington Colliery, Morpeth.
Mr. George Owens, Overman, 4, St. Cuthbert Terrace, Dean Bank, Ferry Hill.
Mr. Thomas Amour Scott, Deputy Overman, 5, Swarland Terrace, Acklington, S.O., Northumberland.

Students—
Mr. Joseph Gallon, Mine Surveyor, 71, Seventh Row, Ashington, Morpeth.
Mr. Matthew Lilburn Parrington, Mining Student, Hill House, Monkwearmouth, Sunderland.
Mr. John William Strong, Mining Student, 7, Earl's Drive, Low Fell, Gateshead-upon-Tyne.

DISCUSSION OF MR. ROBERT NELSON'S PAPER ON "ELECTRICITY IN COAL-MINES."

The President (Mr. T. E. Forster) said that although Mr. Nelson's paper was read and discussed at the meeting of The Institution of Mining Engineers in London, and was further discussed at the Annual General Meeting of that Institution in Newcastle-upon-Tyne, members who were not present at either of those meetings might wish to offer some remarks; and perhaps those members who had already taken part in the discussion might have further observations to make.

Mr. A. L. Steavenson (Durham) said that with respect to the question of the use of electricity in mines, during all the years that they had been discussing the subject, he had always said "be careful," and it looked to him very much as if the men were going to step in and say "you shan't have it." His feeling on the subject was that if managers were in charge of it themselves, electricity might be safely used, but there were very many people who would not take the care that they ought to take, and who foolishly forgot that a large number of lives were at stake. He also felt that if people would take half the trouble to compress air properly that they took in using electricity, they would find compressed air not only equal in efficiency, but very much safer. The great difficulty was to see that it was kept moist during
compression—to keep it cool—because all the useful effect was lost by transmitting it in a heated state. If a force-pump were used, such as he had employed for many years, and if water in the shape of a spray was driven into the cylinder during compression, it would be found that the efficiency was quite as good as that obtained by the use of electricity. It was really a very serious matter; it was not a question of whether it was going to cost one-tenth of a penny or even a penny a ton more, but as to the possibility of using other media than electricity, and thereby protect the lives of the men which were at stake.

Mr. W. C. Blackett (Sacriston) said that he could scarcely allow Mr. Steavenson’s statement to go unchallenged, lest a construction should be put on his (the speaker’s) silence which would not be correct. He could not agree with what Mr. Steavenson had said. It appeared to him that electricity could be practically as safe in mines to-day as any other agent that they used: and he was quite certain of this, at any rate, that electricity in mines could be as safe as, or safer than, safety-lamps. Mention had been made of the men; the men used safety-lamps every day of their lives, and they were so familiar with them that they never stopped to question their general safety. When they became as familiar with electricity, there would, similarly, not be heard anything of their objections. The objections to electricity that were being raised at the present moment arose not out of knowledge and familiarity, but out of ignorance and unfamiliarity with it. Compressed air, he thought, was a useful source of energy under some circumstances, but its efficiency could not be compared with that of electricity. He had used compressed air in past years, and had moistened it and cooled it, and had introduced sprays, and, when all that had been done, its efficiency was not one-half, nor anything like one-half, that of electricity. It appeared to him to be a grievous circumstance that reflections should be cast upon electricity, reflections such as had been and were being cast upon it, owing to the West Stanley disaster, where he, for one, was absolutely certain that electricity was not to blame.

Mr. Steavenson said that he had no prejudice against electricity. He had used it for many years, and was using it now in Cleveland for drilling purposes, but an ironstone-mine, where there was no coal-dust and practically no gas, was very different from a coal-mine.

Mr. Edward Barrs (Newcastle-upon-Tyne) said that the question of cables had been fully discussed at previous meetings, and he did not think that he had anything new to add; less prominence had, however, been given to the problems of protection and switch-gear, and lie would like to offer a few remarks on those points.

Mr. Nelson had dealt fully with various forms of protective gear from the point of view of safety, but from the point of view of the network something might be added.

In addition to breakdowns of the insulation, which could be readily guarded against by the leakage or balanced systems, a motor might itself require isolation owing to overloading. A perfect motor-overload device would only isolate the motor when the heating of the coils became dangerous; it would operate instantaneously on a dead short, and allow, in the case of ordinary overloads, a period to elapse proportionate to the amount of the overload, thus preventing temporary overloads interrupting the supply. This perfect form of overload device had yet to be made, and at present the fuse seemed the simplest and best.


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Mr. Nelson pointed out that oil-immersed switches should always be used with alternating current; these switches could be readily made of the automatic circuit-breaker type. A time element, with all the advantages of the common fuze, could readily be added to these by putting a small fuze across the secondaries of the current transformers, and by varying the size of the fuze the current required to trip the switch could be varied. Small fuzes for that purpose were standardized, and worked accurately at their rated current. He would suggest that by using concealed contacts on the fuze-base, and having a special length of fuze for each rating, it might be possible to prevent fuzes of the wrong size from being inserted or a piece of copper wire from being tied across the terminals; this arrangement would tend to prevent an unauthorized person from tampering with the setting. Apparatus of the type already mentioned had a great advantage over a simple fuze, especially for large currents, as it was well known that it was most difficult, if not impossible, to tell at what current a large fuze would act, even with the best modern ventilated types. A common defect of the cheap porcelain-handle fuzes was their liability to burst on short circuit. Mr. Nelson mentioned cartridge fuzes favourably. The objection to them was that they were expensive to renew, and, further, some types were affected by moisture in course of time. In spite of their advantages in the matter of rating, he did not think that they would become common. He thought it would be agreed that the simpler colliery switch-gear was, the better it was from all points of view. With fuzes in series it was, of course, impossible to obtain satisfactory discrimination. Leakage protection offered a partial solution of the difficulty, and had great advantages from the point of view of safety; the switch-gear required was simple, and not much more costly than overload protection. In combination with balanced protection, as suggested by Mr. Nelson, this offered a very perfect system of protection, rendering each section of cable independent of faults in other sections.

The balanced protective system was costly, and required skilled attention, and, except where an automatic duplicate supply was required, in which case it seemed to be the only system at their disposal, he thought that colliery owners would prefer to take the rather greater risk of stoppage and install a combination of overload and leakage protection.

He welcomed Mr. Nelson's remarks on earthing the neutral point of three-phase systems. A leakage indicator, as required by the Board of Trade, merely indicated the existence of a leak, and did not attempt to isolate it, so that it was quite a simple matter to overlook its indications, and the breakdown of a second phase was the first indication of trouble. This breakdown often followed rapidly on the breakdown of the first, and caused a severe fault. A fatal accident occurred near Nottingham some time ago, at a pit where the system was three-phase, with an insulated neutral. The earth-wire of a coal-cutter was, inadvertently, not connected, and an attendant received a shock on touching the frame. It appeared that one of the phases had broken down in another part of the pit, and the attendant had completed a circuit to a second phase through his body. This accident illustrated the importance of an earth-connexion and also the dangers of insulated neutral, for had the neutral been earthed the breakdown of the first phase would have been noticed and the fault isolated. It was, evidently, a great safeguard to cut off the supply as soon as a fault developed, before it had grown sufficiently severe to operate overload gear (this might take a considerable time), and in districts where Rule No. 8 applied it was of the greatest importance. The only method of effecting this was by installing leakage protection which required an earthed neutral, and the advantage gained from this form of protection seemed to him to outweigh any advantage of the insulated system.
Mr. T. Campbell Futers read the following paper on "Automatic Cage Tub-stops".

AUTOMATIC CAGE TUB-STOPS.
By T. CAMPBELL FUTERS.

Among the more important details in the construction of a cage for raising minerals contained in tubs are the stops, or snecks, for holding the tub in position whilst the cage is running in the shaft. As is well known, almost every colliery has its own individual type of sneck, which secures the tub either by dropping over the body or catching the axles; and, as a rule, these appliances are not automatic in their action. For quick decking it is very desirable that the snecks should be automatic in action, simple in construction, every part visible and accessible for changing or repairs, and that they should hold the tub securely in the cage. In the opinion of the author, all these advantages may be claimed for the arrangement about to be described, which is the invention of Mr. J. Winter, of Auckland Park Colliery, Bishop Auckland.

Fig. 1 (Plate IV.) shows a general arrangement of one form of the apparatus, in which the ordinary rail or angle-bars on the cage-deck for the tub-wheels are replaced by channel-bars, laid flat, upon which the treads of the wheels run, similar channel-bars being also laid upon the heapstead immediately in front of the cage. The snecks are fixed upon these channel-bars, and consist of two pairs of arms, A, each pair hinged together at B, but separately pivoted to the channel-bars at C, in such a manner that any motion at the end of one arm will give a corresponding motion at the end of the other arm; to these arms are fixed the chocks, E, which engage with the wheels of the tub when the latter is in position in the cage. The arms, A, are constantly pressed inwards from the side of the cage by the flat springs, D. In order to release the tubs, these snecks are pushed outwards at one end by the levers, F, which are normally always held in the position shown by the springs, G, a position which is quite clear of the cage. The levers, F, are moved by means of the arms, H, which are pivoted at one end, and abut against the stop, J, at the other end in such a manner that, as the tub approaches the cage, the wheels force outwards the arms, H, and these in turn force outwards the arms, F, which, swinging round, engage with the ends of the levers, A, and thus push outwards the chocks from the tub-wheels inside the cage, setting them free, and allowing the tub to be pushed out by the ingoing tub. As soon as the ingoing tub is in position inside the cage, the chocks automatically spring back and secure the wheels.

Fig. 2 (Plate IV.) is an end cross-section showing the method of connecting the levers, F, by chains to a hand-lever, so that the snecks may be held open by the banksman when necessary. Figs. 3 and 4 (Plate IV.) show details of the method of joining the levers, A, while Figs. 5 and 6 (Plate IV.) show details of the levers, F, from which it will be seen that they are in two parts and jointed in a vertical direction: the reason for this being that, if under any circumstances the levers were projecting into the cage, and the latter was to be raised, it would simply lift the lever with it without doing any damage. Fig. 7 (Plate IV.) is a detail of the stopper-pin, J; while Figs. 8 and 9 (Plate IV.) show details of the wheel chock, and Fig. 10 (Plate IV.) is a detail of the channel-bar for the cage-bottom.

Figs. 11 and 12 (Plate IV.) show another general arrangement, in which the ordinary rails are retained for the cage-deck, the springs being arranged on the inside, instead of the outside, as in Fig. 1. In this case also it is the flange instead of the outside of the wheel...
which forces the arms inwards. In other respects the arrangement and operation of the apparatus are the same.

Figs. 13, 14, and 15 (Plate IV.) are intended to illustrate the operation of the snecks in connexion with a steam ram, placed immediately in front of the cage. It has been assumed that the cages are double-decked, with two tubs on each deck, and that it is inconvenient from want of room or for other reasons to have a line of four tubs in front of the cage ready for loading two at a time. In that case a bogey is mounted upon rails so that it may be moved transversely backwards and forwards in front of the cage, by means of a small steam cylinder, as shown. This bogey is provided with three sets of rails, each set holding two tubs

which are loaded upon the bogey during the period when the cages are running in the shaft.

Immediately a cage comes to bank, the banksman puts the ram in motion by opening the ram throttle-valve, and pushes the empty tub into the cage and the full one out. While the winding-engineman is changing the decks, the pushing ram is quickly withdrawn and the bogey moved into a new position by the small cylinder, also operated by the banksman. If the cages are multi-decked, and the heapstead is arranged for simultaneous decking, then a separate ram would be placed opposite each deck, and all the rams could be operated by one man.

A set of these stops has recently been fitted to the cages at the Harton Colliery, and the author would point out that the snecks appear to be an ideal arrangement for application to revolving tipplers.

The President (Mr. T. E. Forster) said that Mr. Futers' paper was on a very important subject. He must say, from his own experience, that accidents, and sometimes serious ones, had occurred through defective stops or chocks in the cages, and when tubs got partly out, or fell out of the cage, the result was a great deal of damage in the shaft. Quick loading, or anything that would induce quick loading in the future, was important, in the face of the shorter drawing hours that would be upon them very soon.

Mr. Futers exhibited a working model of the apparatus described in his paper, and said that the idea of the invention was to facilitate quick loading as much as possible. The device was perfectly automatic, and all that was necessary was to push the tub into position.

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) asked what would happen if the engineman drew away before the tub was got fully into the cage.

Mr. Futers said that the same thing would happen as in the case of any other type of sneck under such circumstances: the tub would simply be driven back out of the cage again. Once the tub was in the cage, however, it was very securely locked, the chocks being on the wheels. It was not necessary for the tubs to be

shoved slowly into the cage: there was no fear of them going too far, because, as soon as ever the tub was in position, the chocks immediately came into action and locked the tub.

Mr. W. C. Blackett (Sacriston) said that the only possible objection he could see to the device was that as tubs were sometimes not in such a state of repair as was desirable, it might be possible for the body of the tub to swing out from its bogey, owing to play on the axles, and unless there was plenty of margin in the cage it was possible that the top of the tub might get a little outside of the cage. Of course, most of the stops in use at present took
the body of the tub, although there were a number of appliances in use which held the
wheels.

Mr. John H. Merivale (Acklington) said that, so far as he could see, the invention
seemed to overcome every difficulty likely to be met with. He had in use the snecks which
came down on the body of the tub, and he was sorry to say that sometimes accidents
happened, owing to the sneck dropping inside the tub instead of outside. Drawing as they
did 2,000 tons out of one shaft, changing had to be done very quickly. He thought that the
point mentioned by Mr. Futers was very important, namely, that the tub could not go too far,
because, when changing quickly, one of the great difficulties was the getting of the tub into
the right position for snecking. The arrangement was an exceedingly ingenious one, and the
only question was: would it get out of order? He would also like to know what the cost was.

Mr. Futers stated that so far only one had been put into use, and he could not state
the cost.

The President (Mr. T. E. Forster) said that the great trouble with old-fashioned
snecks was that they were apt to bend the top hoop of the tub. This allowed the buffers to
protrude beyond the sides of the cage, and they were liable to catch the sides of the shaft.

Mr. Blackett remarked that, as a rule, the snecks were not put to catch the middle of
the tub. Mr. Futers, he thought, would understand the point he had raised, that some of the
tubs would swing out on the bogies. It was not, perhaps, a very important point in a well-
regulated colliery.

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Mr. Futers replied that, with reference to the point raised by Mr. Blackett, in most of
the other arrangements the snecks acted on the sides of the tubs, but with any apparatus
acting on the wheels he thought it would be found as a rule—even supposing the bearings
were more or less worn that the centres would remain approximately about the same, and
although there might be a little swing on the body, he did not think that would affect the
position inside the cage. In using side snecks, very frequently they were put down just a
second too late; again, cages frequently came to bank with the tubs off the rails, owing to
their having been bumped violently against the snecks, but with the arrangement described
this could not happen.

The President (Mr. T. E. Forster), in proposing a vote of thanks to Mr. Futers, said
that they were very much obliged to him for having brought the arrangement under their
notice.

Mr. Blackett seconded the proposal, which was carried unanimously.

A new patent combined pedestal for colliery tubs, rollers, shafting, etc., was exhibited
and described by Messrs. W. Robinson & Company.

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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,
December 11th, 1909.

Mr J. B. ATKINSON, H.M. Inspector of Mines, Vice-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 November 27th and that day, and of the Council of The Institution of Mining Engineers on September 15th.

The following gentlemen were elected, having been previously nominated:

Honorary Members—
Mr. John Dyer Lewis, H.M. Inspector of Mines, Glanrhyd, Sketty Road, Swansea.

Members—
Mr. George Pilcher Bartlett, Engineer, The Motories, Durban, Natal, South Africa.
Mr. Daniel Cullen, Mechanical Engineer, 14, Neville Street, Newcastle-upon-Tyne.
Mr. Leonard Clifford Creen, Geologist and Mining Engineer, Wienholt Street, Torwood, Brisbane, Queensland, Australia.
Mr. John Douglass Haggie, Colliery Agent, Walbottle Colliery, Newcastle-upon-Tyne.
Mr. Nicholas Holman, Mining Engineer, The Gibraltar Consolidated Goldmines, Limited, Sheppardstown, New South Wales, Australia.
Mr. Robert David McCowan, Manager of Coke-ovens, Barngill, Districting, Cumberland.
Mr. Cornish Millett, Mining Engineer, Worbas Down Mine, Lelant, Cornwall.

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Mr. Ernest Arthur Smith, Coal and Fuel Expert, H.M. Office of Works (Supplies Division), 18, Queen Anne’s Gate, Westminster, London, S. W.
Mr. Robert Simon Tate, Colliery Manager, St. Hilda Colliery, South Shields.
Mr. Andrew Young, Engineer, Bede House, Hebburn Colliery, Hebburn, County Durham.

Associate Members—
Mr. John Coggin Brown, Geological Survey of India, Calcutta, India.
Mr. Ralph Lewis Wedgwood, North-Eastern Railway Company, Newcastle-upon-Tyne.

Associates—
Mr. James Frederick Booth, Land and Mine Surveyor, 8, Uxbridge Terrace, Felling, County Durham.
Mr. Ernest Oughton, Mining Engineer, Minas de Soria, Gergal, Provincia de Almeria, Spain.
Mr. James Smith, Back-overman, View Lane, Stanley, County Durham.
Mr. Edward Summerside, Back-overman, 255, Beaconfield Street, Newcastle-upon-Tyne.

Students—
Mr. John Hunter, Mining Student, West View, Front Street, Sacriston, Durham.
Mr. George Jacobs, Mining Student, Fulwell House, Sunderland,
Mr. Hooper Rutherford, Mining Student, Mainsforth, Ferry Hill.

Subscribers—
DISCUSSION OF MR. T. CAMPBELL FUTERS' PAPER ON "AUTOMATIC CAGE TUB-STOPS."

Mr. T. Campbell Futers said that, when the paper was first discussed, the question of cost was raised. This matter had, to a certain extent, been gone into, and the cost was estimated to be about £20 to £25 per deck, for a cage with two tubs on each deck. For a cage with only one tub on each deck, the cost would be proportionately less, but only on account of the smaller amount of material; the charges for labour would be about the same.

Mr. T. L. Elwen read the following paper on "Some Results of Experiments made to Test the Effect of Sprayers upon the Moisture of Main Roads at Brandon Colliery":—


SOME RESULTS OF EXPERIMENTS MADE TO TEST THE EFFECT OF SPRAYERS UPON THE MOISTURE OF MAIN ROADS AT BRANDON COLLIERY.
By T. L. ELWEN.

The importance of the coal-dust question, and the interest that is now being taken in this subject, have induced the writer to place on record a number of experiments, with particulars of the method used to reduce the danger of coal-dust; and it is hoped that the information given will be of interest to the members.

[Graph of Humidity vs. Experiment Number]

Fig. 1. —Showing Hygrometric Conditions before and after Spraying. The dotted line indicates the conditions before and the firm line the conditions after spraying.

In the first place, a large number of experiments were made to ascertain the hygrometric condition of the seams, which are dry and dusty. In Table I. the observations on the leading district of one seam only are given, as the results tabulated are identical with those in all the districts and seams. These results have been plotted as a curve, and are shown in Fig. 1, the conditions, before spraying was resorted to, being also shown. The usual conditions prevailing in mines of this depth are as follows: the temperature of the air-currents in their passage in-bye

[Table I.—Hygrometric Observations taken in connexion with Experiments on Spraying Coal-dust at Brandon Colliery. Depth of Shaft, 411 feet.]

gradually approximate to the normal temperature of the mine, whether by a gradual increase, as in winter, or by a decrease, as in summer. The atmospheric conditions, both as
regards temperature and moisture, have an important bearing on the conditions prevailing 
underground.

When air enters a mine at a low temperature, and in a dry state, with its 
corresponding great capacity for absorbing moisture, the coal-dust on the engine-planes is 
rendered very dry and sensitive. On the other hand, when the conditions are exactly 
reversed, the air-currents may actually deposit moisture, and thus make the coal-dust on the roadways damp.

The efforts of the writer have been directed by two considerations, namely, (1) the 
establishment of wet sections in various parts of the main intakes, with the hope that these 
may prevent the extension of an initial explosion; and (2) an attempt to bring the air-current into such a fully saturated condition as to prevent the desiccation of the coal-dust.

[Diagram: Fig. 2.—Showing Position of Sprays in Downcast Shaft. Scale, 6 feet to 1 inch.]  

As there is already in operation a system of watering by means of a hose-pipe, fed from water-pipes laid along the engine-planes, it was decided to make these service-pipes available for extended treatment by water.

After several trials of various types of sprayers, it was decided to use the Saint sprayer, and it has given entire satisfaction. The water is thrown off from these sprayers in such a comminuted form as to resemble a “Scotch mist,” and thus thoroughly saturates the air. The pressure of water at these sprayers varies from 112 to 179 pounds per square inch, and each discharges from 170 to 200 gallons per day. The water is conveyed down the shaft from the service reservoir by means of pipes; and the above-
mentioned pressures are obtained by the depth of the pit, which to the several seams varies from 400 to 500 feet. All this water is, of course, not absorbed by the air-current; a large portion is deposited on the floor through the “wet sections,” and arrangements must be made to convey it to the water-levels. In fact, the position of the sprayers will be determined to some extent by the facilities for getting rid of the surplus water.

Near the downcast shaft in each seam the first wet section is 300 feet in length, the remaining sections being 150 feet long. In each case either side brick-walls, with steel girders on the top, or brick-arching was erected for the length stated, so that the conditions were less favourable to the accumulation of dust;

[Diagrams: Figs. 3 and 4.—Showing Position of Sprays in Main Intake. Scale, 6 feet to 1 inch.]  

or advantage was taken of the position of stone drifts. At the intake entrance to each wet section (and repeated at the end of 150 feet in the 300-foot section) there are in operation several sprayers, varying from two to four, according to the sectional area of the airway. These are kept in continuous operation. The sprayers erected in the downcast shaft are shut off during coal-drawing hours, for the comfort of the workers at the shaft-bottom. In these wet sections there is absolutely no dry coal-dust, the whole of the exposed roadway being kept in a dripping condition. Figs. 2, 3, and 4 show the sprayers in one of the pits, and illustrate the method of erection under varying conditions. It is still necessary to continue the old arrangement of having the accumulated dust filled up and
removed from the main roads. During coal-drawing hours much dust is brought down the shaft by the air-current from the screens, as well as that which is blown off the tubs in the cages.

On the main roads the greatest amount of dust is deposited where the velocity of the air-current is greatest. The effect of these sprayers on the hygrometric condition of the air-currents is shown in Table I.

Before the sprayers were set to work, a length of intake road of about 1,500 feet was watered every night from the service-pipes laid along the engine-plane. During the day this water was absorbed by the air-current, as shown by the increase in the humidity. In fact, so far as the coal-dust was concerned, the effects of the watering ceased soon afterwards, when the incoming air was very dry. From the figures given in Table I., it is calculated that 1,373 gallons of water were absorbed per day on the route, or, say, 1 gallon per minute. The total quantity of water in the form of moisture brought out of the seam per day was 4,580 gallons, and nearly the whole of this water was absorbed by the air-current from the surface of the main intakes. On the same route the air-current passes through five sets of sprayers. In summer all these sprayers would probably not be required, although no alteration has been made.

As an example of the power of the sprayers, one of many such trials is here given. A set of four sprayers, acting on 36,000 cubic feet of air per minute, gave the following results:—Before entering the sprayers: thermometer, dry- and wet-bulb, 48° and 45° respectively; humidity, 79 per cent.; after leaving the sprayers at a point 300 feet farther inbye: thermometer, dry-and wet-bulb, 46° and 45° respectively; humidity, 93 per cent.

Under the influence of a fully saturated air-current the condition of the coal-dust between the sections has undergone an advantageous change; and whilst the writer does not feel justified in saying that he has solved the coal-dust problem, he has the conviction that the coal-dust has been rendered to some extent less dangerous than under former conditions.

The timber in the main intakes soon shows signs of decay in the fully-saturated air, and in consequence it is being replaced by steel girders with brick pillars. The effect on the roof and sides has caused no inconvenience, and very little extra cost.

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The Chairman (Mr. T. B. Atkinson) said that Mr. Elwen's paper was a practical one, and was upon a subject which was of very great interest to everyone at the present time. The Royal Commission on Mines had the subject in hand, but they were, in a way, waiting until they got a report from the coal-owners' committee, who were conducting experiments. In the meantime, Mr. Elwen seemed, to a certain extent, to have solved the problem at his particular colliery. The pit was a shallow one, being only about 400 feet, and the difficulties were not, of course, so great as in a pit 1,800 to 2,400 feet deep.

Mr. A. L. Steavenson (Durham) said that Mr. Elwen's method of dealing with dust was an excellent one, and was moreover both scientific and satisfactory. There were other methods of dealing with dust—by the use of chloride of sodium and chloride of calcium, for example, which were both strongly recommended. In a paper which he (Mr. Steavenson) was reading recently, it was mentioned that experiments were made in Lancashire where they had 3 inches of dry dust on the road. He thought that any manager who had 3 inches of dry dust on the road should be sentenced to hard labour. Another system, Mr. Harle's, which had already been described in the Transactions* aimed at the prevention of the accumulation of dust by spraying water on each tub as it passed out of the in-bye landing, thus preventing any dust from rising as the sets travelled out. A set of fifty or sixty tubs travelling out at 14 or 15 miles an hour caused dust to rise, and this dust was deposited on
the timber of the roof and sides. Of the many systems in use, he could not say whether one was better than the other; but he thought that a combination of at least two of them would be very useful, and would, at all events, minimize, if not do away entirely with, the risk of coal-dust explosions.

With respect to the sprayer, the other day he (Mr. Steavenson) supplied to one of his managers one which was not unlike that shown by Mr. Elwen. His (Mr. Steavenson's) sprayer, however, had a copper ball fitting into a cup, and, with a strong pressure, the water was forced through and thrown off as spray in a fine mist. He was sure that everyone was always on the


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alert to prevent explosions, and the more attention that they paid to coal-dust, the fewer explosions there would be.

Prof. Henry Louis (Armstrong College, Newcastle-upon-Tyne) asked whether the effect of the sprayers was to make the ground sopping wet. He noticed that the writer stated that "the effect on the roof and sides has caused no inconvenience," but nothing was said about the floor, which was rather an important point. He should like to know whether the author had experienced any inconvenience with the floors of the roadways, and whether they might take it that in a colliery, less fortunate than Brandon, where there were soft and swelling shales in the bottom, the wetting would be sufficient to cause trouble under such circumstances. He (Prof. Louis) would also like a few particulars as to the crucial statement that "the coal-dust had undergone an advantageous change." Did the writer mean that the coal-dust was so sopping wet that it would not rise at all, or that it was sufficiently moist not to be liable to ignite or explode under a different set of conditions? Unfortunately, they did not really know the essential point, which was to determine just how damp the dust should be to render it innocuous.

Prof. P. Phillips Bedson (Armstrong College, Newcastle-upon-Tyne) said that in a paper already communicated to the Institute by Mr. Henry Widdas and himself,* it was demonstrated that the coal-dust must be wet—so wet that it would not rise in a cloud,† in order to prevent its inflammation. The dangerous point was reached when it began to rise in a cloud.

The Chairman said that he would like to know whether Mr. Elwen had found, that the saturation of the air produced any effect on the working capacity of the men. He did not know that it would in a shallow mine like Brandon; but, in a very deep mine, if the air was fully saturated, he thought that it would lead to considerable diminution in the capacity of the men for work.

Mr. Mark Ford (Washington Colliery) said that it would be an advantage if Mr. Elwen would give them the number of

†Ibid., 1907, vol. xxxiv., page 93.

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sprayers necessary to keep, say, 300 feet of roadway in a damp condition. The velocity of the current also had a very great effect; his (Mr. Ford's) experience was that in a current of 180 feet per minute the spray did not carry more than 12 to 15 yards.

Mr. T. Campbell Futers (Whitley Bay) said that it might be an advantage to add also the pressure of water necessary. One could conceive that there might be a colliery where such sprayers would be useful, but where it was impossible to get a sufficient head of water, unless a pump, something like that used by Mr. Harle, were adopted.

Mr. Steavenson asked whether Mr. Elwen had any fixed time for clearing the roads, or how many inches of coal-dust was allowed to accumulate.

The Chairman said that possibly Mr. Elwen recommended the use of sprayers in conjunction with regular cleaning, and possibly cleaning would be found easier on account of the dust being moistened.

Mr. T. L. Elwen, replying, said that the spraying had had no effect on the floor, although it had become very wet indeed. He could quite imagine, if one had a very big pressure and a soft bottom, that trouble would ensue, and this would have to be met in another way. With regard to the coal-dust having undergone an "advantageous change," he meant that the dust was in a damper condition on the top. By blowing it on the sides there was not the same readiness for it to come up in a cloud as there had been before spraying was introduced.

Respecting the effect, if any, on the working capacity of the men, he had had no complaints on that score, and he was not aware of any deleterious effect either on their health or their working capacity. If Table I. were consulted, it would be found that at the face of the workings before spraying, where the normal temperature was 60°, the humidity was 93 per cent., and that after spraying the humidity was 100 per cent., so that there was not a great change. If the temperature had been high, it would have made a difference. He agreed with Mr. Ford in his remarks respecting a very still current. He had only tried the sprayers on the main roads, and would not attempt to put them in the face or a short distance out-bye where there was a low current of air, as the water would simply drop down and wet the floor. The number of sprayers required was dependent on the velocity of the current of air, and had to be ascertained by experiment. The sprayers were made to suit varying pressures, and they could be made to suit a low pressure.

It had been found that formerly, when the sides and top were wetted, if it was a frosty night at the surface the roads were dry next day; whereas now, after a road had been wetted one night, it remained very much longer in that condition than before, on account of the air not having such a drying capacity.

The Chairman proposed a vote of thanks to Mr. Elwen for his paper, which was cordially adopted.

[37]

Mr. John Cumings read the following paper on "Sinking the John Shaft at Hamsterley Colliery, through Sand and Gravel, by means of Underhanging Tubbing":—

[38]

SINKING THE JOHN SHAFT AT HAMSTERLEY COLLIER Y, THROUGH SAND AND GRAVEL, BY MEANS OF UNDERHANGING TUBBING.
By JOHN CUMMINGS.

Introduction.—Hamsterley Colliery is situated on the southern slope of the Derwent Valley, about 10 miles south-west of Newcastle-upon-Tyne, and on the Consett and Blackhill branch of the North-Eastern Railway.

The royalties, which lie chiefly to the east, have a slight dip in that direction, and are heavily watered. Most of the coal in the upper seams lies above the drainage level of the district, and has been drained by a water-level drift driven from the level of the River Derwent; but, as a large area of coal in the lower seams is below this level, it was decided to sink a shaft at the lowest point in the royalty, and fit up a pumping-station in order to drain this area.

The most suitable site was on the alluvial flat near the River Derwent, close to and on the dip side of a large fault which intersects the royalties. A bore-hole was put down on the site of the shaft, and proved the existence of a bed of sand and gravel extending from the surface to a depth of 25 feet 9 inches, and of very soft and loose ground to a depth of 54 feet 8 inches. The following is a section of the strata sunk through:

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Ft.</th>
<th>Ins.</th>
<th>Ft.</th>
<th>Ins.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand, dry</td>
<td>2</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand, with water</td>
<td>9</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand, with gravel, heavily watered</td>
<td>12</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue clay, with boulders</td>
<td>6</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large boulders</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark blue to black shale, very soft</td>
<td>11</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seggar-clay</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White post, very soft</td>
<td>5</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stronger and darker post</td>
<td>30</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[Photograph: Fig. 5.—View of Sinking at the John Shaft, Hamsterley Colliery, County Durham.]

It was at first proposed to sink by means of piles and afterwards to tub the shaft, but as the site was close to the river, and heavy flow of water was expected, it was decided to adopt the following method of underhanging or suspended tubing, in order that the feeders might be at least partly tubbed off as met with.

Sinking Plant.—The finished shaft is 10 feet in diameter, and the whole of the plant in connexion with the sinking was driven by electrical power, which was generated by the colliery company at their power-station, about 1 ¼ miles distant, the current being three-phase at 550 volts and 50 cycles.

Fig. 5 is a general view of the sinking plant, which consists of:—

1. Two electrically-driven winches, one for raising and lowering the pump, and the other for dealing with the kibble, etc. Both winches and motors are exactly alike, but the rope from the crab (or pump) winch passes over a pulley in the headgear, round one of the pulleys on the pump, then up and over a
second pulley in the headgear, down and round a second pulley on the pump, and finally up, and is made fast to the headgear. This gives a 4 to 1 ratio of reduction, so that the greater weight of the pump and rising-main (full) can be raised at one-quarter of the speed of the kibble with the same power of motor. Each winch is driven through double reduction gear, and the motor-shaft is extended with square end, to which a handle can be fitted, so that both men and pump can be wound out of the pit by hand in the event of the current failing. For starting and stopping, a three-phase reversing controller is provided for each winch.

(2) The sinking pump (Fig. 6) consists of a vertical-spindle single-stage centrifugal pump of the turbine type, with gunmetal impeller, and is capable of delivering 500 gallons per minute. It is driven direct from a vertical-spindle three-phase motor. The motor is protected, but ventilated, a fan for forcing air through being provided on the rotor. The weight of the rotor-shaft is taken on ball-bearings, and as the impeller of the pump is coupled direct to the rotor-shaft, these bearings have also to take the weight of the revolving parts of the pump. The delivery of the pump is taken out on two branches which pass up, as shown in Fig. 6, one at each side of the motor, into an inverted Y-piece on the top, and through a non-return valve into the rising-main, this non-return valve being also provided with a bye-pass for priming the pump. The pump casing is bolted onto the distance-piece of the motor, and the impeller shaft on to the rotor spindle as already described. Under the Y-piece is fixed a block carrying two pulleys to take the wire rope which supports the pump, motor, rising-main, and column, as before mentioned. By this arrangement, as the sinking proceeds and the water level goes down, it is only necessary to add lengths or piping at the top and lower the pump by the ropes. In the engine-house at bank is placed the switch-box with 3-pole switch, fuses, and ammeter for controlling the pump circuit, and also an oil-filled compensator with change-over switch, for starting the motor. The handle of the compensator is placed in a convenient position within reach of the motor attendant while sitting at either of the winch-motors, so that the whole of the electrical installation is easily controlled by one man.

The sinking. --A commencement was made by excavating an annular trench in the sand to a depth of 4 feet, with an outside diameter of 19 feet. An annular concrete foundation-ring, having an internal diameter of 10 feet 10 inches, and an outside diameter of 19 feet, and 3 feet deep, was then laid, the top of the concrete being 1 foot below ground level. The concrete block was strengthened by scrap-iron bars and rails laced across each other. The concrete was composed of equal parts of cement, sand and broken bricks. Great care was taken to level the top of the concrete block, as this formed the bed for the cast-iron hanging-ring, from which the whole of the tubbing was suspended, and upon this the vertical position of the shaft depended.
The hanging-ring or curb (Figs. 2 and 3, Plate VIII.) was of cast-iron, 11 inches deep and 19 ¾ inches wide in the bed. It was in six segments, bolted together to form a circle 10 feet in diameter inside the flanges. Three out of these six segments had holes. A, sloping downwards (Figs. 2 and 3, Plate VIII) through which the liquid cement was poured for grouting the course of tubbing below. All the joints were machined, and lead-sheeting 1 inch thick was placed between them to form a watertight joint. The hanging-ring was laid on the foundation with the inner flanges projecting over the edge of the concrete, the top of the ring being flush with the surface of the ground. As a further precaution against slipping, and in order further to spread the weight, two baulks of timber, 20 feet long and 12 inches square, were laid across, one at each side of the pit, and bolted to the hanging-ring.

The sand was then taken out of the centre of the pit for a depth of 5 feet. This was done without difficulty, as there was a concrete lining for a depth of 3 feet. A course of tubbing was then put in, and bolted to the bottom flange of the hanging-ring, strips of lead-sheeting being inserted between all joints, both vertical and horizontal, before the bolts were put in.

The bolts being thoroughly tightened up (Fig. 7), the space at the bottom of the tubbing all round the shaft-bottom was rammed tight with well-puddled clay, and liquid cement was poured into the grouting holes of the hanging-ring above, so as to fill up the space behind the tubbing. Long tapered plugs were driven into the bottom grouting holes, these having a twofold purpose—first, to prevent the liquid from being wasted, and, second, to preserve the holes for grouting the next course below.

Fig. 8 shows the method of grouting, the cement and sand being mixed in the requisite proportions at the surface and sent down dry in a box to the pit-bottom. Pails of water from the sump were filled up with the cement, and stirred well before being poured into the grouting holes by means of the funnel, as shown in the illustration (Fig. 8).

The mixture of grouting was varied, as required: near the surface, where the sand was fairly dry, the mixture was 2 of sand to 1 of cement; but in the worst ground, where it was required to set quickly, pure cement was put in.

Little or no difficulty was experienced in putting in the first course of tubbing, as the water was just showing in the pit-bottom: in fact the whole of the work was done by ordinary surface labourers, with a mechanic to direct operations. The only point that need be mentioned was the manner of getting the closing cement of the circle into place while the adjoining ones were in position. This was done on this and subsequent occasions by excavating the shaft-side behind the last segment, thus making room for it to swing endways in behind the adjoining segment, and then bringing it forward into position.

[Photograph: Fig. 8.—Showing Method of grouting the Tubbing.]

The tubbing (Figs. 2 and 3, Plate VIII.) is of cast-iron, 1 inch thick, with six segments to the circle. It is in two sizes, namely, eight courses of segments, C, 2 feet 5 ½ inches deep, for going through the sand and worst ground, and eight courses of segments,
B, 4 feet 11 inches deep (Fig. 3, Plate VIII). The object of the deeper rings was to save joints, as these, being machined, are costly. Every alternate segment in the circle is provided with a grouting hole, A, just above the bottom flange (Fig. 2, Plate VIII.) which slopes downwards as in the hanging-ring. All the joints are made with strips of sheet-lead, 1/8-inch thick, accurately cut to pattern (Fig. 4, Plate VIII.), each strip projecting 1/8 inch beyond the face of the joint to allow for caulking, which was done after the tubbing was completed. The bolts were all turned 1 5/16 inches in diameter, and to prevent the threads from being damaged, 1/8 inch of it was turned off at the end of each bolt. In order to make the bolt-holes as well as the joints watertight, a conical lead washer (Fig. 4) was put on next the flange at each end of the bolt, and a metal washer (Fig. 4, Plate VIII.), having an inverted cone to fit over the lead one, was put on next to it. When the nuts were tightened up, the soft-lead washer was squeezed between the cast-iron of the flange and the conical space in the metal washer, and formed a perfectly watertight joint.

It will be seen from Fig. 2 (Plate VIII.) that small projecting horizontal ribs were cast on the outside of the tubbing. These formed supports for the tubbing in the cement grouting.

On Monday, July 27th, 1908, the actual sinking was commenced below the first course of tubbing, with four men in the pit-bottom, who began by digging out the sand at one side of the pit, wide enough to get in one segment of tubbing. This segment was made good and bolted to the course above, sand being next taken out for the adjoining segment, which was also bolted up, and so on, until the circle was completed, when the bottom was rammed with clay as before, and cement grouting poured in through the holes in the course of tubbing above. While excavating for this course, the sand was somewhat difficult to keep back until the segments were got in, especially as the men were new to the work, but it was finished without mishap by 6 am., two days later. For the next and subsequent courses short slabs of wood, 2 ½ feet long, were used as piles. These were driven in a sloping direction under the tubbing, so as to keep back the sand until a sufficient depth was obtained to insert a segment, continuing around the shaft until the circle was complete. A great quantity of brushwood was also used for the same purpose, being especially necessary at the open ends of the segment until the next one was joined up against it. When sinking for the fifth course of tubbing, the sand was so soft that the men had to have short planks to stand on to prevent them from sinking into it.

For the first three courses the quantity of water was not great, and was kept down by a hand-pump worked by two men. At a depth of 12 feet a small electric centrifugal pump, having a capacity of 150 gallons per minute, was put in. A sump was prepared for it by having in the centre of the pit a frame, 3 feet square and 18 inches deep, made of battens. This was driven down into the sand as the pit-bottom advanced, and the suction of the pump kept working out of it. It was only found necessary to keep this pump going intermittently, as the quantity of water varied most remarkably. It was noticed regularly, while the men were sinking and putting in the segments, the shaft sides being then more or less open, that the quantity of water increased considerably, and the pump was kept going at its fullest capacity to enable work to be carried on in the pit-bottom; but, after each course was completed and the bolts tightened up, the quantity was greatly reduced, especially after the grouting was put in. This was most particularly noticeable when the Boulder-clay was reached at a depth of about 30 feet, as when this course of tubbing was completed the pit was quite dry, and the pump was temporarily taken out. It was, in fact, so dry that water had to be brought from the river for the purpose of mixing the cement for the grouting. Although the large sinking pump
was at hand on the works, it was not found necessary to use it until the tubbing was finished and the pit was being sunk through the stone below in the ordinary manner.

Fig. 1 (Plate VIII.) gives a section of the shaft as tubbed. It will be seen that at the surface a course of deep segments was put in, as the ground was fairly easy, and it was deemed advisable to keep the shallow segments for the worst ground. The eight shallow courses were next inserted, the remainder of the deep segments being put in last. Before the sixteenth course was put in the sinking had reached a good firm stone; this last course was therefore not quite so necessary, and was not inserted until later: The sinking was carried down for over 30 feet into the post stone, when a walling bed was formed, and the shaft was lined with walling lumps 9 inches thick. This walling was

[Plate VIII, Figs. 1 - 4, is inserted between pages 46 and 47 of the text.]

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carried up to within about 6 feet of the bottom of the tubbing, and a wooden crib of elm was made to suit and laid on the top of it, being-wedged firmly from behind. The last course of tubbing, before mentioned, was then put in, and the joint between it and the crib wedged and made tight.

While the sinking and walling was being carried out below it the whole length of tubbing remained suspended from the hanging-ring at the surface, entirely without support at the bottom (except so far as it was self-clinging in the grouting) until the walling was joined up below it. The total weight of tubbing with bolts, etc., in the shaft was over 56 tons.

The time occupied in sinking the shaft, putting in grouting, and completing the tubbing to a depth of 55 feet from the surface, was 28 working days, including the time occupied in laying the hanging-ring, but not including a stoppage of 6 days after the tenth course was finished in the Boulder-clay, due to a consignment of bolts being delayed in transit.

Cost.—The total cost of sinking, tubbing, and finishing the pit for the above-mentioned depth was as follows:—Materials, £627 2s. 10d.; labour, £141 0s. 3d.; total, £768 3s. 1d., or £13 19s. 4d. per foot.

The whole of the work was executed without an accident of any kind to the workmen; and, in the opinion of the writer, the economy and safety of this method of putting in tubbing should make its adoption general in all cases where ordinary wedged tubbing can be used.

The initial cost of the machined tubbing with bolts, etc., is no doubt greater than ordinary tubbing, but this is more than compensated for by inserting the permanent lining as the work progresses, thus saving the cost of both materials and labour for putting in any temporary lining, and also affording greater protection to the workmen below from falls of side. The actual cost of putting it in will also be less than for wedged tubbing.

The only objections to its general use, so far as the writer can see, are:—(1) The absence of a good foundation from which to suspend the tubbing; (2) the difficulty of getting in the grouting against high pressures; and (3) the difficulty of securing a tight joint at the bottom of the tubbing courses to hold the grouting when the pressure is great.

[48]
The Chairman—(Mr. J. B. Atkinson) said that they were much obliged to Mr. Cummings for his very clear account of tackling a somewhat difficult problem. Although the method of sinking was German, and tubbing from that country was used, the work had been done by purely British labour. At a meeting held in that room a short while ago, there seemed to be a
disposition on the part of some of the members to think that British mining engineers ought to be able to do everything themselves. For his own part, however, he did not see why one should not go to any country for assistance if one had not a better way of doing the work. He noticed that Mr. Cummings had given them the cost, a thing which was very often omitted from papers. This was important, as in many cases it was the factor which decided what method was to be selected. The cost in the present instance seemed to be comparatively small, and it would apparently not have paid to have adopted either freezing or the method that was used at Newbiggin.

Prof. Henry Louis (Armstrong College, Newcastle-upon-Tyne) said that he would like to congratulate Mr. Cummings upon being the first person in this country to adopt the method of sinking described in his paper. He quite agreed with Mr. Atkinson that one ought not to stick to the old-fashioned insular system of thinking that one could do everything and anything better than anybody else; and when other people who had had bigger difficulties to fight, had worked out new methods, he thought that it only showed common sense to take advantage of their experience. The present method was first devised by Mr. J. Riemer, of Dusseldorf, who drew his (Prof. Louis') attention to it some 4 or 5 years ago, when he, at the same time, submitted some of the results of his work. Ever since that time, he (Prof. Louis) had been continually advocating and urging the Riemer method as being the best for getting down through running ground where the difficulties were not exceptionally great. He should imagine that there would be difficulties in using it in the case of a very deep layer of quicksands; but for ordinary conditions of running ground, especially near the surface, he thought with Mr. Cummings that there was no better method. Moreover, Mr. Cummings had broken fresh ground in the method he had used for securing the bottom of his tubbing while grouting. The German method was to cut strips of sheet-iron to a template of the side of the shaft, to bolt these up temporarily against the bottom flange, and then grout against this temporary bottom under considerable pressure, pumping the grouting in instead of just pouring it in. He thought that that method of cutting an iron plate, bolting it up against the bottom flange and forcing the grouting in, would probably be preferable where considerable difficulties were met with, although undoubtedly more expensive, and perhaps more cumbersome, than the method used in the present case.

Mr. Cummings, replying, said that the idea was first got from an article in a text-book by Prof. Louis. The method was there described, and, although they had practically decided to pile the shaft, the idea was abandoned, and the method used adopted instead. An endeavour had been made to get the tubbing in England, but this was found to be impossible, and it had to be obtained from Germany. If it could have been got in England, it was possible that it might have been purchased cheaper; having to go to Germany, they had to pay a higher price for it.

He had been asked whether any trouble was caused by the metal washers in the joints breaking while the bolts were being tightened up. Although the paper stated that "metal" washers were used, he ought to have said that they were made of cast-steel. They were quite able to stand the pressure, and no trouble whatever had been experienced from that cause. So far as he knew, not one of them had been broken.

The Chairman proposed a hearty vote of thanks to Mr. Cummings, which was unanimously adopted.

The Secretary read the following paper on "Electric Shot-firing," by Mr. James Douglas: —
ELECTRIC SHOT-FIRING.
By JAMES DOUGLAS.

Simultaneous electric firing from a switchboard outside the mine is an absolute safeguard, not against explosions of coal-dust through miss-shots, or against fires, but against loss of life. It is not generally adopted in the United States of America, but more than one coal-mine in the Rocky Mountains has adopted it. The following description of its application at Dawson, New Mexico, is by Mr. David Crow, late General Superintendent of The Stag Canon Fuel Company.

"The primary object of the electric shot-firing system is to ensure greater safety to the men working in the mine. The method consists in firing simultaneously all the shots when all the workmen are outside the mine, by closing for a second, a switch in a cabin on the side of the hill away from the pit-mouth. The system has been installed for somewhat over a year, and has given entire satisfaction."

"The current is carried into the mine on the trolley-wires in the main haulage ways (Fig. 1, Plate IX.). From the ends of these trolley-wires, No. 8 insulated wire is used to branch off into the various side entries, No. 14 wire then being used to conduct the current to the face of each room (Fig. 2, Plate IX.). These auxiliary wires are strung up as far as possible from the tracks and near the roof, and are held by three-wire porcelain cleats, the two outside grooves being used."

"The cleats are fastened to props, legs, caps of timber, or wooden plugs driven into the roof or rib, the supports being placed sufficiently only close to ensure that the wires will not come into contact with each other, should the insulation become worn off."

"There are two switches in the entry where the No. 8 wire is taped on to the trolley. One of these switches is in a box under lock and key, the box being constructed so that it cannot be closed and locked when the switch is thrown in; the other switch is in the open, and only acts as an auxiliary. Where two pairs of side-entries are directly opposite each other, one set of these switches is used for the four entries, but otherwise there is a set for each pair of entries. Just inside the pit-mouth there is another set of switches, one being between the outside and inside trolley-wires, another between the outside and inside feed-wires, and a third between the outside feed-wire and the wire to the shot-firer's cabin on the side of the hill, and only the first of these is locked up (Fig. 3, Plate IX.). The main switch, by which the firing is done, is in the shot-firer's cabin."

"The explosive used is Du Pont 40-per cent. dynamite, which is fired with 6-foot Reliable exploders, clay being employed for tamping."

"There is a set of rules governing the firing and other operations which are printed in various languages, for distribution amongst the men. Those which relate to the firing are as follows: —

1. The mining or cutting must in all cases extend at least 6 inches beyond the back of the holes. (The mining is always at the bottom of the seam.)
2. All holes must be at least 30 inches in length; no shorter holes will be fired.
3. All coal-dust must be extracted from the holes before they are charged.
4. No holes must be charged with more than five sticks of powder.
5. Standing-holes or parts of standing-holes must not be re-charged.
6. The holes in a tight corner must be at least 12 inches from the rib at the back end of the holes."
(7) In solid faces, holes must not be more than 6 feet apart horizontally, and not less than two such holes shall be fired.

(8) The object of these rules is to prevent and remove the danger from blown-out or windy shots; and it shall be the duty of the shot inspectors, in addition to the above rules, to refuse to shoot any holes which, in their judgment, may be dangerous, whether the circumstances are fully covered by the rules or not."

"Near the pit-mouth, a check cabin is located. To every employee in the mine a check is given when he goes into the mine. He hands over this check to the check-man in the cabin, and he calls for it again when he comes out. It is the duty of the check-man to see that an employee does not get some other man's check as well as his own. He fills in his time during the day fixing the fuzes, and making them ready for use."

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"Every man must be accounted for before the firing is done; if a man is missing, the shot-fixer must find him. If the miner is not in his regular working-place, the shot-firer marks the date and time on the rib with chalk to show that he has been there looking for him. Then a search is made for the man."

"The men employed in connexion with the firing system are one wireman, or shot-firer, and two fire-bosses. The duty of the wireman is to see that all the employees are out of the mine and that the power is cut off, before he enters to connect up the firing-circuits; to ascertain that all firing-circuits are disconnected from power-lines after shots have been fired; to see that the firing-lines are kept up in good shape, that the miners are furnished with wire for extensions, and that all wire is removed from pillars and abandoned places. He puts in a great part of his shift giving the miners wire for repairing lines."

"After he has reported that the switches are all connected, he remains for at least an hour after the shots are fired, and then re-enters and disconnects the switches, looking in the return from each split to see whether there are any indications of fires in the mine. The firing is done about 7 p.m., and when entering after the shots are fired, he uses a safety-lamp."

"The fire-bosses enter the mine at 3 a.m. to examine their districts, and are out at the mouth of the mine by 6 a.m., so that they can inform the men as to the condition of their respective working-places. The miners work from 7 a.m. to 5.30 p.m., and no work is done in the hour and a half before the shots are fired, to ensure all hands being out of the mine. No miner is allowed to go into the mine until he sees the fire-boss."

"The duty of the fire-bosses in connexion with the firing system is to distribute electric caps. They enter the mine again at 1 p.m. and examine all shot-holes in their districts before they are charged, to see that they comply with the rules governing the same; then they issue the number of caps necessary to fire properly the shots prepared by the miners."

The extra cost involved, as shown in the following extract from the cost-sheet of May, 1909, is about 3/5 d. (1.2 cents) per ton of coal:—

[53]

[Table omitted, showing Cost or Shot-firing by Electricity at Dawson Mixes, New Mexico, U.S.A.]

Mr. J. E. Sheridan, the New Mexico Territorial Mine Inspector, writes as follows with regard to electric shot-firing: —*

"The shooting is done by electricity after all the men are checked out of the mine. As the men enter the mine, they are required to deposit a metallic check at the shot-firing house outside, near the entrance to the mine. These checks are placed on a checkboard and returned to the men as they come from the mine. A record of the working-place of each check-number is kept in the shot-firing house, and in case any check is uncalled for the shot-

*
firer makes a search for the man until he is found. No shots are fired until it is known positively that no one is in the mine."

“To ensure safety against accidental discharge of the shots by electricity, there are two or more locked switch-boxes in each mine, with throw-off switches, one at the mouth of the mine and another at one or more stations inside the mine. After inspecting the inside-connexions with the shots to be fired, the shot-firer en route from the mine makes connexion at each of the switches mentioned. He then goes to the shot-firing cabin to turn on the electric current, but before doing so he turns on an electrical signal-light in a red globe, to warn all persons to remain away


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from the vicinity of the month of the mine; so that should an explosion occur within the mine, no one outside could be injured by flying debris. The shot-firing system has proved a success; the safety of the men from disastrous dust-explosions due to blown-out shots is assured; miners make better wages, and the production of coal is proportionately greater per man employed. A record is kept of the number of shots fired, showing less than 2 per cent. of missed shots. The missed shots are left for the next day's shooting, and are either reprimed or a new hole drilled to perform the work intended for the original shot. Very little fire-damp has been encountered thus far in the mines; but a supply of Wolf safety-lamps is kept ready for use."

The Chairman (Mr. J. B. Atkinson) said that he thought that it would strike a good many of the members present that the last two lines of the paper supplied the reason why this system was possible, namely: —“Very little fire-damp has been encountered thus far in the mines; but a supply of Wolf safety-lamps is kept ready for use.” It seemed to him that in a great many cases where shots had been fired, if no one had been in the mine at the time when the shots were fired, or near them, there would have been fires, or something left burning. In the United States of America they had had some very disastrous explosions in recent years, attended by heavy loss of life—he thought the second largest in the world after Courrieres. It seemed to him that the method just described was one that would be of very doubtful utility in British mines—at least where there was a considerable amount of fire-damp in the mine: as, very often after a shot had been fired, there was a risk of fire-damp being ignited, and, of course, if there was nobody at hand a standing fire in the pit was the result.

Mr. C. H. Steavenson (Redheugh Colliery) said that the paper was interesting, from the point of view that it brought the American way of doing things on a big scale to their notice. The method was one, he thought, which they in this country would never dream of carrying out. He himself did not believe in two shots being fired simultaneously in one place, there being the possibility that a blower of gas might come off in one or more places after the shot-firer had left the face, preparatory to connecting the various cables, etc., with disastrous results. The fact that there was nobody in the mine to be killed

[Plate IX, Figures 1, 2 & 3, illustrating the wiring layout, is inserted between pages 54 & 55.]

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was, of course, a very great point in favour of the method, but at the same time, one did not want to have one's pit blown to pieces.

The Chairman proposed a vote of thanks to the writer of the paper, which was cordially adopted.

The following paper upon "A Natal Colliery Explosion, and Underground Fires in Fiery Mines," by Mr. William Taylor Heslop, was taken as read:

[A NATAL COLLIERY EXPLOSION, AND UNDERGROUND FIRES IN FIERY MINES.]

By WILLIAM TAYLOR HESLOP, F.G.S.

Introduction.—On February 13th and 14th, 1908, an ignition of fire-damp, followed by a series of explosions, took place at Glencoe Colliery, Natal, the circumstances connected therewith furnishing some interesting points connected with the combustion of gases.

The colliery is situated near Dundee (Natal), about 4,250 feet above sea-level. The main shaft is 357 feet deep, and is sunk through 122 feet of sheet-basalt and 216 feet of underlying sandstones and shales before reaching coal-seams of the following sections:

<table>
<thead>
<tr>
<th>Ft. Ins.</th>
<th>Top Seam coal</th>
<th>Ft. Ins.</th>
</tr>
</thead>
<tbody>
<tr>
<td>{ 15 0</td>
<td>Laminated sandstone</td>
<td>3 6</td>
</tr>
<tr>
<td>{ to</td>
<td>Bottom Seam coal</td>
<td>3 6</td>
</tr>
<tr>
<td>{ 18 0</td>
<td></td>
<td>5 8</td>
</tr>
</tbody>
</table>

The coal is bituminous, the following being an average analysis:

<table>
<thead>
<tr>
<th>Moisture</th>
<th>Sulphur</th>
<th>Volatile hydrocarbons</th>
<th>Ash</th>
<th>Fixed carbon</th>
<th>66.69</th>
<th>Total</th>
<th>100.38</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent.</td>
<td>1.5</td>
<td>0.97</td>
<td>18.75</td>
<td>12.82</td>
<td>66.69</td>
<td>100.38</td>
<td></td>
</tr>
</tbody>
</table>

The seams lie approximately level, only the Bottom Seam is at present worked, the pillar-and-stall system being employed. Coal was first produced in the year 1902, and the output up to the date of the explosion was a little under 600,000 tons. The coal gives off fire-damp freely. The mine is well laid out and well equipped with machinery and plant, and is ventilated by a Capell fan, which was circulating 136,000 cubic feet of air per minute at the time of the explosion. The mine has always been worked entirely with safety-lamps, and its condition is generally dry, water having only been encountered when piercing a dyke.

The Explosions.—In the face of the North Level, 2,360 feet from the shaft, a small igneous dyke had been cut through:

and on account of the large emission of fire-damp, work had been suspended for some months, and had only been resumed in coal beyond the dyke about a fortnight before the explosions occurred. The level had been driven some 20 feet in the coal, through the igneous dyke.

Three shots put in the face of this drive on February 12th, 1908 were all fired, but one failed to bring down the coal, and "chambered," leaving the face of the coal and stemming intact, and the wires of the electric detonators hanging down from the bore-hole. Another
hole was drilled to within about 15 inches of the chamber made by the ineffective shot, for the purpose of bringing down the remaining coal, the coal from the first three shots being removed by the night-shift workmen. A “permitted explosive” (Nobel Carbonite) was being used, and was fired by a No. 6 electric detonator.

What occurred on the morning of February 13th and afterwards may be described by the evidence of the European ganger, or fireman in charge, and others in their evidence before the Enquiry Commission, which is summarized as follows*:

"The miner Phillips states that on the morning of the 13th February, the heading was reported to him by the fireman as being free from gas. Eight shots were fired in the next heading, eastward, by a miner named Thompson, about 7 a.m. There is no evidence, however, that this blasting had any effect on, or connection with, the subsequent explosion."

"Phillips also stated that he examined the heading for gas before he commenced work at about 6.30 a.m., and again very shortly before firing the shot at 8.30 or 8.45 a.m., but failed to detect any gas. These examinations were stated to have been made with the safety-lamp in use in the colliery— the 'bonneted Clanny' which Phillips and other witnesses describe as not being a good lamp for testing purposes. The evidence showed, however, that no other pattern of safety-lamp was provided or used in this colliery."

"Phillips further stated that the coal which it was intended to bring down by the shot on February 13th had not been loosened or shaken by the shots fired on the 12th; that it was solid and could not have been conveniently brought down with a pick, so a hole was put in for the purpose."

"This hole was drilled about 1 foot from the roof, and about 5 feet from the floor, being a little larger than the diameter of the cartridge used. The tamping used was damp sandy loam, the hole being filled. The hole, which was 2 feet 9 inches in depth, was charged with three cartridges of "Carbonite" together weighing 6 ounces, and was fired by a low-tension electric detonator fuze; the wires from the detonator projecting outside the hole.

After connecting the wires of the battery with those of the detonator,

*The Natal Government Gazette, 1908, pages 1135 to 1137.

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Phillips retired, with two or three natives, who were with him, to the first stoop out-bye the dyke on the western side. The usual warning was given, and the shot fired. At the time when the warning was given, two other natives who were engaged in bringing in timber were in the Main North, 40 or 50 yards from the face where the shot was fired. One of these natives (Adam Jacobs), thinking he was at a safe distance, stood where he was; the other (Mackenzie Sikwatsha), upon hearing Phillips call out "boss up", took shelter."

"Immediately after firing the shot, Phillips stated that he looked out into the heading and saw a large flame of a bluish colour over the whole working-face, which changed to a reddish or orange tint as it came rushing towards him. Moses Setha, one of the natives who had assisted Phillips, and who was in the stoop with him, stated that a flame of a blue colour filled the whole drive, and came round the corner of the stoop where Phillips and he were, extinguishing the safety-lamps. The native, Adam Jacobs, who was standing in the level, in a position to see what happened, stated that he heard the shot, and saw a small flame (the size being indicated by comparison with the bulb of an ordinary incandescent electric lamp), and immediately a 'big' flame came rushing towards him, which knocked him down. The native induna or headman (Zokwe Butelezi), working under the miner Thompson, stated that he was clearing away stone, which had been blasted down in the morning, when he heard
the shot, which made a whizzing or hissing sound, and saw a flame 'like lightning in quickness,' which set fire to the brattice. The lamps were extinguished, and he felt a strong wind and great heat—'there was no other wind like it'—and, being nearly suffocated, he fell down."

"The miner Phillips and seven natives were burned by this explosion, and were sent into hospital at Dundee. Three of these natives died from the effects of the burns."

"A miner, J. A. Davis, who was working in the day-shift on February 13th, stated that about 8.30 a.m. he was at his station—his section being the next on the west to that in which Phillips was employed—when he felt the concussion of an explosion and saw a cloud of dust coming towards him. After visiting the working-faces in his own section to see whether anything was wrong there, he proceeded to the North Level, where he found that he could not go northwards on account of dust and smoke. He went down the level as far as the second haulage wheels, where, shortly after his arrival, he met the Mine Captain, Ogilvie, who asked him what was the matter. Ogilvie and Davis went up to the level, and were joined by Thomas Clark, a miner working in the section next to that of Phillips on the east. Clark was sent to bring out the natives working in his section, and, on his return, was told to bring out any natives that still remained in Phillips' section, some of the natives of Phillips' gang being employed in drawing pillars at some distance from the scene of the explosion. He attempted to make his way through the Main North and along the cross-heading, but was obliged to return on account of the heat and smoke. Returning, he was joined by Ogilvie, when they went by way of Clark's own section and brought out all the natives (twenty-six) for whom they were in search. Having returned, Ogilvie, Clark, and Davis went up the Main North Level to within two stoops of the face where the fire was, but could not approach nearer, owing to the smoke and heat."

"Ogilvie, Clark, and Davis remained to watch the fire, it being then about 10 a.m. It is stated that the fire was blazing in the face, the brattice and timbers were burning, and here and there were small flames on the face and here and there were small flames on the face of the coal. While they were watching, the sandstone parting between the upper and lower seams fell, about 20 to 25 yards from where they were standing. The upper seam and its roof then commenced to fall, and continued to do so for some time. This fall hid the flames from their view. Ogilvie said that they had better return, and they retired eight stoops length—about 240 yards—down the level. Clark made two journeys up the level to see how things were going on. 'After his first journey he reported 'that he could not see anything wrong,' but he stated after his second journey that he reported to Ogilvie that he did not think that the fire was out. Ogilvie then proceeded to the surface, where he told the engineer not to send down any more 'daaga' as the fire had 'put herself out.' This was about 11 a.m. About 9 am, or soon after, instructions had been given by Ogilvie for 'daaga' to be sent into the mine, in case it might be required to build off the fire."

"Clark and Davis made several attempts to go into Clark's section, but the smoke prevented them."

"Natives were put to work to timber the roof on the out-by side of the fall, Clark and Thompson being in charge of this work. Davis went to visit his section, where he found nothing wrong, and returning joined Clark and Thompson."

"About 10 minutes after Davis had returned to the North Level, a small explosion took place, which slightly burned some coolies who were engaged in the timbering work. It was agreed that Davis should go and bring all the natives in his section out, and this was done. Clark and Thompson retired two stoops' length to Phillips' cross-heading. While they were
there, another small explosion took place. At this time Ogilvie had gone towards the shaft. Clark, Thompson, and the 'boys' then retired to the Second East and West, which is also known as 'Clark's Road,' when another explosion, making a loud report, took place. They then retired a further distance of three stoops. By this time all the natives in the northern parts of the mine had been withdrawn. A more violent explosion occurred, and the party retired down the level and met Ogilvie coming up, all returning together up the level. When they were a little in-bye in the second air-crossing, a still more violent explosion happened, which shook the air-crossing. This was about 2.50 p.m., and the men then went to the surface."

"Mr. George Sneddon, the manager, had been absent from the colliery from about 8 a.m. until a little past 1 p.m. About 2 p.m., upon his return, Ogilvie reported to him that the brattice-cloth had caught fire before he could get into the place, and that very shortly afterwards the roof or stone parting had fallen; that owing to this and the heat it was impossible to get, but that he thought that the stone falling on the top of the burning brattice had put it out. In order, however, to save more roof from falling, and to protect the roadway, he had left Clark to put up timber outside the dyke."

"About this time Ogilvie asked Pender, the engineer, to send more 'daaga' down into the mine."

"Shortly after his first interview with the manager, Ogilvie returned to him and reported that the gas had blasted twice since he had seen him, there being only about 20 minutes between the blasts. Mr. Sneddon instructed Ogilvie to withdraw all natives from the mine, but that, before this could done, he would be down in the pit."

"Loam or clay-mortar.

*[60]*

"The natives working in the southern part of the mine were withdrawn about 4 p.m."

"Mr. Sneddon went underground between 4 and 5 o'clock, and, accompanied by John Bellis, a miner who worked in the south of the mine, proceeded up the Main North, meeting several miners who were waiting for him near the haulage wheels. The whole party then went about two stoops beyond the first air-crossing, where they waited, discussing the pros and cons of the situation. No further explosion taking place, Sneddon, Ogilvie, and Thompson decided to go farther up the level. At the second air-crossing Sneddon drew attention to some boards which had been displaced in that structure, but this was not considered sufficient to impede the natural course of the ventilation. The party proceeded as far as the second cross-roads. It being thought advisable to get into the return airway when they had gone eight stoops' length into Clark's Road, Ogilvie and Thompson went forward to open the door on the road. Sneddon gave instructions for the door to be left open for 10 minutes, as also the check-screen at the entrance of the road, in order to clear the smoke from the back workings. Leaving Ogilvie and Clark to attend to this, Sneddon returned to the surface with the intention of returning with the night-shift."

"Ogilvie soon came out of the mine, when a consultation was held between Sneddon and himself, at which the nature and position of the falls in the vicinity of the site of the explosions was discussed, and reference made to the plan of the mine. It was decided that it would be necessary to build off certain roads in the first instance with 'daaga' walls, in order to confine the fire to a limited area. To avoid any error, tracings were made from the plan of the mine, showing the most convenient places at which to build off. One of the tracings showed the proposed position of three dams, the other an alternative scheme for building six dams, in case the dams first decided upon could not be erected. These tracings Ogilvie took with him, and they were afterwards found upon his body."
"Between 6 and 7 p.m., a party under Mine Captain Ogilvie, consisting of James Barclay, David Thompson, James McCallum, and Thomas Hickman, with forty natives, went into the mine."

"About 7 o'clock, a report was made by the engineman to the engineer (Mr. J. B. Pender) to the effect that he thought that something was wrong in the pit, as he had seen some black smoke come out of the fan-vent about 4 minutes before, and a native had come out of the mine whose safety-lamp had been extinguished quite close to the bottom of the shaft."

"Mr. Sneddon arrived almost immediately afterwards, and, upon being informed of the circumstances, went underground, accompanied by the miner J. A. Davis. Two miners, Crossan and Baird, had preceded Sneddon and Davis by a few minutes, but were unable to go further than half a stoop length beyond the second cross-roads on the in-bye side of the haulage wheels, where Sneddon and Davis joined them."

"Two natives who had been seriously injured were found near the haulage wheels on the out-bye side, and they were sent to the surface. No reply was received to the shouts of the party, and the opinion was arrived at that none of Ogilvie's party could be alive. It was found that the second air-crossing had been destroyed by the explosion, and a stopping had been blown out, thus allowing the air to short-circuit itself instead of going up the Main North Level, and that this damage would have to be repaired before the party could go farther. The roof was 'working' and dangerous, and the situation unsafe, so the party returned to the surface."

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The foregoing evidence indicates the following sequence of explosions: —

February 10th.—(1) 8.30 a.m.—A small explosion and ignition of blowers of gas, brattice, and timber, burning one European and seven natives, three of whom afterwards died; followed at 10 a.m. by a fall of sandstone roof, Top Seam coal, and shale of Top Seam roof, immediately out-bye from the dyke.

(2) 11.10 a.m.—A small explosion.

(3) 12.0 noon (?).—A small explosion.

(4) 1.0 p.m. (?).—A small explosion.

(5) 2.50 p.m.—A larger explosion, damaging the second air-crossing.

(6) 7.0 p.m.—A large explosion, killing five Europeans and some fifty natives, and destroying several brick stoppings and the second air-crossing.

February 14th.—(7) 8.15 a.m.—A tremendous explosion of fire-damp and coal-dust, which resulted in the death of seven Europeans and about twenty-one natives, the explosion traversing nearly the whole of the mine, and destroying stone stoppings and air-crossings throughout the mine.

It is not the purpose of the writer to discuss all the features of the disaster, but to confine himself more particularly to the factors incidental to the recurrence of explosion after explosion.

It is the general opinion amongst Natal colliery managers that the Natal coal-seams and the adjacent strata are more permeable to marsh-gas than are those of Great Britain. In consequence, leading development drives, whether in a new mine or after penetrating an igneous dyke (which forms an impervious barrier to the gas), are especially liable to heavy blowers of gas. From time to time it has happened that these blowers of gas have become ignited during blasting operations, even when "permitted" explosives have been in use. In many cases the blower of burning gas has been extinguished by promptly beating it out with a piece of brattice-cloth, but in other cases it has been necessary to build dams to seal off the fire, and thus extinguish by shutting off the supply of oxygen.
Some 7 or 8 years ago such a fire occurred in a main development drive at the St. George's Colliery under the writer's charge. During blasting operations the blowers in the face of the intake side of a pair of main drives (Fig.1) became ignited. There was no accumulation of gas and consequently no explosion. The European miner in charge took off his coat and attempted to beat out the fire, but he was compelled to retire to allow two shots, already ignited, to explode. On his return he was quite unable to subdue the fire: the brattice cloth took fire and he was compelled to send to the surface for help. On the writer's arrival at the spot the fire, (of gas blowers, timber and coal) was burning so fiercely that it was impossible to approach within 50 feet of it on account of the dense clouds of smoke which forced their way outwards against a current of air of 25,000 cubic feet per minute. It soon became evident that the fire could not be extinguished by direct means, and the only way to save the pit was to dam off the fire. On the intake road practically all the gas was being burnt as it issued from the coal, and on the return road gas was issuing from the coal face, and also from a bore hole some distance back, which had been put up into the Top Seam, the section of which is similar to that of the Glencoe Colliery. The combustion was so rapid and fierce that it was apparent that if the air supply was cut off, the supply of oxygen would soon be used up. One crucial question was - whether the non-ignited gas in the return-drive face might, after the air was cut off, accumulate, reach the fire and explode before the fire was subdued to a temperature that would not ignite gas: or whether the proportion of oxygen would be so reduced that the mixture would be non-explosive.

After considering all the local conditions, the writer came to the conclusion that the fire could be sealed off, that gas would accumulate in the return heading whilst so much smoke pouring out from the intake, and that with such a fierce fire in the other heading the proportion of oxygen requisite to produce an explosion would be very quickly consumed. A canvas brattice was placed across the intake road as near the fire as practicable, and in actual contact with the smoke from it This was followed as quickly as possible by a stone stopping, plastered up to make it quite air-tight, the return road meanwhile being still open. When the intake was nearly sealed, a brattice was thrown three-fourths of the way across the return road to divert the smoke, and a stone stopping commenced immediately behind it. This latter stopping was completed about 14 hours after the outbreak of the fire, and smoke continued to issue in dense volumes all the time. A small observation pipe was left in the return stopping, from which smoke issued for more than a week, and was afterwards followed by fire-damp. The stoppings were left for some 3 months, and, when taken down, no trace of remaining heat could be found. A very considerable quantity of exceedingly spongy coke was found where the fire had been. The evidence of the combustion that had taken place, as indicated by this coke, was greatest at the "cut-through" between the two headings. In the actual face, where the fire had originated, there had been very little burning of the coal.

Reverting to the Glencoe Colliery incident, the first explosion at 8.30 a.m., on February 13th, 1908, was very small, but it ignited an exceedingly strong blower of gas,
which in turn set fire to brattice, timber, and, to a small extent, coal. This fire might have been dammed off without disaster; but, unfortunately, a fall of stone took place on the out-by-side of the dyke out 10 a.m., which fell up to and including the Top Seam and its roof, leaving a cavity as shown in Fig. 2.

Gas from the upper seam would accumulate in this cavity, that from the lower Seam meanwhile being consumed, as it issued, by combustion- or rather, to be precise, as it underflowed--until it came into contact with, the fire, and the second small explosion occurred at 11.10 a.m., an hour after the fall of stone. In another hour the cavity again filled, and the third explosion occurred at about 12 a.m. Another interval of an hour took place, and then the fourth explosion occurred at 1 p.m. The evidence, however, as to the number of explosions up to this time leaves it not absolutely certain whether there were four or five small explosions.

Probably about this time (1 p.m.) the cavity was enlarged by a further fall of stone, and the next explosion did not occur until 2.50 p.m., by which time the enlarged cavity had again filled. This explosion was more severe, and damaged a wooden air-crossing on the main intake, known as the second air-crossing, and to a certain extent short-circuited the ventilation of that part of the mine. This introduced another factor, which, if associated at all with the earlier explosions, could have only affected them in a minor degree. The violence of the explosion, together with the continued combustion in the face of the heading, must have depleted the atmosphere at that point of so large a proportion of its oxygen that it was unable to support combustion, and the short-circuiting of the air at the Second North air-crossing delayed the renewal of oxygen necessary to restart the active combustion of the glowing embers. It was not until an interval of 4 hours and 10 minutes had elapsed that the next explosion (that at 7 p.m.) occurred. By that time, not only the cavity in the roof but the whole of the area that had been on fire, and several adjacent places, must have been charged with gas. The fall of stone had blocked the regular air-way; the magazine of gas was there, the match was ready, in the shape of the glowing embers of the fire, at a temperature below the ignition-point of fire-damp, namely, 1,200° Fahr. (650° Cent.), so that to cause an explosion it only required sufficient oxygen to enable the glowing embers of the fire to burst again into flame.

As the gaseous products of the former explosions cooled, the heavier carbonic-acid gas gravitated into the lower workings and was replaced by fresh air, and another explosion of a very violent character occurred at 7 p.m., killing five Europeans and some fifty natives, who were attempting to build off the fire by means of dams. This explosion destroyed several brick stoppings, and did further damage to the second air-crossing.

After some alterations to ventilation, sufficient to permit the attempt of rescue-work, had been carried out, the writer, with a rescue-party, penetrated almost to the edge of the fall, and about 4 a.m. on February 14th found fire-damp in explosive proportions mixed with the products of the explosion at the point where the dam had been commenced in the Main North Drive, which showed that the whole area that had been on fire was at that time
charged with fire-damp; and, in a pillar to the east, in the return air-way, he observed carbonic-acid gas in process of gravitation from the fire area. The replacement of carbonic-acid gas by fresh air must have taken place very slowly, and at a time when it was thought that further danger of explosion had ceased.

At 8.15 a.m. on February 14th (or 13 ¼ hours after the previous explosion) another violent explosion took place, killing nearly all the members of a further rescue-party, including the Inspector of Mines (Mr. Muir), and originating a coal-dust explosion which extended over the greater portion of the mine. This explosion was of such violence that both cages were blown into the headgear, one from the surface-landing, and the other from near the bottom of the shaft. Notwithstanding the extreme violence of this explosion, some six natives who had been near the shaft-bottom were subsequently rescued alive. Fig. 3 shows the damage to the headgear by the projected cages.

Five days later, the next exploration party found fire-damp near the second air-crossing. This indicated that in the northern section of the mine there was approximately 5,000,000 cubic feet of fire-damp. Assuming that this consisted of, on average, a 10-per cent. mixture, then marsh-gas was being emitted at the rate of 100,000 cubic feet per day. Exploration was subsequently delayed for a month, in order to put down a bore-hole to the face of the North Level, to ascertain whether the fire was really extinguished.

Some 3 or 4 months later, a series of explosions, which originated in the same way, took place at the Natal Cambrian Colliery, some 7 miles distant from the Glencoe Colliery. A chambered shot ignited a blower and small accumulation of gas, and again a series of some half-dozen explosions, each more violent than its predecessor, and each occurring after a longer interval, took place, culminating with a gas-and-coal-dust explosion of such violence that a coal-truck was blown from the shaft-bottom to the shaft-top, and jammed fast in the bottom of the cage hanging at the "banking-out" platform.

[Photograph: Fig. 3—Showing damage to the headgear by cages projected by the force of the explosion at Glencoe colliery, Natal.]

The foregoing will furnish some idea of the conditions prevailing, and of the risks incidental to any attempt to dam off a fire where firedamp is one of the combustibles.

Useful information bearing on the subject has been furnished by Prof. Frank Clowes in his paper on "The Proportion of Carbon Dioxide (Choke-damp) in Air which is Extinctive to Flame," from which the following table is extracted* :


[Table omitted: Results obtained with Naked Flames. Extinctive Proportion of Carbon Dioxide added to the Air.]

From this it would appear that if the percentage of oxygen in any volume of air be reduced from 20.7 to 17.0, then a flame of methane, candle, colza, and petroleum (or inferentially also coal or wood) would be extinguished.

Unfortunately, an atmosphere containing not only air and carbon dioxide, but also methane has to be considered.
The experiments of Dr. Haldane and Mr. Atkinson* show that carbon dioxide has "little or no influence on the explosibility of the mixture, provided that sufficient oxygen is present for the complete combustion of the fire-damp. If, however, the oxygen is insufficient, as in experiments Nos. 8 and 12 (in each of which there were less than two volumes of oxygen to one of marsh-gas), the explosibility of the mixture is of course diminished by the black-damp."†

Experiment 8. ‡

<table>
<thead>
<tr>
<th>Component Gases</th>
<th>Percentage Composition</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire-damp</td>
<td>6.88</td>
<td>Partly inflammable; flame went up tube sometimes nearly to top by candle. With hydrogen flame the mixture seemed more inflammable.</td>
</tr>
<tr>
<td>Black-damp</td>
<td>37.59</td>
<td></td>
</tr>
<tr>
<td>Air</td>
<td>55.53</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

† Ibid., page 502.
‡ Ibid, page 500.

[68]

Experiment 12. *

<table>
<thead>
<tr>
<th>Component Gases</th>
<th>Percentage Composition</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire-damp</td>
<td>7.43</td>
<td>Slightly inflammable; flame went about half-way up tube</td>
</tr>
<tr>
<td>Black-damp</td>
<td>40.58</td>
<td></td>
</tr>
<tr>
<td>Air</td>
<td>51.99</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

In experiment 11,† on the other hand, it is shown that a mixture of 6.25 per cent. of fire-damp, 34.16 per cent. of black-damp, and 59.59 per cent. of air is still explosive.

It would appear, therefore, that in damming off a fire in an area giving off fire-damp, a condition of affairs would arise when there was insufficient air to support combustion of the coal, timber, or issuing fire-damp, but that at the same time the atmosphere would be explosive. Therefore, if the fire was, by the exclusion of oxygen, subdued to a temperature below 1,200° Fahr. (650° Cent.), before such time as the fire-damp reached the explosive proportion (5 per cent.), then no explosion would occur as the fire-damp increased in proportion, unless fresh air were admitted to re-kindle into flame the smouldering embers.

The writer's experience, taken in conjunction with the above, indicates the following precautions that must be taken in dealing with a fire where fire-damp is issuing from the coal:—

The conditions must be so controlled that there is a minimum danger of accumulation of fire-damp in explosive proportions at a point not in contact with the fire, but which, as the accumulation increases, may possibly be brought into contact with the still active fire. It is therefore necessary that the area dammed off should be confined within the smallest possible limits. If it should happen that it became necessary to dam off both of a pair of main drives, of which only one was on fire, then, provided that there was no accumulation of
fire-damp, it would, so soon as preparations for building the dams were completed, be advisable to ignite the gas-blowers in the second drive, before commencing the actual work of building the dams. Until the building of the dams has actually been commenced,

† Ibid.

it is preferable that the fire should burn fiercely, so that combustion may be rapid and the air inside the dams be quickly consumed. It is therefore not advisable to decrease the amount of air passing over the fire until the preparations to shut it off completely are concluded. This would, by accelerating the exhaustion of the oxygen within the dams, reduce the likelihood of any unignited blower of gas accumulating in such quantity as to cause an explosion before the active combustion, or flame of the fire, had ceased.

Where the blower of fire-damp is insignificant, and the resultant fire only small, a chemical fire-extinguisher depending on the generation of carbon dioxide might be tried, but, in case of a large fire, the fire itself would furnish the carbonic-acid gas in sufficient quantity more readily.

It is of vital importance that after the air-supply has once been shut off from the fire, the greatest precautions should be taken to prevent any possible re-admission of air. As soon as the activity of the fire has ceased, and the gases begin to cool, then in a rising or level place the carbon dioxide would find its way along the floor, away from the region of the fire, and if it were possible, fresh air would rush in to take its place.

In a dip-place the risk of re-kindling the fire would not be so great, but the risks of accumulation of an explosive mixture at a point not in initial contact with the fire might be greater, unless specially provided for by the arrangements made.

The point has sometimes been raised whether the intake or return road should be first shut off. In practice, it will generally be found very difficult indeed to deal with the return airway first, on account of the state of its atmosphere, as far as breathing and working is concerned. Apart from that, the selection should depend on that which would be less likely to cause an accumulation of fire-damp away from initial contact with the fire.

It must always be remembered that the cutting off of either airway will stop the supply of air to the fire, except so far as convection currents and diffusion are concerned. If one dam is at a lower elevation than the other, it would be preferable shut it off first, with a view to giving any fire-damp a better opportunity of escaping by the higher airway.

Ultimately, at both the Glencoe and Cambrian Collieries,

the zone of foul gases formed the only barrier, preventing the ingress of fresh oxygen to the fire. That zone was of such an extent that neither diffusion nor convection currents were able to break through it after the final explosion until the embers of the fire were effectually extinguished; but in each case convection-currents were able to break through the zone of oxygen-depleted gases left by the earlier and smaller explosions.

The writer has endeavoured to confine his attention to the features incidental to the outbreak of fires in proximity to firedamp. Where conditions are so dangerous, they may at any time become of most vital interest, and he trusts that discussion may bring forth points of further interest, and possibly induce further experiments dealing with the combustion or
extinctive points of various mixtures of gases, or the time that must elapse before a smouldering fire reaches such a stage that resuscitation becomes impossible.

He also begs to express his indebtedness to Prof. P. Phillips Bedson of Armstrong College, Newcastle-upon-Tyne, for valuable information bearing on the subject.

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Mr. F. A. Steart (Inspector of Mines, Dundee, Natal) wrote that fires caused by the ignition of fire-damp through blasting, and more especially at the faces of headings, or in main development drives after cutting through igneous dykes, had not been infrequent in Natal collieries in the past. The problem of dealing with such fires when they did occur was very different from that of dealing with a gob-fire. The circumstances of no two of such fires were alike, and, whilst some might be quite easily extinguished, in other cases, such as those which gave rise to the terrible explosions at the Glencoe and Natal Cambrian Collieries (especially if the mine was a dry and dusty one), prompt action with great presence of mind was essential to prevent a great disaster. The writer considered Mr. Heslop's paper to be a very valuable one, the more so as Mr. Heslop had had practical experience in dealing with this danger, and in dealing with it successfully.

The circumstances in connexion with the disaster at the Natal Cambrian Colliery were different, and, perhaps, even more difficult, than the case dealt with by Mr. Heslop. The ignition of gas caused by blasting did not occur in the face of the main development heading immediately inside the dyke, but in the face of an ordinary stall, in a section which had advanced a good distance from the dyke and was opened out to a considerable extent. The entire section was giving off gas freely in every stall, and when the ignition occurred the capacity of the roads and workings was not less than 250,000 cubic feet. Attempts were made to build off this entire section with brick stoppings at the three entries on the out-by side of the dyke. This attempt failed when the work was all but completed; and the builders, with those in charge, narrowly escaped with their lives. He had no doubt whatever that had each of the three entries been built up successfully, the proportion of fire-damp and air in some parts of the section on the inside of the dyke, when reached by the burning brattices and timbers, would have been sufficient to have caused a violent explosion, which would have blown out the stoppings. The writer therefore agreed with Mr. Heslop that, in dealing with such fires, it was necessary that the area dammed off should be confined within the smallest possible limits, otherwise any such attempts simply courted disaster.

An ignition of fire-damp might sometimes occur in a stall after every precaution had been taken in testing for gas, through the shot encountering and igniting a blower. Such cases, however, were very rare: they were merely ignitions of gas-jets, but not explosions, and were more easily dealt with and extinguished if brattices and timbers were not set on fire.

In his opinion, many ignitions of fire-damp, originated by blasting, should not and would not have occurred if the miner who fired the shot had carried out properly his duty in thoroughly testing for fire-damp before firing the shot. In the case of the Natal Cambrian Colliery disaster, he had no doubt, from his own investigations, that there was a considerable accumulation of fire-damp—at least 60 feet in length—in the place where ignition occurred when the shot was fired, and that the miner ought never to have fired the shot under such conditions.

The experience of others who had had to deal with problems similar to that stated by Mr. Heslop in his paper would be of great value and interest.
The Chairman (Mr. J. B. Atkinson) proposed a vote of thanks to Mr. Heslop, which was heartily adopted.

A new reinforced-concrete mine prop was exhibited and described by Mr. F. Elford Gulley.

A patent self-oiling colliery guide sheave was exhibited and described by Messrs. Jno. Alf. Jackson & Son.

THE INSTITUTION OF MINING ENGINEERS.

TWENTIETH ANNUAL GENERAL MEETING,
Held in the Lecture Theatre of The North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne,
September 15th, 1909.
Dr. ROBERT THOMAS MOORE, Retiring-President, in the Chair.

RECEPTION IN WOOD MEMORIAL HALL.
The members and visitors were received in the Wood Memorial Hall by The Right Honourable the Lord Mayor of Newcastle-upon-Tyne (Alderman John James Forster), The Sheriff (Councillor Thomas William Rowe), and the President (Mr. Thomas Emerson Forster) and Members of the Council of The North of England Institute of Mining and Mechanical Engineers.

The Lord Mayor of Newcastle-upon-Tyne (Alderman John James Forster), in welcoming the members of the Institution, said, that he was delighted to receive them. On behalf of the Corporation of Newcastle-upon-Tyne he extended to them a most hearty and cordial welcome to the city on the occasion of their meeting. The work which they would be called upon to perform was extremely important, and, as one of the leading centres of the coal-trade, Newcastle was highly favoured. The work that had been done by the Institution in carrying out improvements in the mining industry was of vital interest to such a city as Newcastle-upon-Tyne. "Newcastle" and "coal" were synonymous terms. The association between Newcastle and the coal-field of the North-- one of the most important coalfields of the world -- had been a happy one for the general prosperity of the whole district. Having regard to the great wealth of the nation and also of the Empire, which was wrapped up in mining industries, it was impossible to overestimate the importance of the work which they, as mining engineers, were called upon to perform. These investigations were of the greatest advantage to the mining industry, in lessening the cost of working, and in adding to the wealth of the Empire. The benefits received by coal-owners, which, but for the industry of the mining engineers and their inventions would not accrue, were of advantage not only to the individual but to the nation at large. Mines that
had been improved, and were being improved, added not merely to the benefit of the pitmen, but also made the lives of the workmen less onerous and less dangerous, and increased their comforts above-ground. That being so, the advantage all round was considerable. Humanity was much indebted to the able investigators, who, through papers and lectures, brought their individual knowledge before the younger members of the Institution, thus encouraging them in their endeavours to bring about a lower death-rate in mines. He believed that the death-rate of the miner was not any greater than the death-rate of those working in their cities or on board ship. The improvements all round brought about by mining engineers and by marine engineers were all tending towards the lengthening of life. In holding their meeting in Newcastle, the members were coming back to the home where the Institution was founded, and he trusted that their deliberations would add further to the developmental and material advantage as well as the material prosperity, not only of the country at large. He trusted that the visits they were going to make to different centres and works about Newcastle would also be interesting, and that they would be able to carry away happy remembrances of their visit to Newcastle.

The President-Elect (Mr. J. B. Simpson) thanked the Lord Mayor for his kind words of welcome to The Institution of Mining Engineers. Newcastle, as one of their Mayors, once said, was always an ancient place, and if they extended, that view they might say it was always an ancient place for mining. So far back as 1300, they had the Mayor and burgesses of Newcastle mining coal not more than 100 yards from where they were standing at that moment. The story went that the monks of Tynemouth, who had coal-mines to the west of the walls of the town, were working their coal, but the burgesses of Newcastle came across their boundary and worked away the coal of the monks. The latter appealed to Edward II., and it was found that the burgesses of Newcastle had gone beyond their boundary. A division-line was therefore made, which was now beyond the Castle walls, at what was called "The Forth." Since that time coal-mining had developed in that part of the world, as well as in others, and during the 50 years that he had been connected with mining, the output of coal had increased from 50,000,000 to 220,000,000 tons per annum. One of the most favourable points about this increase was that the death-rate in mines was just about the same as it was at that time; in other words, the death-rate percentage had been reduced nearly five times. He hoped that, by all scientific means which they could now devise, it would be still further reduced. The great cause of death in those days was explosions in mines, and the number of men who perished in explosions was about 50 per cent. of those who were killed. Now the proportion had been reduced to about 12 per cent. There was still other casualties, such as falls of roof, which were a great source of danger; but mining engineers were doing all they could to reduce still further the risk in mines.

The members then adjourned to the Lecture Theatre.

The Retiring-President (Dr. R.T. Moore) said that his first duty, and indeed his only one as Retiring-President, was to introduce to them their new President, Mr. J. B. Simpson. It was quite unnecessary, however, for him to say anything about the new President to a Newcastle audience; all the members of the Institution knew him, and esteemed him. He was sure that under his presidency the Institution would progress as it had done in the past, and that it would be very much benefited by having his influence to secure its aims.
The President-Elect (Mr. J. B. Simpson) then took the chair and thanked the members for the honour done him by electing him their President. He would endeavour to do his best to fulfil the duties which naturally devolved upon him, and he hoped that he might be able to hand down, at the end of his office, the affairs of the Institution in no worse condition than he found them. Although his predecessor had now resigned office, he (Mr. Simpson) felt perfectly sure that he would not desert them but would continue to take the same lively interest in the Institution as he had done before. He again thanked the members for the honour that they had conferred on him in electing him their President, but they should not forget their old one, and he asked them to join with him in proposing a hearty vote of thanks to Dr. Moore for the able manner in which he had conducted the proceedings during his term of office. They all knew him (Dr. Moore) well, and he (Mr. Simpson) did not think that he could say anything more than that he had made an excellent President. He only hoped that he (the speaker) might be able to follow in his footsteps.

Mr. H. C. Peake (Past-President) had great pleasure in seconding the motion. One thing for which he thought the members ought especially to thank Dr. Moore was for having entertained the party of Silesian mining engineers who had visited the country early in July. Dr. Moore had been kind enough, when it was proposed that they should come, to offer at once to give them a reception in London, and had entertained them at dinner.

The resolution was put to the meeting and carried unanimously.

The Retiring-President (Dr. R. T. Moore) thanked them all in the most heartfelt manner for the cordial vote of thanks which they had accorded him. He could only say with regard to his duties as President that they were most agreeable; he had had a most pleasant Council to deal with, everything was well done, and the officials were very anxious to do all that lay in their power for the benefit of the Institution. He could not wish his successor anything better than that he should have an equally pleasant time as President as he had had.


The Hon Secretary (Prof. L. T. O'Shea) announced the election of officers for the ensuing year as follows: —

President: Mr. John Bell Simpson.

Vice-Presidents:
- Mr. W. Armstrong.
- Mr. John Ashworth.
- Mr. T. E. Forster.
- Mr. M. H. Habershon.
- Mr. James Hamilton.
- Mr. W. Armstrong.
- Mr. G. P. Hyslop.
- Mr. R. McLaren.
- Mr. G. May.
- Mr. J. H. Merivale.
- Mr. J. G. Weeks.

Auditors:
The Hon. Secretary (Prof. L. T. O'Shea) read the Annual Report of the Council as follows:

TWENTIETH ANNUAL REPORT OF THE COUNCIL.

The constitution of The Institution of Mining Engineers remains unchanged, and comprises the following societies, namely:

The Manchester Geological and Mining Society; the Midland Counties Institution of Engineers; the Midland Institute of Mining, Civil, and Mechanical Engineers; the Mining Institute of Scotland; the North of England Institute of Mining and Mechanical Engineers; the North Staffordshire Institute of Mining and Mechanical Engineers; and the South Staffordshire and Warwickshire Institute of Mining Engineers.

The progress of the membership since the formation of the Institution in 1889 is shown in the following table:

<table>
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<tr>
<th>Year ending July 31st</th>
<th>No. of Honorary Members</th>
<th>No. of Members</th>
<th>No. of Non-federated Members</th>
<th>Totals.</th>
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<td>18</td>
<td>3,083</td>
<td>60</td>
<td>3,161</td>
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The year which has just passed marks a most important step in the history of the Institution. Founded in 1889, it included four mining societies, and its membership then amounted to 1,239. Since that time the number of Institutes in the federation increased to seven, and the members on the register for the year ending July 31st, 1908, numbered 3,137; whilst for the financial year just ended there were 3,083 members, 60 non-
federated members, and 18 honorary members, a total of 3,161. The steady progress made by the Institution is a matter of gratification to the Council, who feel that it is a standing monument to the zeal and devotion of their late Secretary, Mr. M. Walton Brown. The Council also recognize that the federation could not have been possible without the assistance and generosity of The North of England Institute of Mining and Mechanical Engineers, and welcome this opportunity of acknowledging how much of the success of the Institution is due to their disinterested co-operation.

A unanimous vote of thanks was accorded to The North of England Institute of Mining and Mechanical Engineers for their kindness in having, during the past nineteen years, provided office accommodation, free of rent, rates, taxes, etc., for the staff of the Institution, and the Honorary Secretary was instructed to forward a letter to the President of that Institute, conveying the resolution of the Council.

The appointment of a successor to the late Mr. M. Walton Brown and the future home of the Institution received the very serious attention of the Council. By resolution of the Council, of July 29th, 1908, it was decided to advertise the appointment of an independent Secretary. About two hundred applications were considered by a sub-committee, who recommended that the best interests of the Institution would be served by the appointment of an Honorary Secretary, with Mr. Percy Strzelecki (who had acted as Secretary pro tem, from November 22nd, 1907, to September 1st, 1908) as Assistant Secretary; and the Council, at their meeting on September 2nd, 1908, unanimously agreed that Prof. L. T. O’Shea, of the University, Sheffield, be appointed Honorary Secretary, and Mr. Percy Strzelecki, Assistant Secretary.

As notified in the last report, a decision to remove the head-quarters of the Institution from Newcastle-upon-Tyne to London been arrived at, and at the same meeting of the Council as above, after consideration of the report of the Offices Inspection committee, it was unanimously agreed to take offices in Albany

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Buildings, 39, Victoria Street, Westminster, S.W., at a rent not exceeding £335 per annum, inclusive of rates, and on a lease of fourteen years, terminable at the end of the third, sixth, or twelfth year. A small committee was appointed to make the necessary arrangements for the fitting up and furnishing of the offices, and for the removal of the stock, etc., from Newcastle-upon-Tyne to London. On November 23rd, 1908, the offices in London were opened with a staff of five, consisting of the Assistant Secretary, Cashier, Stock-keeper, Lady Shorthand-typist, and Office-boy.

The offices for the Assistant Secretary and Staff have been suitably furnished, and two rooms facing Victoria Street have been made into a large Council Chamber, which has been fitted up as a reading-and-writing room for the convenience of the members.

Stock-rooms have been fitted up with shelving, and the whole of the stock of Transactions, etc., has been removed from Newcastle-upon-Tyne to London.

The Council look forward to the continued success of the Institution under the new conditions, and confidently anticipate the hearty co-operation of the Federated Institutes to achieve this end.

That the Institution now comprises seven mining institutes in Great Britain may be looked upon as testimony to the value of its work; but the Council feel that its sphere of action would be widened, and the interests of scientific mining more fully served, if mining societies outside the federation were to join. The advantages to be derived from membership of the Institution are so many that, in the interests of the whole of the members of these non-federated societies, the Council trust that the time is not far distant when The Institution of Mining Engineers will represent the entire mining interest in the United Kingdom. At the
present time a member by subscribing to one Federated Institute receives the proceedings of not only his own society, but also those of the separate meetings of the Institution and of the other six institutes. Founded in order to advance the sciences of geology, mining, and metallurgy, by the interchange of opinions, by the reading of communications from members and others, and by discussions; to supply information to the Government upon the

practical requirements of legislation affecting the mining and metallurgical industries; and more especially to promote a more general recognition of the status of mining and metallurgical engineering as scientific professions, the aim of the Institution has been attended with success. The mass of information contained in the thirty-seven volumes of its Transactions forms a most valuable reference library for all engaged in mining or its allied sciences.

The nineteenth annual meeting of the Institution was held in Edinburgh on September 1st, 2nd, and 3rd, 1908, and a general meeting was held in London on May 27th and 28th, 1909. Both meetings were well attended, and papers of great interest to the members were communicated. The thanks of the members have been sent to the owners of works, collieries, etc., which were thrown open to those who attended the meetings.

Prizes have been awarded to the writers of the following papers, which are printed in Volumes XXXIV. and XXXV. of the Transactions: —

"Winding-engine Tests, with Notes and Suggestions on the Design and Testing of Plant." By Mr. S. L. Thacker.
"Strength of Cast-iron Tubbing for Deep Shafts." By Dr. John Morrow.
"Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air. Part II." By Dr. P. Phillips Bedson and Mr. Henry Widdas.
"Accidents in Winding, with Special Reference to Ropes, Safety-cages, and Controlling Devices for Colliery Winding-engines." By Mr. George H. Winstanley.

Addresses have been delivered during the year by the following gentlemen:—Dr. Robert Thomas Moore, President of The Institution of Mining Engineers; Sir Lees Knowles, Bart., President of the Manchester Geological and Mining Society; Mr. William Hay, President of the Midland Counties Institution of Engineers; Mr. M. H. Habershon, President of the Midland institute Mining, Civil, and Mechanical Engineers; Mr Robert McLaren, President of the Mining Institute of Scotland; Mr. G. P. Hyslop, President of the North Staffordshire Institute of Mining and Mechanical Engineers; and Mr. A. W. Grazebrook, President of the South Staffordshire and Warwickshire Institute of Mining Engineers.

The papers communicated during the year and printed in Volumes XXXVI. and XXXVII. of the Transactions are summarized under the following heads, and demonstrate the varied subjects brought before and discussed by the members: —

Geology and Mineralogy.
"What is a Mineral?" By Prof. J. W. Gregory,
"Geological and Mining Notes on China." By Mr. A. Hassam.
"Scottish 'Eenie' Coal." By Messrs. C. T. Clough and James Kirkpatrick.
"Manjak as worked at the Vistabella Mine, Trinidad." By Mr. J. C. T. Raspass.
"Note on a Deposit of Sulphur in a Colliery Water." By Mr. G. H. Stanley.
"Note on the Effect of an Igneous Dyke on a Natal Coal-seam." By Mr. G. H. Stanley.
"Borate Deposits of California." By Mr. Wilfrid B. Wainewright.

Mining Engineering.
"Hydraulic Stowing of Gob at Shamrock I. and II. Colliery, Heme, Westphalia, Germany." By Mr. Hugh Clarkson Annett.
"The Working of the Inclined Seams in the St. Etienne Coal-field, at the Montrambert and La Beraudiere Collieries." By Mr. Hugh Clarkson Annett.
"The Working of Oil-shale at Pumpherston." By Mr. William Caldwell.
"The Use of Concrete for Mine Support." By Prof. W. R. Crane.
"The Wemyss Coal-field." By Mr. John Gemmell.
"Machine-mining under Difficulties." By Mr. John Gibson.
"Damage to Surface Buildings Caused by Underground Workings." By Mr. William Hay.

"Brickwork Dams in Thick Coal." By Mr. Laurence Holland.
"Notes on Working the Thick Coal of South Staffordshire and Warwickshire." By Mr. Laurence Holland.
"Tapered Timber." By Mr. P. Horan.
"Holywell-Halkyn Tunnel and Mines, Holywell, North Wales." By Mr. John Philip Jones.
"Drilling with Bamboo Rods." By Mr. W. A. Moller.
"Deep Diamond-boring at Balfour Mains, Fifeshire." By Mr. James G. Thomson.
"Coal-mining on the Kirghese Steppe, in the Akmolinsk District of Southwestern Siberia." By Mr. Edward Watson.

Mechanical Engineering.
"Repairing Leaky Seams." By Mr. Ugo Bagnoli.
"Notes on Straightening Steel Girders." By Mr. J. T. Browne.
"Notes on the Working and Testing of Locked-Coil Winding-Ropes." By Mr. James Elce.
"Stresses on Winding- and Conducting-ropes, as used in Mine-shafts." By Messrs. Joseph Hindley and John Stoney.

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"Exhaust-steam Turbines at Lancashire Collieries." By Mr. Gerald H. J. Hooghwhinkel.
"Notes on certain Alterations to a Large Winding-drum." By Messrs. G. P. Hyslop and J. Magee.
"The Cramp Safety-device for attaching to Mine-cages." By Mr. E. D. Spencer.
"The 'Bold' Box-controller and Box-switch." By Mr. J. G. Thompson.

Electricity.
"Experiments with Two Electrically-driven Pumps." By Mr. Thomas Lindsay Galloway.

"The Regulation of Colliery Electrical Power-station Supply, with Special Reference to the Tirrill Regulator." By Mr. E. Carton.

"The Use of Electric Lamps for Miners, with Special Reference to the ‘Float’ Lamp." By Mr. Mansfeldt Henry Mills.

"Some Recent Electrical Winding and Haulage Plants." By Mr. M. B. Mountain.

"Electricity in Coal-mines." By Mr. Robert Nelson.


"The Recovery of Bye-products from the Distillation of Coal, with Special Reference to the Koppers New Process." By Mr. A. Victor Kochs.


Rescue-apparatus and Brigades, and Underground Fires.

"The Use of Breathing-apparatus at a Mine Fire in Cape Breton, with some Notes on the Central Rescue-station of the Dominion Coal Company, Limited, at Glace Bay, Cape Breton, Nova Scotia." By Messrs. F. W. Gray and James McMahon.

"On the Practical Use and Value of Colliery Rescue-apparatus, and the Organization of Rescue-corps." By Mr. George Blake Walker.


Coal-dust, Fire-damp, Mine-gases, and Ventilation.

"Notes on Recent Demonstrations of Coal-dust Phenomena." By Mr. James Ashworth.

"Notes on a Small Contrivance to More Easily Detect Fire-damp." By Mr W. C. Blackett.

"Coal-dust to date, and its Treatment with Calcium Chloride." By Mr Henry Hall.

"Ignition points of Wood and Coal." By Mr. Henry Hall.

"The use of Electric Lamps for Miners, with Special Reference to the ‘Float’ Lamp." By Mr. Mansfeldt Henry Mills.

"Spontaneous Combustion." By Mr. T. Seabridge.

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"Methods of Dealing with Gob-fires in the Main Coal-seam at Netherseal Colliery." By Mr. F. N. Siddall.

"Carbon-monoxide Detector." By Mr. O. Simonis.

"Hygrometric Observations in Coal-mines." By Mr. A. H. Stokes.

Miscellaneous.

"Canadian Mining Institute Summer Excursion-meeting, August-October, 1908." By Mr. James Ashworth.

"Delegate's further Report of the Summer Excursion-meeting (1908) of the Canadian Mining Institute." By Mr. James Ashworth.
"Report of the Delegate appointed by the Mining Institute of Scotland and The Institution of Mining Engineers at the Excursion-meeting of the Canadian Mining Institute, August-October, 1908." By Mr. James Barrowman.


"Coal-shipment and the Laying-out of Staithe Heads, with Special Reference to Anti-breakage Appliances." By Mr. John Kirsopp, Jun.

"A Tour with the Canadian Mining Institute through the Chief Mining Districts of Canada." By Mr. D. B. Langford.

"Report of the Delegate to the Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, Dublin, 1908." By Mr. J. A. Longden.

"Memoir of Henry Lawrence." By Mr. John H. Merivale.

"List of Fatal and Non-fatal Explosions of Fire-damp or Coal-dust, and Barometer, Thermometer, etc., Readings for the Years 1907 and 1908." By Mr. Percy Strzelecki.


The "Notes of Papers [75] on the Working of Mines, Metallurgy, etc., from the Transactions of Colonial and Foreign Societies and Colonial and Foreign Publications" have been continued, and form a valuable addition to the Transactions.

The Council are pleased to state that a collective index to Volumes I. to XXX. of the Transactions was issued to the members during the year, and forms a useful adjunct to the Transactions.

Mr. James Barrowman and Mr. John Ashworth represented the Institution at the Summer Excursion-meeting of the Canadian Mining Institute, August 24th to October 1st, 1908, and their reports have been printed in the Transactions.

Mr. J. A. Longden was appointed to represent the Institution at the meeting of Delegates of Corresponding Societies of the British Association for the Advancement of Science, to be held in London on October 25th and 20th, 1009.

The Institution was represented by the Hon. Secretary (Prof. L. T. O'Shea) at the Fiftieth Anniversary of the Oxford University Museum, held on October 8th, 1908, and at the laying of the foundation-stone of the mining extension to the Imperial College of Science and Technology, London, by H.M. the King, on July 8th 1909: and by Prof. Frank Clowes (in place of the late Mr. Bennett H. Brough) at the International Congress of Applied Chemistry, London, held on May 27th to June 2nd, 1909.

Mr. Arthur Sopwith continues to represent the Institution on the Governing Body of the Imperial College of Science and Technology, London.

Messrs. J. Dyer Lewis and R. A. S. Redmayne, H.M. Inspectors of Mines, and Mr. Robert Nelson, H.M. Electrical Inspector of Mines, have been elected Honorary Members of the Institution during their terms of office.

The Council deeply regret to have to report the death (which occurred on October 3rd, 1908) of Mr. Bennett H. Brough, the Secretary of The Iron and Steel Institute, and one of their colleagues. Mr. Brough took an active interest in the affairs of the Institution, and tendered valuable advice in connexion with the removal of the headquarters to London.

The Institution has also suffered loss in the death of Mr. Henry Bramall, a member of the Council, which occurred on July 10th, 1909.
Owing to want of room at Newcastle-upon-Tyne and the excellent Library of The North of England Institute of Mining and Mechanical Engineers, which was available for reference purposes, no attempt was made in the past to form a Library for the Institution, beyond binding and storing such books and periodicals as were sent either in exchange or presented by the author and publishers. Steps are, however, being taken for the formation of an adequate Library, and the Council have Pleasure in stating that gifts of books have already been received from several of the members and others, particulars of the same being contained in the list of "Books added to the Library" appended to this report. The thanks of the members are particularly due to Mr. G. Elmsley Coke, Mr. G. Alfred Lewis and Mr. John Nevin.

Some of the exchanging societies did not in the past supply a copy of their publications to this Institution, and a request has

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been sent to them, asking that an additional copy should be forwarded direct to the Library of the Institution. Favourable replies have been received from a number of these societies. The Council will be very pleased to receive gifts of books on mining, etc., or sets of Proceedings of any of the engineering societies, for placing in the Library, as the want of suitable works of reference is greatly felt in connexion with the editing of the Transactions.

In order to reduce the surplus stock, and thus provide room for future additions, the Council have decided to offer to members only, who wish to complete their sets, a limited number of single copies of Volumes I. to XXIX. (with the exception of Volumes XXIV. and XXV.), and single copies of odd Parts, at greatly reduced prices, and the fact has been advertised in the Transactions. As this offer will not be repeated, and only holds good until December 31st, 1909, the Council trust that members wishing to avail themselves of this concession will make an early application for the volumes and parts that they require.

On July 11th, 1909, a party of Silesian mining engineers, numbering about twenty, visited England, and were entertained at dinner in London by the President (Dr. H. T. Moore) on the evening of July 12th. A programme of visits to collieries and works, etc., was arranged for their entertainment by committees in the various mining districts visited by them during their stay in this country.

An application was made to the Registrar of Friendly Societies for the exemption of the Institution from rates, which the Council, however, regret to state was refused, on the ground that the judgment against The Institution of Civil Engineers in a similar application applied equally to The Institution of Mining Engineers. Had the application been granted, a saving of about £65 per annum would have been effected.

From a perusal of the accounts, it will be seen that the expenditure has considerably increased during the year just ended as compared with the previous year. This has been due to several items of extraordinary expenditure, including the compiling and printing of the Index to Volumes I. to XXX. of the Transactions, at a net cost of £166 10s.; furnishing of the offices and Council Chamber, £372 4s. 1d. ; cost of removal from

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Newcastle-upon-Tyne to London, £146 0s. 9d. : and accumulated law-charges, £29 6s. 4d. In addition to these items, there are rents and rates, cleaning, lighting, etc, amounting to £298 10s. 1d. ; telephone rent, etc., £8 14s. 6d., and an increase in salaries amounting at present to about £100, which will, of course, continue in the future. On the other hand, the amount guaranteed by the various Institutes has fully met the increased normal expenditure.
The costs in connexion with the printing of the Transactions have again received very careful attention during the past year, particularly those relating to the plates, and a considerable saving has been effected by the judicious selection and reproduction of only such illustrations as were necessary for the purpose of explaining the subject-matter of the papers concerned.

The balance of assets over liabilities, exclusive of the stock of Transactions, etc., but inclusive of the value of the furniture and fixtures, now amounts to £1,780 18s. 5d., as against £1,450 15s. 8d. at the end of the previous year, so that the financial position of the Institution is most satisfactory.

An income and expenditure account was added to the accounts for the year ending July 31st, 1908, and this will be continued from year to year; and now that the Institution is the owner of property in the shape of office and Council-room furniture, etc., a capital account has also been added.

In order to meet the increased expenditure incurred through the removal to London, a Guarantee Fund has been formed, amounting to £500, each of the Federated Institutes guaranteeing an amount, proportionate with its membership, for 3 years, payable in equal moieties on January 30th and June 30th, in 1909, 1910, and 1911, and calculated on the membership as at July 31st, 1908, 1909, and 1910. It will be necessary, therefore, to consider the finances of the Institution, and the best means of providing for the increased expenditure after the expiration of the above-mentioned 3 years; and this important matter will receive the careful attention of the Council when the proper time for its consideration arrives.

In conclusion, the Council trust that the hope expressed, in the last annual report—that the step taken in removing to London would prove to be in the ultimate interests and welfare of the Institution—may be fully realized.

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The Treasurers in account with The Institution of Mining Engineers for the year ending July 31st, 1909

[Tables omitted]

[92-93]

The Institution of Mining Engineers, Balance Sheet--July 31st 1909

[Tables omitted]

[94-95]

The Institution of Mining Engineers. Income and Expenditure Account for the Year ending July 31st, 1909.

[Tables omitted]

[96]

The Institution of Mining Engineers. Capital Account for the Year ending July 31st, 1909.

[Tables omitted]
The Local Institutes in Account with The Institution of Mining Engineers, for the Year Ending July 31st, 1909.

[Tables omitted]

[These tables may be obtained from the Library Scans]

BOOKS, ETC., ADDED TO THE LIBRARY SINCE JULY 31st, 1908.

—, —. Treatise on the Winning and Working of Collieries. 1848. Presented by Mr. John Nevin.
------------. Vols. 1.-lxiv.; Charter and Bye-laws for the year 1889; Abstracts of the Proceedings, Nos. 619-625; 627-643; 645, 647, 649, 651-661; 663-676; 678-681; 683-712; 714-730; 732-735; 737-855; 858, 859, and 861-881. Presented by Mr. John Nevin.
------------. Centenary, 1907, recorded by Prof. W. W. Watts.
------------. Address delivered at the Anniversary Meeting, by Sir Archibald Geikie, February, 1908. Presented, by Mr. G. E. Coke.
------ vol. xiv., parts A, B, F, J, M, O, and S.
------ vol. xv., parts A, AA, F, and S.
------, vol. xvi., parts A, B, C, and CC, G, H, and S.
Reports Nos. 923, 939, 947, 949, 953, 959, 961, 962, 968, 971, 974, 977, 979, 982, 983, 986, 988, 992, 996, 1021, 1028, 103C, and 1072.

The Falls of Niagara, by J. W. W. Spencer, 1905-190*.;
Maps, British Columbia, Shuswap Sheet, No. 604.
------, Ontario, Province of, Hastings, Haliburton, and Peterborough Counties, No. 770.
------, Hudson Bay, South-western Coast, No. 915.
----------, West Somerset and North Devon, July 27th to August 1st, 1896, by R. S. Herries.
----------, Weldon, Dene, and Gretton, April 29th, 1899, by B. Thompson.
----------, Charnwood Forest, May 17th to 20th, 1902, by Prof. W. W. Watts.
Report of Committee on the Thermal Efficiency of Steam-engines, 1898.
Tunnels on the Dore and Chinley Railway, by P. Richard, 1894.
Application of Mechanics to Engineering Practice, by A. Barr, 1S99.
Presidential Address, by Sir Guilford L. Molesworth, 1904.
------, by Sir Alexander R. Binnie, 1905.
------, by Sir Alexander B. W. Kennedy, 1906
Notes of a Voyage to Kerguelen Island to observe the Transit of Venus, December 8th, 1874, by the Rev. S. J. Perry. Presented by Mr. G. E. Coke*
----------, --- Subject-index to vols. i.-lvii.; lix.-exviii.; and cxix.-clxx.
----------, --- Name-index to vols. i.-lviii.
----------, --- General-index to vols. i.-xx.; and xxi.-xxx.
----------, --- Catalogue of the Library, corrected to December 31st, 1865.
----------, --- Appendix to the Catalogue of the Library, corrected to December 31st.1865 Presented by Mr. G. E. Coke.


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Massachusetts Institute of Technology, Society of Arts, Boston. Bulletins for December, 1908; January, February, March, and April, 1909; and Bulletins, vol. xliv., parts 1 and 2.

———, Technology Quarterly, vol. xx., No. 4; and vol. xxi., No. 3. By exchange.

Mines, list of, in the United Kingdom of Great Britain and Ireland, 1907. Presented by Mr. John Gerrard.

——, Electricity in, Minutes of Evidence taken before the Departmental Committee on the use of, with Appendices and Index, 1904.


——, Report for the South-western District (No. 12) for the years 1887, 1888, and 1890.

Mines and Minerals: Mineral Statistics for the years 1891 and 1892.

Part II.—Labour.

———, General Reports and Statistics for the years 1900-1902: and 1906-1907.

Part III.—Output.

———, General Reports and Statistics for the years 1900-1902; and 1906.

Part IV.—Colonial and Foreign Statistics.


———, Report for the South-western District (No. 12) for the years 1899-1900.

———, Report for the Southern District for the years 1901; and 1904-1907.


———, General Report and Statistics for the years 1900; and 1903-1907.


Part IV. — Colonial and Foreign Statistics.


Reports of the Manchester and Ireland District (No. 6), for 1908, by John Gerrard, H.M. Inspector of Mines. Presented by Mr. John Gerrard.
Reports of the Liverpool and North Wales District (No. 7), for 1908, by Henry Hall, H.M. Inspector of Mines. Presented by Mr. Henry Hall.
Mining Year Book, The, 1909. Presented by the Publisher.
Municipal School of Technology, Manchester. Journal, vol. i., parts 1 and 2. Presented by the Principal.
National Physical Laboratory. Report for the year 1908. Presented by the Laboratory.

South Wales Institute of Engineers, Cardiff. Proceedings, vol. xxv., No. 8; and vol. xxvi., No. 4. By exchange.


Whitaker's Almanack for 1909. By purchase.


EXCHANGES.
The following is a complete list of the societies exchanging publications with the Institution:—

Annales des Mines de Belgique.
* Australasian Institute of Mining Engineers.
* British Association for the Advancement of Science.
British Federated Society of Mining Students.
* Canadian Mining Institute.
Chemical, Metallurgical, and Mining Society of South Africa.
Comite Central des Houilleres de France.
*Cuerpo de Ingenieros de Minas del Peru.
Franklin Institute of the State of Pennsylvania.
*Geological Institution of the University of Upsala.
Geological Survey of Canada.
*Institution of Mechanical Engineers.
Institution of Mining and Metallurgy.
*Lake Superior Mining Institute.
*Maryland Geological Survey.
Massachusetts Institute of Technology.
*Mining and Geological Institute of India.
*Mining Society of Nova Scotia.
Missouri, Bureau of Geology and Mines.
New South Wales, Department of Mines and Agriculture, Geological Survey.
* North-East Coast Institution of Engineers and Shipbuilders.
*Revue Universelle des Mines, de la Metallurgie, etc.
*Rugby Engineering Society.
*Sociedad Nacional de Mineria de Chile.
South Wales Institute of Engineers.
*Transvaal, Department of the Mining Commissioner.
United States Geological Survey.

* No publications received during the current year. July 31st, 1909.

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The following paper on "Fire-damp Caps and the Detection of Fire-damp in Mines by means of Safety-lamps" by Messrs. E. Bessell Whalley and W. M. Tweedie, was read by Mr. E. Bessell Whalley:—

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FIRE-DAMP CAPS AND THE DETECTION OF FIRE-DAMP IN MINES BY MEANS OF SAFETY-LAMPS.

By E. BESSELL WHALLEY, F.G.S., H.M. Assistant Inspector of Mines, and W. M. TWEEDIE.

Introduction.—The detection of fire-damp in mines is a subject of special interest to the mining community at the present time: and a great diversity of opinion exists as to what proportion an ordinary man can detect in the atmosphere of a mine with any of the types of safety-lamp in common use. Much valuable evidence from any witnesses has been collected by the Royal Commission on Accidents in Mines, and it is premature to discuss many of the questions involved until the Commission issues its report; but the writers trust that the following record of observations concerning gas-"caps" will be useful.

Some time ago, Mr. Tweedie succeeded in producing a photograph of a gas-cap; and this, so far as the writers know, was the first time that gas-caps had been successfully photographed. The method commended itself at once as a practicable and accurate means of recording the indications and conditions to be observed in miners' safety-lamps. The requirements of practical mining have been kept in view throughout the series of experiments, and an effort made to investigate the following points. namely: —

(1) The appearance and nature of a safety-lamp flame.
(2) The effect of introducing this flame into an atmosphere containing combustible gas.
(3) A practical and accurate method of obtaining a testing-flame of constant dimensions.
(4) The ratio between the size of the testing-flame and the size of the gas-cap.
(5) A comparison between various illuminants as regards the caps shown by them.
(7) The effect of the presence of black-damp.
(8) A comparison between the coal-gas and fire-damp caps.

Most of the photographs have been taken in laboratories, but some were taken in coal-mines to verify the laboratory results.

(1) Appearance and Nature of Safety-lamp Flames.—The writers do not attempt to discuss the chemistry of flames, but some points in connexion therewith are possibly of interest in deep or hot mines, and need further investigation. It is known, that in a rarefied atmosphere flames become less luminous, and that an increase of pressure alters the shape, size, and colour of a flame. Under sufficient pressure, for instance, a hydrogen flame becomes luminous, and a coal-gas flame varies in luminosity at different altitudes. No doubt the amount of oxygen necessary to consume a definite bulk of fuel has an effect upon the size of a flame. In a mine the amount of oxygen in a given volume of atmosphere varies, and this probably has something to do with the size of the flame. The temperature of the atmosphere feeding the flame, as shown later, has apparently no appreciable effect in mines, as the temperatures there do not vary sufficiently: but, if a flame of carbon monoxide be fed with very hot oxygen, its colour changes.

(2) Effect of introducing a Safety-lamp Flame into a Combustible Atmosphere.—In a large flame, such as that given by a candle, the gases unconsumed in the inner zone are carried upwards as they become heated, and in their ascent meet with oxygen and burn, while the nitrogen and incombustible products of combustion are dispersed: the combustion
is slower and the illumination less in the upper than in the lower part of the flame. Fig. 1 (Plate XVII.) shows a spire of incandescent gas surmounting a small bunsen flame. It is very feebly illuminating, and of yellow colour. It will perhaps interest some to know that this plate was exposed for 6 hours, and even then only the lower part of the spire is depicted: the full height was fully five times as long as is shown in the figure.

Fig. 2 (Plate XVII.) is a photographic enlargement of a reduced flame in a safety-lamp and a flame of natural size in an atmosphere containing combustible gas, and shows the constituent parts of the flame. Above the wick-tube is a transparent area of volatilized fuel, kept below the ignition-point by the cooling action of the metal; above this is a narrow bright blue line, which is seen to be part of an envelope around the flame, and is caused by the fuel undergoing partial combustion in a limited air-supply. Inside this envelope is a small area of semi-transparent roasted gases, the top of which contains incandescent particles of carbon. This incandescent area is the darkest part of the flame in the photograph. Outlining all but the base of the thin bright blue envelope is a pale blue transparent halo, where final combustion is taking place. In a large flame there is sufficient heat to form and render incandescent a larger mass of carbon particles, and the luminous area in the flame becomes greater in consequence. There is often to be seen over the flame of the safety-lamp another zone of flame, which for want of a better name the writers have called a "fuel-cap." This has nothing to do with the flame proper, and is in reality a gas-cap. It is caused by the heat of the lamp volatilizing some of the fuel outside the burner, possibly because of its not fitting properly, or because of the lamp not having been well cleaned. This fuel-cap always makes its first appearance on the outside edge of the testing-flame, and seldom has a visible tip. It is often to be seen in lamps in use in mines, and may easily be mistaken for a firedamp cap. This is an important point to consider in connexion with the design of a lamp and the choice of an illuminant. Above the flame in Fig. 2 is seen a gas-cap, the size of which for any given flame and fuel is dependent upon the proportion of combustible gas present. If a small percentage of gas be present, the molecules are so far apart that they are only heated to the ignition-point near the flame. As the percentage of combustible gas increases, a point is finally reached at which the molecules are sufficiently numerous to produce enough heat by their combustion to carry the flame throughout the mixture. To illustrate this, a series of photographs was taken of a safety-lamp flame in various percentages of coal-gas and air. (This series Fig. 3 plate XVII.) was taken in a testing-chamber at Leeds University, designed by Prof. G. R. Thompson, who will describe it in detail in his paper to be communicated at this meeting. The lamp used was a single-gauze unbonnetted Clanny, burning White Rose paraffin-oil, and having a circular wick-tube 0.23 inch in diameter.


The percentages of coal-gas shown in Fig. 3 are approximate only, but are relatively correct. The following notes were made on the spot while the photographs were being taken, and are interesting because they agree with what is shown in the prints:

No. 1, 1 per cent. of coal-gas, showing very faint cap.
Other photographs were taken of the higher percentages, and are of particular interest; but these will be dealt with by Prof. Thompson in his paper. The photographs are accurately natural size, with the exception of the 5-per cent. cap, so that they form a record which can be correctly measured. Many other photographs were taken in this chamber, but only the more important are here produced.

The measurements and percentages of gas are shown in Fig. 4 (Plate XVII.), which is plotted as a curve and illustrates the growth of the cap. It is interesting to see that with from 4 to 5 per cent. of gas the curve rises rapidly, and at 5 per cent. spires into the gauze.

(3) A Practical Method of obtaining a Testing-flame of Constant Dimensions.—If the flame is reduced to testing-height in pure air, and then introduced into an atmosphere containing combustible gas, the flame increases and the luminous part becomes obviously larger. This of itself is a valuable indication in a mine, provided that the observer knows that he is in comparatively pure air when he adjusts his testing-flame and can move the lamp at once into the atmosphere to be examined. In order to compare results, it is necessary to bring the flame down again in the mixture, otherwise the luminous part would eventually mask the cap. To illustrate this, Fig. 5 (Plate XVII.) shows a flame reduced in pure air and then placed in an atmosphere containing combustible gas, without trimming, and Fig. G (Plate XVII.) a full flame under the same conditions.

The wick was a flat one, and is viewed lengthways. The growth of the luminous part is clearly shown, as also the disproportionate growth of cap resulting. When a large flame is introduced into such a mixture, the effect is more marked. Nos. 4, 5 and 6, (Fig. 6 Plate XVII) show a full flame under similar conditions to those of the reduced flame. These flames were first photographed at their increased height, then reduced to their reduced to their original height, and the caps photographed. The amount of growth is shown by the detached luminous tip of the flame.

![Table I. ---Measurements of Flames and Caps shown in Figs. 5 and 6 (Plate XVII.).](image-url)

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.12</td>
<td>0.40</td>
<td>0.75</td>
<td>1.57</td>
</tr>
<tr>
<td>2</td>
<td>0.13</td>
<td>0.62</td>
<td>0.70</td>
<td>1.92</td>
</tr>
<tr>
<td>3</td>
<td>0.17</td>
<td>1.05</td>
<td>0.70</td>
<td>2.20</td>
</tr>
</tbody>
</table>

Since the size of cap depends upon the size of flame for any given lamp and illuminant, it follows that, in order to make an accurate estimation, the flame must at each test be brought to a standard height, and this is one of the difficulties experienced by mining men. Various methods of measuring the flame were tried, and perhaps the most accurate was by means of a scale fixed close to and alongside the flame. When the scale is so placed, the observer’s eye is always in the same position relative to the flame and the scale. If the scale is fixed before or behind the flame, the readings are likely to be inaccurate, because the eye may not always be held in the same place relative to the flame and scale.
was, moreover, found impracticable and tedious to measure the actual height of the testing-flame, and instead the flames were standardized by being so adjusted that the luminous speck in the flame touched, but did not penetrate, the intense bright blue envelop. Fig. 2 (Plate XVII.) shows such a flame. It is an easy matter with a well-trimmed lamp to reduce repeatedly the flame to this standard. As will be seen later, this method was successful, and a flame so reduced time after time in different atmospheres, but with the same percentage of gas, gave the same height in each case. In different percentages of gas the standard flame differs in height, but with the same lamp and oil always to the same extent. This standard was adopted for all requirements as a "standard flame."

In order to place on record the results obtained in these experiments, the camera was so arranged as to give photographs in natural size. These can therefore be measured accurately.

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It was found best to make the measurements on the negatives by marking the tip of the cap by transmitted light, and then placing the negative on section-paper or paper containing some other suitable graduations. The prints are not, in some instances, as good as the negatives. To get satisfactory results, the lamp must be thoroughly well trimmed and the wick carefully cut, so that when reduced the flame extends completely across it. It was found that some illuminants produced after a while a crust on the wick, which made it impossible to obtain the "standard flame." This crust could seldom be satisfactorily removed by the prick er. It is caused by certain constituents being left unconsumed; these clog the wick and hinder the capillary attraction, and so cause the lamp to burn badly. It must, of course, be remembered that, in order to take a photograph, it was necessary for the flame to remain accurately at "standard" height for a considerable time. For this reason it was found impossible to take photographs in a main return-airway, because the current of air cooled the lamp to such an extent that the flame could not be maintained at the standard height long enough. Some illuminants were more affected in this way than others. For ordinary observations the standard flame need, of course, only be maintained for a short while.

The error resulting from not being able to standardize accurately the testing-flame on account of bad trimming, is well shown by a curve in Fig. 8 (Plate XVII.).

(4) Ratio between the sizes of Testing-flame and Gas-cap.—It is not a universal custom amongst mine officials to reduce a testing-flame to what the writers have called "standard height," in fact, with some lamps as used it is not possible to do so. A series of photographs were therefore taken in a Clowes chamber, the atmosphere in each case containing 2 per cent. of methane. The height of the testing-flame was gradually increased, with the result shown in the series depicted in Fig. 7 (Plate XVII.).

It is obvious that, unless an accurate standard is adopted, the estimations are not reliable.

Fig. 8 (Plate XVII.) shows the measurements of these flames and caps plotted as a curve. The continuous line represents the series shown in Fig. 7 (Plate XVII.).

The chain-line is the second series, which need not be shown, and represents the growth of the cap over a naphtha flame. It

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will be noticed that the flame commences at 0.12 inch, and gives a cap no higher than would be given by a paraffin flame of rather less than 0.1 inch, which would show a small point of white light in this atmosphere. Gradually, however, the naphtha flame seems to gather
intensity, until at about 0.4 inch the two coincide. The other curve resulted from a badly-
cut wick, so that the flame could not be maintained at the standard. The jump occurred at
the moment when the flame extended right along the wick, and the luminous speck suddenly
penetrated the blue envelope. The caps over the large luminous flames are not visible to the
eye in an ordinary safety-lamp, but in a darkened non-luminous Clowes chamber it was
possible to distinguish them by screening off the luminous flame. It was found that in the
chamber it made no difference to the cap whether the flame was enclosed in the lamp or not,
and the top part of the lamp was therefore removed. The camera was purposely used to see
more than the human eye, in order to demonstrate the conditions which, under certain
circumstances, may obtain unobserved in a safety-lamp. It is interesting to know that over a
large flame, such as is produced by the open lights used by miners in various parts of the
country, there may exist a large cap invisible to the eye. Such a cap in a safety-lamp might in
an air-current be impinged upon the gauze. The necessity for using a testing-flame of
suitable size is obvious.*

(5) Comparison between various Illuminants and their Caps.— A comparison
between various safety-lamps photographed in Prof. Thompson's chamber showed that they
varied considerably as regards the size of cap.

Table II.—Showing relative size of Caps given by different Lamps.

<table>
<thead>
<tr>
<th>Lamp No.</th>
<th>Description.</th>
<th>Percentages of Gas in Mixture.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>Circular wick, 0.23 inch in diameter, burning paraffin oil, gave a cap of</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.200</td>
</tr>
<tr>
<td>2</td>
<td>Flat wick, 0.65 inch wide, burning naphtha (boiling point 55° Cent.), gave a cap of</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.520</td>
</tr>
<tr>
<td>3</td>
<td>Flat wick, 0.55 inch wide, burning colza, gave a cap of</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.175</td>
</tr>
</tbody>
</table>

The Colza tests are not very reliable, as the photographs were taken facing the wick
broadside.

*See Royal Commission on Mines: Reports of an Enquiry Into the Ventilation of coal mines
and the Methods of Examining for Fire-damp, by Messrs. John Cadman and E. B. Whalley,
1909 [Cd. 4551], pages 93 and 94.

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Table II. on the preceding page shows three different lamps in 1, 2, and 3 per cent.
of coal-gas-and-air mixtures respectively. The difference is due partly to the difference in the size of the wick and partly to the different oils burned. The flat wick gives a good light, but when viewed from the front, the top of the cap being extremely thin, becomes gradually invisible, and in many cases shows no definite point or edge (Fig. 9, Plate XVII.). The same lamp, however, viewed edgeways—that is, looking along the flame—shows a longer and more complete cap, because in the latter case one looks through a thicker mass of cap and sees less of the luminous part of the flame than when viewing it broadside on. Table III. illustrates this.

Table III. Showing Difference in Size of Cap according to Direction of View.

<table>
<thead>
<tr>
<th>Percentage of Gas.</th>
<th>End View Height of</th>
<th>Side View Height of</th>
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The cap is obviously longer and more complete in the first of each pair. This effect is also very marked in the case of a Barton burner, as used in the Thornebury lamp. In testing for small amounts of fire-damp, this is important. It would seem, therefore, that a fiat wick which gives good illumination in one direction is a good testing flame when viewed from another direction, and thereby possesses some advantages.

In order to compare the gas-testing values of various illuminants, one lamp was selected with a flat wick 0.45 inch wide: various illuminants were burned in it in turn, in a Clowes chamber, and the results were photographed. The atmosphere being of the same composition in each case, colza oil proved difficult to work with, especially for photographic purposes: because the reduced flame required constant trimming to maintain it at the standard height, and the crust formed on top of the wick was also a disadvantage. Further, the oil used as colza at collieries is of very variable composition.

It will be seen from Fig. 10 (Plate XVII.) that paraffin showed quite a distinct cap with small percentages of gas, but the lamp became very hot in a stagnant atmosphere. Paraffin also creeps over the surface of the oil vessel and volatilizes, forming a fuel-cap. This effect is dealt with later.

Naptha gave very good results, and the flame from this required less trimming or adjustment than those from other oils used, while the lamp remained clean for a longer period. It will be seen that the volatile oil, having the lowest specific gravity and initial boiling-point, gave the largest for a given percentage of gas. This is due to the fact that the "standard" flame with such a fuel was higher than with others if the naphtha be too volatile, a fuel-cap is produced. It was necessary to have the lamp especially well cleaned and trimmed for these tests, for the wick to fit its tube accurately, and to have no opening into the oil-chamber except the wick-tube. Unless these precautions were taken, the oil volatilized and burned as a cap over the flame. The volatile oils always showed more or less cap, and the more volatile the oil was, the larger the cap became. At moderate temperatures, it is incomplete in a well-fitted clean lamp. Fig. 10 (Plate XVII.) illustrates very well the "standard" flame of petroleum spirit, naphtha, Thornebury oil, paraffin, and, but not with the same accuracy; colza, in 2 per cent. of coal-gas. It will be immediately apparent that the larger caps correspond to the larger flames. The measurements of the flames and caps are:

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</tr>
</thead>
<tbody>
<tr>
<td>Caps</td>
<td>0.32</td>
<td>0.40</td>
<td>0.40</td>
<td>0.42</td>
<td>0.50</td>
</tr>
<tr>
<td>Flames</td>
<td>0.10</td>
<td>0.07</td>
<td>0.08</td>
<td>0.10</td>
<td>0.12</td>
</tr>
</tbody>
</table>

With regard to the colza, the notes made at the time of the exposure explain why the initial flame is larger than should be expected. The point has already been touched on. The notes were:—"Standard flame could not be kept constant, a small cap apparently complete, top edge well defined; when flame raised to remain constant, white light drowned cap." So that this Photograph was taken with the flame rather above the standard, but not extended quite across the wick.
(6) Effect of Variations of Temperature.—

In order to determine what effect, if any, was produced by variations of temperature a Cowes chamber was fitted inside with a coil of pipe,

*Special oil used in the Thornebury lamp.

connected with a steam boiler. The temperature inside the chamber was recorded by wet- and dry-bulb thermometers. Unfortunately, owing to the many difficulties that cropped up, the photographs of this test are not yet thoroughly conclusive; but they seem to point to an interesting conclusion, namely, that the higher temperature does not appreciably affect the cap given by the combustible gas in the atmosphere, but only makes it appear larger on account of the added cap of the extra fuel consumed. There is no doubt about a fuel-cap being produced by certain (and probably all) fuels, or that this cap increases as the temperature increases, the increase apparently varying with the initial boiling-point of the fuel; it is therefore obvious that when passing from a cool to a hot place, or vice versa, the same amount of gas gives a different indication in the lamp. Lamps in daily use in a mine cannot always be absolutely so clean and accurately adjusted as those used for these experiments, hence the "fuel-cap" described above is important. It ought, however, to lead one to over-estimate the percentage of gas in a hot atmosphere. In the hot chamber, the effect of a badly-fitted lamp was very evident.

Some photographs were taken of a specially constructed lamp. first burning naphtha of a specific gravity of 740 (water = 1,000); and then burning colzaline with a lower specific gravity. The temperature of the oil-vessel was in each case raised from 62.5° to 95° Fahr. (17° to 35° Cent.).

The negatives showed no cap in either case. The experiment was then repeated in an atmosphere containing 2 per cent. of coal-gas, and the caps were identical. A paraffin lamp was then lighted, and left to burn for an hour in a still atmosphere at a temperature of 90° Fahr., and the temperature of the oil in the reservoir was found to have risen to 139° Fahr. (59° Cent.).

The initial boiling-point of naphtha in common use and having a specific gravity of 715 (water = 1,000) is 131° Fahr. (55° Cent.), so that if a safety-lamp burning this fuel heats up to the same extent, or anything like it, one would expect to see a large fuel-cap.

(7) Effect of pretence of Black-damp.—

In order to ascertain what effect, if any, black-damp had upon gas-caps, a few experiments were made in a Clowes chamber. A safety-lamp was

photographed in the chamber, into which-methane and carbon dioxide were introduced as follows: (1) 2 per cent. of methane (CH₄) + 1 per cent. of carbon dioxide (CO₂); (2) 2 per cent. of CH₄ +1.5 per cent. of CO₂; (3) 2 per cent. of CH₄ + 2 per cent. of CO₂; 2 per cent CH₄ + 3 per cent. of CO₂, the carbon dioxide being added after the methane in each case and the atmosphere thoroughly mixed. There was no difference observable in the cap; and the photographs are interesting, because they not only show this but also the accuracy with which the standard height of the testing-flame can be obtained. The flame was trimmed afresh for each test, and the measurements of the photographs prove that the height of the testing-flame was the same in each case (Fig. 11, Plate XVII.).
In a coal-mine the presence of carbon dioxide would, of course, entail a loss of oxygen, whereas in these experiments the former gas was added to the atmosphere from an extraneous source.

(8) Comparison between Coal-gas and Fire-damp Caps.—
To compare the cap of Leeds coal-gas with that of methane, a number of experiments were made in a Clowes chamber. Methane was prepared from aluminium carbide, and purified by being passed through a solution containing potassium permanganate and caustic potash. Fig. 12 (Plate XVII.) shows the caps obtained in methane and those in Leeds coal-gas, the conditions being identical in each case. It will be seen that the caps are very similar, so that coal-gas can be used for experimental purposes as a substitute for fire-damp, and vapour, such as benzene, might also be employed. Probably benzene would be preferable, as the composition of coal-gas is very variable.

Table IV.—Caps and Flames obtained from Mixtures of Combustible Gas.
[Table omitted]

The results for coal-gas and methane have been plotted as curves in Fig. 13 (Plate XVII.), and it is interesting to notice that the curve for Leeds coal-gas is rather flatter than that for methane, but the difference is so slight as to be almost inappreciable to the eye. The composition of atmospheres in the Clowes chamber were checked once or twice by analysis.

To compare these results with actual mine atmospheres, some photographs were taken in selected collieries. Several different kinds of safety-lamps were used, burning different oils. Samples of the atmospheres were taken and carefully analysed. There were many difficulties encountered in taking the photographs in the mines, but the results agree with the laboratory tests, and the writers have therefore recorded a few of them. It is interesting to note that in most cases the observers overestimated the percentage of gas, as is shown by the analyses made subsequently. Probably this was due to the fact that, after several months of observation and many days spent in darkened laboratories, their eyes had become trained to appreciate small percentages as they had never done before; but it must also be remembered that the mine was hotter than the laboratory, that the lamps were those ordinarily used in mines, and not specially fitted, and that the inside of the glass in each lamp was darkened with a non-reflecting substance.

After the mine samples had been analysed, and the amount of fire-damp determined as methane, the experiments were repeated in a Clowes chamber, substituting prepared methane for the mine fire-damp and using the same lamp in each case.

Fig. 14 (Plate XVII.) shows some of the results, the photographs being in pairs, with the mine-gas on the left and the methane on the right.

It must always be remembered that the lamp underground had been burning for some time; also that there is always a certain amount of dust, etc., in the atmosphere which, together with the smoke from the flames in the lamps, renders the taking of photographs under these conditions somewhat different from laboratory work, where the lamps are clean and in many cases never turned up before the exposure is made, so that the faint tips of the caps underground are sometimes difficult to see on the negative.
It will be noticed that, with the smaller percentages, the point of the cap is not distinct when the name is broadside on.

Table V. contains the notes recorded on the spot by the observers:—

Table V.—Experiments with Methane compared with Pit-gas.

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<tbody>
<tr>
<td></td>
<td>Per cent.</td>
<td>Inches.</td>
<td>Inches.</td>
<td></td>
</tr>
<tr>
<td>Paraffin</td>
<td>1.50</td>
<td>0.25</td>
<td>0.90</td>
<td>Clear cap, visible sideways, possible tip: facing very doubtful.</td>
</tr>
<tr>
<td></td>
<td>1.50</td>
<td>0.25</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>Naphtha</td>
<td>2.17</td>
<td>0.42</td>
<td>0.10</td>
<td>Complete clear cap-tip, visible edgewise.</td>
</tr>
<tr>
<td></td>
<td>2.25</td>
<td>0.57</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Paraffin</td>
<td>2.75</td>
<td>0.50</td>
<td>0.10</td>
<td>Distinct cap, very blue.</td>
</tr>
<tr>
<td></td>
<td>2.75</td>
<td>0.52</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Naphtha</td>
<td>2.75</td>
<td>0.70</td>
<td>1.50</td>
<td>Complete clear cap, visible edgewise and facing.</td>
</tr>
<tr>
<td></td>
<td>2.75</td>
<td>5.75</td>
<td>1.25</td>
<td></td>
</tr>
</tbody>
</table>

The analyses were made with Dr. Haldane’s laboratory apparatus, and checked in duplicate.

It is interesting to note that the results confirm the laboratory experiments. The mine fire-damp was not quite pure methane, while the methane prepared in the laboratory no doubt contained some hydrogen. The amounts of impurities are not sufficient to affect the accuracy of the cap measurements. If the mine atmosphere, for instance, contained ethane, the method of analysis adopted would over-estimate the methane, because the ethane would be taken as methane which gives on combustion considerably less contraction than ethane.

As it requires less ethane than methane to form an explosive mixture, the one error would compensate the other so far as the mining engineer is concerned here, whilst sulphuretted hydrogen would, of course, be absorbed as carbon dioxide. The error, however, is too small to need consideration in this paper.

Conclusion.—In most of the photographs the wick-tubes have been sketched in by hand, but the caps have not been retouched in any way, with the exception of one or two of the large ones, which are over full flame, where a rough attempt was made to eliminate in part the effects of halation. In no case has the apex of a cap been touched, and half of the inside of the lamp-glass was always blackened with smoke. It was found that camphor produced a dry smoke, with a non-reflecting surface which was of great assistance, and rendered distinctly visible small caps which would otherwise have been doubtful. Perhaps it would be helpful to dispence with all the bright metal work about safety lamps and substitute some dull non-reflecting material. In order to make the caps appear as realistic as possible, a piece of tinted glass has ben placed in the lantern, and the photographic prints have also been made on tinted paper. The effect is, however, not perfect, because it does not show the difference in intensity of colour which is actually seen in comparing the different caps. An attempt to photograph gas-caps by colour process has so far not been successful, owing to the long exposure necessary and other difficulties. It would seem from the foregoing experiments that each type of lamp should be standardized by actual experiment and the writers suggest that, if the results were recorded they would form a valuable aid to those responsible for the examinations of the mine. For this purpose photography offers many possibilities. Without
some such foundation of fact to work upon, it is difficult for anyone to make accurate
estimations, especially if different types of lamps be used day by day under different
conditions.

It often happens that an official becomes familiar with a certain lamp and oil at one
mine, and is then transferred to another mine where a different set of conditions obtain and a
different type of lamp is used. Under such circumstances he is liable to error. The personal
element must always be an important item, and in the absence of facts it is not to be
wondered at that great diversity of opinion exists, and that, although mining officials as a
class are particularly observant they may still not correctly appreciate the significance of the
caps which they see.
The names of the lamps have been purposely omitted, because these experiments are
meant as an attempt to record a few observed facts and principles only, and not to
recommend any particular form of safety lamp. In choosing a safety lamp many
considerations which are not dealt with in these tests are important. The experiments have
shown that to estimate the amount of fire damp in the atmosphere of a mine is by no means
a simple matter, and many factors must be considered. It is certainly practicable to detect
small proportions

[Plate XVII.: Photographs and Graphs, Figs. 1-14, illustrating the lamp flames and caps]

with a safety lamp, but it would seem that for accurate estimation and for checking
observations it is necessary to resort to periodical analyses.

In conclusion, the writers beg to thank the various colliery owners, managers, and
officials who very kindly lent lamps, etc., and allowed experiments to be made in their
collieries, and Prof. Thompson for his valuable help inpermitting the use of his testing chambers.*

Prof. G. R. Thompson read the following paper on "Equipment for the Study of Flame-caps,
and for Miscellaneous Experiments on Safety-lamps":—*

*For the discussion on these papers, see page 132.

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EQUIPMENT FOR THE STUDY OF FLAME-CAPS AND FOR MISCELLANEOUS
EXPERIMENTS ON SAFETY-LAMPS.

By G. R. THOMPSON, B.Sc, A.R.S.M.,
Professor of Mining at the Leeds University.

Many papers have appeared dealing with the general subject of mining education,
but comparatively few have given particular attention to the apparatus by which this
education may be made more effective. It is the writer's object to give details of the
equipment that he has adopted for work with safety-lamps, and of some experiments which
may be performed, in the hope that he may profit by the discussion thereon and that perhaps
the information given may be of some use to others.

A room at the Leeds University has been specially arranged for experimental work of
this kind. The walls are of dark red brick, the ceiling is blackened, and dark blinds are fixed
to the windows. A part of this room is screened off by black curtains for the photometer, and the wall of this section is painted dull black. The wall on the other side is chambered, forming a flue which connects with the fan ventilating the building. Openings into this wall, with adjustable sliding covers, enable the gas used in the experiments to be drained directly away, while a conduit in the floor allows the explosive gases used in the velocity test of safety-lamps to be diluted with air and ejected by a fan directly to the outside.

The chambers for the study of "flame-caps" are four in number, two large and two small. They are built of angle-iron and glazed with plate-glass. A known mixture of gas and air is fed in at the top of the chamber, and, after passing through, is drained away to the flue. Fig. 1 (Plate XVIII.) shows one of the small chambers, and illustrates the method of construction and use. The chamber is 9 inches square in cross-section, and 2 feet high: it is covered at the top by a sheet-iron cover, on which is fixed a mixing-box, A; gas and air are fed into the back of this mixing-box, and pass down at the front to the testing-chamber. The mixing is effected by passage through a series of gauze diaphragms placed across the path of the gases. The middle of cover is perforated by a small hole, through which passes the wire cord supporting the lamp. This cord is taken over a pulley, B, and thence completely round the bent prolongation of the pulley-support to the stretching weight, W, as shown in Fig. 1 (Plate XVIII.). By this arrangement, a friction grip is secured, and the lamp can be drawn up into the chamber or lowered at will without danger to the operator.

The air is supplied by means of a small fan, which maintains a pressure of about 1 inch of water-gauge in the pipe C, (C is 1 ½ inches in diameter) running along the wall, and from this pipe branches, ½ inch in diameter, are taken to the chambers. Coal-gas is supplied through the pipe, D, its pressure being kept constant by means of a Stott governor. A separate cock is provided for each chamber.

The problem of controlling the relative proportions of gas and air was a difficult one, and particularly to do so at small cost. The difficulty is, moreover, increased when it is remembered that coal-gas, as supplied in towns, is a complex mixture of gases, and is liable to variation at different times, and particularly so when sudden calls are made on the generating plant, as in the case of winter fogs. It is desirable to keep the quantity of the mixture supplied roughly constant, and of sufficient amount to carry the products of combustion readily away. For this reason it is better to keep the air-supply constant, and vary the amount of gas, in order to obtain the different compositions of mixture. After much consideration, it was finally decided to vary the gas-supply by steps, and the means of doing this was provided by Messrs. George Bray & Company, Limited, who furnished the writer with a series of ten of their burner nipples, discharging progressively from 1 to 10 cubic feet per hour at 1 ¾ inches of water-gauge. The nipple is placed on the gas-inlet at E, while the air-inlet is controlled by a disc-regulator at F, the fixed opening in which has been filed out to the required size. The quantity of air supplied to the small chambers is about 70 to 80 cubic feet per hour, and about double that amount to the large chambers. It was at first intended to measure the caps produced, and, by comparison with fire-damp caps in the Clowes chamber,

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to standardize the chambers. This is still necessary for the large chambers, but a quicker and more satisfactory method has been devised for the small chambers. It is well known that air containing 6 ½ per cent. of fire-damp just becomes explosive. Advantage is taken of this
fact, and the air-regulator, $F$, is so adjusted that with No. 7 nipple the cap ceases to be a column, and spreads laterally, filling the gauze. When so adjusted, this is taken as representing a mixture containing 7 per cent. of firedamp; but it is not a 7 per cent. coal-gas mixture. If one-seventh of this amount of coal-gas is supplied as with No. 1 nipple, it is assumed to represent 1 per cent. of fire-damp, and in like manner each of the other nipples is assumed to give its corresponding percentage.

In the paper by Messrs. Whalley and Tweedie,* photographs are given of caps taken in these chambers (Fig. 3, Plate XVII), and their comparison with fire-damp caps (Figs. 12 and 13, Plate XVII.) shows how well this assumption is justified.

The large chambers are 3 feet long, 2 feet deep, and 1.5 feet wide, and are of similar construction to the one that has been described, except that they stand on the floor instead of being fixed to the walls; and, as they are used for non-explosive mixtures, pulleys are dispensed with.

The large chambers are not so satisfactory as the smaller, on account of convection currents making the composition of the air variable, and also on account of the greater difficulty of draining away the waste-gas without undue leakage into the room. The small chambers are, however, perfectly satisfactory, and allow steady conditions to be maintained for any length of time and also be reproduced at a moment's notice. At present, the fan is driven by a continuous-current motor, so that its speed can be varied for adjustment of the air, if necessary; but ultimately a constant-speed alternating-current motor will be used, and then the present regulator on the air-supply will be replaced by an adjustable one.

The adaptability of these chambers for teaching students the indications of gas on the ordinary safety-lamp will be appreciated by reference to the foregoing paper by Messrs. Whalley and


They are also very convenient for use with different testing flames such as hydrogen, alcohol, etc., either naked or safety-lamps. Any person, for example, placing a bunsen with a small flame, say, about 1 ½ inches high, in a burner in a 1-per cent. mixture, will be surprised at the size of the cap which surrounds it. A bunsen burner so used forms, in fact, a delicate gas-testing flame. While, if the experimenter swings the flame about in a mixture which is nearly explosive, and watches the isolated balls and tongues of blue flame left in its track, and then tries a candle or naked oil-lamp in the same mixture, he will in perfect safety, undergo an experience which it is to be trusted he will never have in the pit.

The chambers are particularly valuable for the study of the behaviour of safety-lamps in practically still mixtures which are nearly or quite explosive. The excellent series of photographs taken for the writer by Mr. Tweedie (Figs. 17 to 24) illustrate the behaviour of an unbonneted Clanny lamp as the percentage of gas increases. Figs. 17 to 20 show the cap with Nos. 1 to 4 burners, and Figs. 21 to 24 with Nos. 5, 6, 7, and 10 burners respectively. The dark bar across the middle of the latter photographs indicates the position of the brass frame at the top of the glass, the cap above this being seen through the gauze. Figs. 5 and 6 (Plate XVIII.) show the details of this lamp. In Fig. 21 the cap is long and tapering, and reaches to the top of the gauze; in Fig. 22 the width of the cap is seen to increase as the height increases, the cap also "mushrooming" over on meeting the gauze at the top. Figs. 20 and 21 show the lamp in explosive mixtures, where the flame can spread in all directions, laterally as well as vertically. It will be noticed here that the cap does not
appear to extend to the top of the gauze. The cap is, in fact, much brighter at the lower part of the gauze, because the heated products of combustion rise to the top and escape, while near the lower part the fresh supply of gas and air enters.

Fig. 23, taken with No. 7 nipple, is very remarkable, and well worthy of attention. In addition to the cap in the gauze, it will be noticed that the flame of the lamp still survives, and that a small cap appears above this flame; with higher percentages of gas in the mixture, this flame is extinguished. It shows that when the mixture is just explosive the hot gases from the outer cap contain sufficient oxygen to keep the oil-flame alive, and

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that the cooling action of the metal allows sufficient unburnt gas to find its way into the lamp to give the small secondary cap. The most important feature to notice is, however, this: when the wick is pushed up, the ordinary luminous flame of the safety-lamp appears; and, if the lamp be trimmed to give the normal height of flame, the cap burning in the gauze is hardly visible, and would certainly be missed in a bonneted lamp without careful inspection—and this although the mixture is just explosive.

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In addition to the chambers described, a Clowes chamber is used. This has been made about double the size recommended by Prof. Frank Clowes,* but is otherwise similar. The in increased size—combined with a large window—is an advantage when adopted for work with students. Formerly, this was used with coal-gas for rough observations on caps, and was the only means of experiment. Experimenters were naturally limited in general to non-explosive mixtures, on account of the fear that an unexpected defect in the lamp might fire the gas. It now forms a valuable adjunct to the other chambers, and enables the comparison between coal-gas caps and marsh-gas (or fire-damp) to be made.

The recent introduction of aluminium carbide for the preparation of marsh-gas has facilitated the use of the latter for this purpose, since it is now possible to prepare a comparatively pure gas without abnormal labour. In preparing marsh-gas the carbide is placed in a stout round-bottomed flask, fitted with a rubber cork, through which pass a dropping funnel feeding dilute hydrochloric acid (about 10 per cent. acid) and a delivery-tube to carry the gas through washing-bottles charged with an alkaline solution of potassium permanganate, and thence to the gas-holder. The reaction between the water (or dilute acid) and the carbide is very slow at first, but becomes rapid with increased temperature. If much water or dilute acid is introduced at first, the reaction is liable to become violent after a time, when the heat generated has produced a sufficient rise of temperature; it is therefore better to start the reaction by immersing the flask in boiling water, and running in a few drops at a time from the funnel.

The gas evolved from the carbide is not quite pure; it contains more or less hydrogen, according to the purity of the material used. This is not removed by the washing in permanganate, which is intended to destroy oxidizable compounds like phosphoretted hydrogen. As thus prepared the gas may be expected to contain about 95 per cent. of
marsh-gas, the remainder being hydrogen, which for the purposes of cap-tests may be regarded as pure fire-damp. It is collected in a copper gas-holder of about 1 ½ cubic feet (45 litres,) capacity for use in the Clowes chamber, or compressed into cylinders for storage.

* Detection and Measurement of Inflammable Gas and Vapour in the Air, pages 102 et seq.

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The examination and testing of safety-lamps before allowing them to be taken into the pit is of importance; and some collieries have gone so far in this direction as to submit every lamp to a gas-test before delivering it to the collier. It is highly desirable that none but perfect lamps should be served out to the workers, and attempts to secure this object are worthy of all praise. It is, however, most important that by accredited tests one should not be lulled into a false sense of security, since by this the danger is increased and not diminished. The writer knows of no practicable gas-test which will replace a careful lampman and close inspection of the lamps, or which, in fact, is not worse than useless. One form of such test occasionally adopted at collieries is to have a glazed chamber (with a gas-feed at the top), into which the lamp is drawn. The chamber contains pure gas at the top and a mixture of gas and air below. As the lamp is drawn up, the gas usually burns in the lamp; and, finally, as the lamp is pulled up into the pure gas, the flame is extinguished. The lamp which passes this test is regarded as safe. It is obvious that the small chamber described above, when fed with an explosive mixture, constitutes the best type of apparatus for subjecting lamps to this test. The test will, however, invariably fail with a defective and dangerous lamp under certain conditions. A description of two such cases will suffice.

In the collection of lamps at the University of Leeds is a Stephenson lamp, through the top of the gauze of which is a hole the size of a pea. This lamp had been thus mutilated by the writer’s predecessor (Prof. Arnold Lupton) for the purpose of testing. It readily declares itself to be a safe lamp according to this and the Embleton ring-test, to be described later. A little reflection will show why this should be so. The glass in the Stephenson lamp carries the products of combustion to the top, and forms a barrier of these between the explosive mixture outside and the flame burning inside at the bottom inlet. The lamp can only be made defective by getting a train of the explosive gas from the outside through the hole to the flame. This may sometimes be done by having a plunging current of gas at the top of the lamp, but not in the chamber test described.

The second lamp is an ordinary Davy lamp that has been carried about to many public lectures, and has been crushed in transit, so that the longitudinal seam has been ripped for about 2 ins. in length. The two edges of the gauze overlap, as shown in Fig.3 (Plate XVIII.), which is a cross-section of the lamp. When they are pressed fairly close together, the lamp will burn readily in the chamber, the flame filling the gauze, which even becomes dull red, and yet the outside mixture is not inflamed. The lamp would be discarded by anybody on very casual inspection, but nevertheless it registers itself as safe. That the lamp is defective in the condition in which it was tested is easily shown by playing a mixture of gas and air from an ordinary bunsen burner on to the lighted lamp. When the mixture is turned on to the defective part, the flame at once passes and lights the burner.

Another test which is sometimes adopted at mines is the Embleton test, which consists of surrounding the lamp by a ring-jet of gas (Fig. 4, Plate VIII.), the ring in use being
moved up and down over the lamp to bring all parts of the lamp under test. The writer has three of these rings; the first is 3 inches in diameter, perforated with holes 1/16 inch in diameter and spaced 5/8 inch apart; the second is 3 ¾ inches in diameter, with holes 1/30, inch in diameter, and spaced 1/2 inch apart; while for the third the corresponding dimensions are 4 inches, 1/40 inch, and 1/4 inch. This test, like the preceding one, is, as mentioned above, equally fallacious with the Stephenson lamp.

The behaviour of the Davy lamp varies with the three rings. When the overlapping edges of the gauze are close together, as already described, the lamp passes the test under all conditions with the first two rings. With the third ring it may be made to pass the test, or fail, at will. When the defective part is placed near the ring, A (Fig. 4, Plate XVIII.), it passes the test, for then the seam is filled with pure gas; but when the seam is taken as far back as possible from the ring, B, it fails. In this case the fine jets of gas draw in sufficient air to make a combustible train of gas through the split.

By pressure on the gauze the split in the seam may be so arranged that the lamp may be made to fail successively under test by each ring.

The well-known work of Marsaut showed that lamps were liable to pass the flame owing to an internal explosion. Figs.

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5 and 6 (Plate XVIII.) give the details to scale of a lamp which admirably illustrates this danger. The lamp is an old one, and was used some years ago in collieries in the neighbourhood of Leeds. It may be described as a Clanny lamp, modified by the addition of a bottom inlet. Fig. 6 (Plate XVIII.) shows the gauze and glass and the gauze-ring under the glass, Fig. 5 the oil-vessel and the brass supporting frame.

It will be noticed that this lamp is of rather large capacity and that, while being unbonneted, the brass ring, A (Fig. 5, Plate XVIII.), forms a somewhat close-fitting protection to the top half of the gauze cylinder, preventing to a certain extent the free escape of gases during an internal explosion, and thereby increasing the velocity of discharge through the remainder of the gauze.

A most instructive experiment may be performed on this lamp in the following manner:—The lamp is trimmed, with a small flame as if for gas-testing, and, by means of two large bunsen burners held in the hands on opposite sides of the lamp, an explosive mixture of gas and air is fed on to it, so as to fill the upper part of the gauze first and afterwards the lower part of the lamp. By this means a quantity of explosive mixture is got into the lamp before it is ignited, and on ignition the flame is projected through the gauze lighting the gas outside. When a large flame, instead of a small one, is kept in the lamp, it is impossible to get sufficient of the mixture into the lamp before ignition to transmit the flame through the gauze, thus showing the enhanced danger in gas-testing with a small flame when explosive mixtures are present.

The writer's predecessor left an abnormally large Davy lamp which he had fitted up with a sparking arrangement for firing the gas inside the lamp when it was placed in an explosive mixture. The gauze is 4 inches in diameter and 6 inches high, the top being fitted with a gauze-cap 2 inches deep, so placed that the two gauzes overlap 1 ¼ inches. By this arrangement, the lamp can be totally filled with explosive mixture before firing, which is the severest condition of testing. The writer has modified this experiment by reinserting the lampwick and using a small flame and the large bunsen burners as with the Clanny lamp. If very successful, he can get the flame to pass, but only rarely. On failing, however, he
ties a strip of paper round the upper part of the gauze, thus blocking up that part and rendering it ineffective; if this fails, a wider strip is put round, until the internal explosion passes the flame through the gauze, and may be made to pass it practically every time. It is obvious that in this form the experiment illustrates the danger of dirty gauze, with the holes rusted or clogged up, and also the defect in construction of the Clanny lamp described above, in which the closely-fitting brass ring placed round the top of the gauze as a protection enhances the danger due to the large glass and large internal volume.

It must not be supposed that the internal explosion here spoken of is anything violent. The most nervous person would not start when the explosion takes place, and no mechanical damage to the lamp results. Internal explosions in lamps are sometimes credited with strange and abnormal powers.

There is another experiment which the writer hopes to be able to devise, illustrating the danger of dirty gauze where the dirt is combustible. It is well known that the temperature of ignition of fire-damp is relatively high compared with other gases, and that the value of the gauze lies in its power of radiating heat to such an extent that the explosive gases outside cannot be raised to the temperature of ignition by those burning within the gauze. It is also well known that many solids ignite at a lower temperature than fire-damp, and that charcoal and similar substances formed at low temperatures ignite at corresponding low temperatures. It is therefore to be expected that charred materials on the exterior of a safety-lamp may be ignited by the hot gauze, and that their combustion in an explosive current may be the means of causing an explosion although the conditions are such that a lamp with a clean gauze would be safe.

Fig. 7 (Plate XVIII.) shows the apparatus used for performing the well-known experiment illustrating the effect of a blown-out shot which has been fired in the vicinity of a safety-lamp burning in an explosive mixture. The violent sound-wave thus produced swings the flame through the gauze, and ignites the explosive mixture outside.

The lighted safety-lamp is carried on an adjustable platform, A, sliding along the rod, B, on which ring-jets, C, fed with gas from the flexible tube, also move. Placed in front of the lamp is the tube, D, closed in the middle by a rubber diaphragm so as to prevent a direct rush of air to the lamp. When the gas is turned on at the ring-jets, the lamp is filled with flame: the gauze becomes dull red, but the gas outside is not ignited. A pistol shot is now fired down the tube, to give the violent soundwave characteristic of a blown-out shot, and the lamp at the same instant fails.

This experiment is, so far as the writer knows, the one which originally demonstrated the danger of a blown-out shot, and the danger was purely "a matter of sound." At present, in mining literature, the term "blown-out" shot has so far lost its meaning that it can actually be applied to an open charge fired without stemming. The dangers apprehended from such are not primarily associated with sound-waves, although with the modern detonating explosives violent sound-waves may undoubtedly be produced by unstemmed shots.

The type of apparatus which still remains to be described is that for the testing of safety-lamps in explosive currents of high velocity, in order to determine their capacity for safely resisting such currents. Important early work was done on the subject by the Midland Institute of Mining, Civil, and Mechanical Engineers at Aldwarke Main Colliery,* where the apparatus still exists, and constitutes a type from which the present forms may be regarded as derived. Several installations for testing safety-lamps have been established on the Continent, and recently in America. The modification put up at Gelsenkirchen, and afterwards adopted at Framerries, may now be regarded as almost a standard pattern, and
was the type adopted in the present case. At both of these places the gas used for testing is fire-damp derived from pits. It was, however, impossible to obtain pit-gas for use at Leeds, so the writer had to fall back upon an artificial explosive mixture. One would in such a case naturally think of coal-gas: and this was seriously considered, but ultimately abandoned, because, in the first place, it did not seem to be the most convenient form to handle, and, in the second place, the chemical composition of coal-gas is, as stated before, liable to serious changes. The writer has, moreover, grave fears that the presence of such a large proportion of hydrogen, with its special characters of combustion, renders coal-gas less suitable for testing lamps than the vapours of the heavier paraffins or


[129] other hydrocarbons. He resolved therefore to make the experiment of testing lamps in an explosive mixture of hydrocarbon vapour and air. Had coal-gas been used, an exact copy of the installation at Frameries could have been adopted, but the use of petrol has introduced modifications into the working which it is necessary to describe.

Fig. 8 (Plate XVIII.) shows the general arrangement of the apparatus and Figs. 9 to 13 (Plate XVIII.) are details. The gallery in which the lamps are tested is practically identical with that at Frameries, as will be seen from the diagrams. It need not, therefore, be further described. The only features of difference to note are that the windows (Fig's. 10 and 11, Plate XVIII.) are larger, being 8 inches square and placed in pairs opposite each other on both sides of the gallery; and, secondly, that light relief-valves of three-ply board (Fig. 9, Plate XVIII.), held down by springs, are substituted for the heavier hinged valves. This latter has been done to prevent inertia effects in the valves from increasing the pressure before release takes place. To the inlet-end of the gallery is attached a chimney, A (Fig. 8, Plate XVIII.), of a fan which supplies the explosive mixture. Two renewable paper relief-valves are placed at B and C the details of which are illustrated in Figs. 12 and 13 (Plate XVIII.) The former shows the wooden frame for holding down the paper, in position in valve C and removed in valve B, to be shown separately in Fig. 13. The reason for placing these valves here is that a good deal of explosive mixture is contained in the gallery and fan, and the writer knows from experiment that bends such as are shown at the junction of the fan-chimney and gallery have a great effect on explosions, rendering them much more violent and even changing the type of the explosion. The paper valve placed at the change of direction offers very little resistance to the oscillating column of explosive gas, and is very efficient in preventing inertia pressures from developing at the bend, with consequent increased violence of explosion in the path beyond. The fan inlet is covered with what may be described as a square fan-drift, the size of the opening to which from the outside is controlled by a door sliding on the rail, D (Fig. 14, Plate XVIII.), out which the door is also hinged, so that it can open under explosive pressure from within. The size of the opening regulates the velocity, the value of which for each position of the

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door has been previously determined by means of an anemometer placed in the gallery.

The vaporizer for supplying the hydrocarbon vapour is shown in Fig. 8 (Plate XVIII.). A 2-inch vertical pipe, E, is fixed into the bottom of the gallery, and communicates with a sloping length, F, of 2-inch pipe, after which follows another sloping length, G, of 2½ inch pipe, discharging into the square fan-drift. The petrol or benzol is fed into the pipe, E,
through the pipe, H. Under the two limbs, F and G, are jet-burners, J, fed by the 1-inch gas-main, K. The petrol to be vaporized is fed into the downcomer, E, through the pipe, P, which leads from the regulating sleeve, O. It is, of course, necessary to control the supply of petrol, and to proportion the feed to the quantity of air admitted. The method adopted for doing this is to place a valve, L, on the ½ inch tube supplying the petrol, by means of which the flow is regulated, the quantity flowing being determined by the pressure which is indicated by the manometer, M, placed on the delivery tube, N. The delivery tube is stopped at the end and perforated by five holes, each 1/8 inch in diameter. These holes can be uncovered successively by the sliding sleeve, O, so that only one, two, three, four, or five may be discharging together, thus allowing the flow of liquid to be increased continuously to ten times its initial quantity with a pressure-variation ranging between 1 and 4. To reach the highest velocity of explosive current that it is desirable to obtain, it will be necessary to vaporize a little over a gallon of petrol or benzol per minute. Dealing with this quantity, it is impossible to get evaporation without artificial heating. For petrol it would be necessary to pre-heat the air 68° Fahr. (20° Cent.), and for benzol to nearly twice that amount, so as to form an explosive mixture at the normal temperature. The writer has preferred to heat the liquid, and will probably have to extend his vaporizer before being able to deal with the maximum quantity of liquid required. The explosive mixture used must be ejected from the building. This is accomplished by making it discharge into the cowl, Q, and thence through the duct, R, where it mixes with additional air to dilute the explosive mixture, into the fan, S, which drives it along sheet-iron boxes, 1 foot square, placed in the conduit, to the outside. A safety-valve of light cardboard is placed at R, opposite the fan-inlet, to relieve the pressure in case explosions were to take place in the exhaust.

[Plate XVIII, Figs. 1 to 16 illustrating the testing apparatus] [131]

The testing gallery described has so far only been used with a temporary vaporizer for preliminary experiments on the open-gauze lamp, to enable the design of the petrol-feeding and vaporizing part to be undertaken, and these are at present being fixed of the form described. It is large and cumbersome for a laboratory, but it has the advantage of enabling tests to be made under comparable conditions with those of foreign testing-stations using pit-gas. For qualitative experiments to show the failure of safety-lamps in rapid explosive currents, the apparatus illustrated in Figs. 14, 15, and 16 (Plate XVIII.) has been found very useful. This is described in the form in which it was left by the writer's predecessor. The air-current is given by means of a wooden model of the Medium fan, A, which is hand-driven. Above the fan is an adaptor, B, connected up to the gallery, C, at the commencement of which gas is admitted through the hole, F, from a cylinder of compressed gas. Paper valves, D, D, are fixed, as shown, by means of hinged frames and thumbscrews, while windows, E, E, are placed in the wooden gallery to show the progress of the experiment. The lamp is carried in a frame cut to the shape of the lamp and sliding in a groove in the gallery, the cross-section (Fig. 16, Plate XVIII.) being taken through this frame.

The speed of the explosive current is controlled by the fan operator, and its composition by the experimenter, who turns the key of the gas-cylinder as required.

The apparatus has often been used at outside lectures, and invariably with success. On the last occasion it was indeed so successful that the apparatus was wrecked by the explosion.

There is a possibility that a similar but stronger apparatus may serve the purpose of lamp-testing in horizontal currents for educational work, quantitative results appearing
possible if, instead of measuring the velocity, the difference of pressure between the front and back of the lamp be measured, since this is the factor which determines the flow of gas through the latter. In most gallery tests of safety-lamps, the space occupied by the lamp in the gallery must materially accelerate the velocity as compared with a wide road in a mine. The diaphragm (Fig. 10, Plate XVIII.) makes the lamp practically fit the gallery, so that the test may be made as severe as anyone can desire without much expenditure of gas.

Mr. A. L. Steavenson (Durham) said that they would all agree that the paper was thoroughly scientific, and likely to be of great use to the mining engineer; but as to the class below—the gas-examiners who made several hundred examinations for each one made by an official or manager—he did not see that it would be of much help to them. He would not, however, like the present generation to think that the last generation had never considered the subject. On the contrary, in the mid-seventies there was a Dr. Ansell, a very fine chemist at the Mint, who brought before the speaker an invention which depended upon the law of the diffusion of gases. Under that law he had prepared a box or cylinder, at one end of which was an unglazed piece of earthenware through which the gas passed; the gas having passed, created a pressure, which raised a small column of mercury so as to make a contact and ring a bell. Now, if that could be carried out practically and successfully, it would be a very fine invention indeed, but it was really too delicate. He (Mr. Steavenson) had fitted up the apparatus and had the little boxes put into the goaf wherever there was any gas likely to come out, and at Page Bank Colliery had had the appliance working for some time: but he had finally discovered that it made mistakes, and, in addition, it was not convenient to carry such wires about the pit to ring the bells, so that the whole thing was eventually abandoned. In addition to that, he had an aneroid barometer fitted up with an unglazed piece of earthenware at the back of it, and the same diffusion gave the percentage of gas. That was another fine invention, but one had to find the gas first, and then see how it worked. He (Mr. Steavenson) had himself brought out an arrangement calculated to be of value to the ordinary gas-tester, and had read a paper* before the North of England Institute describing it, from which he would quote the following portion: —

"When inflammable gas is present in a proportion sufficient to explode, the lamp is of course filled with flame, and the required observation is a very simple one; but when a lesser proportion is present, then the indications consist of a cap or tail upon the flame, and it requires very great nicety and care to detect small quantities. The nature of this cap appears to be somewhat disputed, although Professor Marreco is clearly of opinion that it is carbonic oxide."

"With a view to render the observation of the safety-lamp, when making


these examinations more simple and effective, the writer has availed himself of one of the most beautiful laws which the study of optics in recent years has put us in possession of, generally known as the "law of absorption of light".

"Newton discovered that the light of the sun consists of rays differently refrangible, and that when a white light is passed through a prism, the constituent rays, separating each at the different angles of its refrangibility, produce the band of colours known as its
spectrum. This subsequent led to the discovery of the spectroscope, and the use of that to the property of coloured transparent bodies.

"If a continuous spectrum is taken, and a piece of neutral-tinted glass interposed, it will cut off the light and deaden the spectrum throughout its whole length, having the faculty of keeping back the light-red, orange-yellow, blue, green and violet, which is an instance of general absorption."

"If instead of interposing a neutral-tinted glass, a piece of coloured glass is introduced, the action instead of being general throughout the spectrum will be limited to a particular part of it; thus a piece of red glass cuts off nearly all the light except the red, and green or blue absorbs red rays."

"By this law of absorption chemists are enabled to recognize different substances and by the same law an attempt is now made with a coloured medium to shut out the flame of the safety-lamp and render evident the pale blue cap (of carbonic-oxide flame ?) in a manner much more distinct than by the unassisted eye."

With this view the writer has had a lamp arranged to receive a small slip of blue pot-opal glass to be adjusted whenever it is desired to make an examination for gas; or a pair of spectacles may be fitted with glass of this colour."

"It is well known that there is a great difference in the condition in which gas is found for affording a top or cap to the flame; gas coming off fresh from a blower can hardly be seen on the flame at all, until the lamp fills, whilst on the other hand gas which may have been standing for some time in a disused place will tail up to the top of the lamp before exploding, probably owing to some admixture of carbonic acid."

"But, under all these circumstances, the writer has proved that the use of a dark-blue glass is most beneficial, enabling the observer to detect the presence of gas when quite invisible to the unassisted eye."*

The result of it was, that if they carried a little piece of blue glass in their pockets, each gas-examiner had very great assistance in detecting the presence of gas: but, like so many things that men are not obliged to do, they would not be at the trouble. The idea was, however, there for anybody who liked to utilize it. He wished the present generation to know that in the past, the helps which might be provided in looking for gas were not entirely overlooked.

He would like to say that whilst Messrs. Whalley and Tweedie's paper was likely to be extremely useful to the officials of the mine, he still thought that it was the gas-examiners or


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deputies that one should chiefly try to help. His suggestion in 1877 was especially for the benefit of these men, who made their examinations almost every quarter of an hour.

Sir Henry Cunynghame (Home Office, London) said that he had come there rather as a learner than as a critic. They had all listened with great interest to the paper, and he congratulated the writers upon it. They were especially indebted to Mr. Tweedie for having shown them what photography could do. They must remember, however, that photography looked at things with a different eye from that of man. Sometimes it was much more sensitive to colour than man, and therefore they had to satisfy themselves—as the authors had satisfied themselves—that the photographic instrument and the plates which they were
using were capable of seeing what the human eye could see, that was to say, the limit of the cap, which was the important point in the present investigation, although, no doubt, the slightly brownish colour in the interior of the flame would not be so easily seen by the camera. It was not, however, to discuss such details that he had risen to speak. The members were aware that a Royal Commission was sitting, with the object of considering certain points connected with safety in coal-mines, of which Commission he had the honour to be a member. He mentioned this because, naturally, the members would not, under the circumstances, expect him to give any views on behalf of that Commission; but, akin to the subject before them that day, there were one or two points which he would like to mention. At present the law was that workmen must be removed from any place in a mine where the quantity of gas was so great as to be likely to be dangerous. Of course, that was a very difficult section of the Act to administer, not only for the Inspectors, but for the managers of mines and those engaged in their superintendence, because of the meaning to be attached to the word "dangerous." Surely common-sense should dictate the removal of men before the mine became dangerous; and therefore the law did not help them very much. Suggestions had been made that, instead of using the word "dangerous," an endeavour should be made to fix upon some percentage of gas which would be taken as indicative of danger. The reason for which he mentioned this was that he was anxious to hear the opinions of the members on the point. Difficulties arose because, of course, one could find gas even in a well conducted mine: and the fact that gas could be found in remote places was not necessarily indicative of a badly-managed mine, but a mine where the conditions were difficult. If, therefore, any such tests were to be applied in the future to a place where men were at work, it would not be right to say that men should not be allowed to remain in the pit, because in remote crevices gas had been found. Again, it would not do to lay down a rule that if gas of greater percentage should be present, men should not be allowed to work in the place, because men must go in to the place to put it right; but they should only be allowed to go in under special supervision. One suggestion was that there should only be a certain percentage of gas allowed to be present in the main air-current, where men worked or went, and if that percentage increased, then any men in the place should work there under special supervision. That seemed to him a proposal worth consideration, and he should like to hear if such an arrangement was practicable. What was the percentage that one could see? He supposed that it would be 1 per cent. in the laboratory, and 1 ½ per cent. in the mine. Anyone, he imagined, could see 3 per cent. If, then, there was to be a figure given, what was it to be? Was it to be 2, 2 ½, or 2 ¾ per cent., or what? and upon that point he confessed, on an occasion like the present, where there were so many clever men assembled—he might say the elite of the profession—who had all their lives been at work on the problem, to a person like himself, engaged to help to administer the law, some information would be very valuable. It was of no use fixing the percentage too high: that would be dangerous and retrograde, and it was of no use putting it too low, because it could not be administered. He had been told that the mining world had been under a mistake, that they had been working under better conditions than they were aware of, that when they saw caps which they thought indicated 3 per cent. of gas, in reality the cap was only 2 ½ or 2 per cent.; in other words, there had been some misunderstanding as to the amount of cap that one could see. On all such questions a paper like Messrs. Whalley and Tweedie’s was calculated to throw light. Experiments were being made on the points that he had put forward; and it would be a very great help if some gentlemen present, in the course of the discussion,
would state their views. He thanked the authors for a most interesting paper.

- Mr. E. B. Wain (Whitfield Collieries) said that the impression that must have been left on the minds of many practical men after hearing Messrs. Whalley and Tweedie's paper was that it was a most difficult matter to test in a practical way for very low percentages of gas. When he said “practical,” he meant “in a practical way” in the mine by the ordinary means, of testing that were in the hands of colliery officials. The diagram exhibited showed a comparatively small difference in the size of the cap between, say, 1 ¾ and 3 per cent. of gas. From 3 per cent. there was a distinct ascent in the line of the curve, and, taking even the best safety-lamp obtainable at the present day, and the large number of tests that had to be made by every deputy, he thought that any standard fixed at less than 3 per cent. would lead to great confusion and great difficulty. But 3 per cent. appeared to him to be the practical standard at which—if a standard had to be fixed—it should be taken; that was the point where, beyond all doubt, there was a distinct and visible measurable cap which was not affected to a very large extent by minor considerations. If it should be decided to fix a standard, it would be extremely useful if those in authority would issue, for the information of colliery officials, and particularly for subordinate officials, such as the firemen and deputies, some graphic illustration of the size of cap for various classes of safety-lamp. It was all very well to say that the man knew when there was a cap, but if there could be some graphic illustration placed in the hands of every deputy, showing what percentage of gas was found by a certain cap, and what he must take as indicative of danger, then he thought that those engaged in mines would work more closely on the lines that the Home Office in particular wished them to follow.

There was one other point, and that was in connexion with the testing for gas by the deputies generally. The deputy was travelling round in the mine making the inspection before the men came in; and he had a limited time in which to do his work before the men arrived. It was a very difficult matter for a man to test accurately for small percentages of gas without losing his light, and he thought that if the writers of the paper could give the members some fuller information on the tests with a slightly luminous flame, and as to how certain percentages of gas could be tried and found, it would be of great service to them.

He thought that Sir Henry Cunynghame had taken the right view to the question of standards of ventilation and the percentage of gas when he said that the standard should be fixed in the main air-current passing through the mine. If that current contained a certain proportion (whatever it was that was fixed), that should be the point to be looked at, and not the presence of a small quantity of gas in a gate-end or top canch, where it was practically impossible to get a strong ventilation, and there should be no necessity for the removal of workmen if the main air-current was clear.

Mr J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) congratulated the writers of the two excellent papers on the good work that they had done, and on tackling a subject of such great importance to the safety of mines. He should say that the ordinary observations that a fireman or deputy could make with a safety-lamp, using it in a proper way, were probably quite sufficient so far as the danger from fire-damp itself in a damp pit was concerned; but when they came to the question of blasting and particularly when it was associated with coal-dust, it seemed to him that much more accurate observations were
necessary. One per cent. of gas with a shot blown out, or partially blown out, or possibly not blown out at all, but raising dust, constituted a very considerable danger; and it would be a very desirable thing if some means could be devised by which these men could detect even less than 1 per cent. of gas. The writers had mentioned a "standard" flame, but they did not actually describe what they meant by a standard flame: he assumed it to be a flame so reduced that no white light was visible. Now, it was very difficult always to obtain that result in a pit. A person was often in a very cramped position, and sometimes perhaps when he was in the act of manipulating the light it would be put out. Sometimes it was not reduced till all the luminosity disappeared and the pricker was put over to obscure the white light. He had with him a lamp which was in use at Wardley Colliery, introduced by Mr. Guy, the undermanager, which contained a sleeve. By pushing the sleeve up, the flame was obscured without any danger of the light being put out. The lamp was in use by all the gas-examiners at Wardley, and he thought that it was a very good contrivance, as there was little risk of losing one's light.

There was one point in Prof. Thompson's paper, in connexion with the concussion from a blown-out shot, which he would mention. He (Mr. Atkinson) had once made some observations underground with a mercurial and an aneroid barometer. He had found that with the aneroid the point went up so rapidly one could not see it when in the vicinity of shot-firing, whereas with the mercurial barometer the mercury did not move, showing that, with an ordinary shot there was something in the nature of a very rapid sound-wave that might cause the flame to pass through the gauze of the safety-lamp.

With respect to the standard of 3 per cent., he thought that the percentage was too high.

Mr. W. C. Blackett (Sacriston) said that it seemed to him that before one could reasonably consider the questions raised by Sir Henry Cunynghame, one must know exactly what was meant by the standard of ventilation and what was its purpose when they had got it. A standard of ventilation for firing shots was a totally different matter from what was reasonable, say in a wet place, for a man to work in. A standard of ventilation in a man's working-place was entirely a different thing from a standard of ventilation in a return airway; and a standard of ventilation in a return would be totally different from a standard of ventilation in an intake. So before any of them, as practical and sensible men, could consider the question of a standard of ventilation, they must first of all know what it was for and under what conditions the standard was to be arrived at. It was the unpractical man who talked about a general standard of ventilation. Take the instance that had been suggested: a standard of ventilation of 3 per cent. of gas in a main return. When they had found that state of ventilation in their main return, what was it intended should be done in the pit? It had been suggested that the workmen had to be considered as to whether they should work. What sort of work? There were pits in the country that had 3 per cent. of gas in the main returns every day, gas drawn from miles beyond coming through them. It might be a workman's duty to see what the conditions of the mine were. Was he not to be allowed to go through that return because there was 3 per cent. of gas present? Was all work to cease, and, if so, what was to be done with the mine? The whole thing was absurd from that point of view. Now if, on the other hand, he saw 3 per cent. of gas in an intake, he should consider it time to get out of the pit. When he
found in a working-place an appreciable amount of gas, the workmen were brought out of that place and not allowed to return until it had been put right. But they did not consider that that had set up a standard of ventilation in the mine. They had only considered for that period, in that particular case, that they had themselves set up a standard of ventilation suitable to the circumstances. Should there be mines where unreasonable caps were seen in working-places, and where the men were not brought out, then that state of affairs was wrong.

The percentages of gas were most interesting points: how men had seen 1, 2, and 3 per cent., and had been able to photograph the caps. He, himself, had endeavoured to photograph such caps, but had not carried on the investigation, simply because he did not think it worth while. A human being could not always see what the eye of a camera could see. They knew that 3 per cent. was not in itself dangerous; and he would feel quite comfortable in going into a return under such conditions. Therefore, under such circumstances, leaving out Mr. Atkinson's question of coal-dust and shot-firing, it did not matter in the least whether it was known that there was 1, 1 ½, 2, or 2 ½ per cent. of gas present. It was an interesting point to determine in a laboratory, but it did not concern those in the pit. But when they had to consider the important point that Mr. Atkinson had raised with regard to shot-firing and coal dust, it was a totally different matter. It was another set of conditions, one of the many that they had to meet every day in the pit; and he was free to confess at once that when firing shots one was bound to exercise much more care with regard to the atmosphere than at any other time, because (as Mr. Atkinson had very properly put it) 1 per cent. of gas helped along an explosion of dust in a very dangerous manner.

Mr. Charles Chandley (Nottingham) said that he was struck by the fact that they had not learned a great deal of a practical value from the first paper. Was it suggested that, in addition to all his other accomplishments, a colliery manager had to become a photographer? He hardly thought so. On the other hand, the personal equation was suggested as being the final referee in a matter of gas-observations. Well, they had all had experience of the personal equation; and it was perfectly obvious that if the men who were the officials at collieries were asked to give their opinions on a certain cap, they would all give different answers. For a standard of gas, therefore, the quantity present would be a matter of personal observation, and, in the hands of officials such as they had about collieries, the result would be perfectly hopeless—at least that was his opinion.

With regard to testing for 3 per cent. of fire-damp, no doubt some of the members had gone round with a deputy at 3 o'clock in the morning, and were aware of the sort of thing that happened. It was putting it mildly to say that the deputy was in a hurry; and he had to draw his lamp-wick down at every place; he had to have his head in such a position as to see the cap when the flame was actually drawn down. Did the members think that he (the deputy) would do it? He (Mr. Chandley) was perfectly certain that he would not. They had to deal with human nature as it was, and not as one expected or hoped it to be. They must also remember that the fireman was looking for something that he did not want to find. Of course, in the case of the Inspectors of Mines, these gentlemen were in an entirely different position; they wanted to find something, and they wanted to find it badly.

He (Mr. Chandley) could not be too thankful to Prof. Thompson for having discovered a satisfactory direct means of producing fire-damp. He thought that it was very necessary in future that they should have some means of showing students the gas in the testing-station, because he was sure that in the very near future gas would be one of the interesting relics of
the past. He considered that Prof. Thompson had conducted his experiments along very excellent lines; he was doing work that ought to result in some reliable information respecting a good many lamps.

Prof. Henry Louis (Armstrong College, Newcastle-upon-Tyne) congratulated Prof. Thompson upon having devised what

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the speaker) thought was the best experimental chamber he had yet seen, and he was of opinion thatProf. Thompson had come a step nearer to the desired end. He (Prof. Louis) had not yet put up any gas-chamber, simply because he had not been able to devise one that met all the conditions of getting a continuous mixture of gas and air into which one could put a lamp and at the same time be quite certain that the percentage of gas and air would not vary throughout a lengthy experiment. He would ask Prof. Thompson why he was satisfied to use coal-gas where the air-current was stationary, and yet would not use it where the air-current was moving with considerable velocity. Possibly his answer would help the speaker to get over the difficulties to which he had already referred. With regard to photographic caps, he admired the ingenuity with which the work had been done, but he feared from a practical point of view that the result was not of very much use. The colours of the different caps was a very important point, but unfortunately photography did not help them in that direction; and, as had been pointed out by more than one speaker, the camera saw things that the eye did not see. Anybody who liked to compare the colour of the caps that were obtained from marsh-gas, coal-gas, or acetylene-gas, would be struck by the marked difference in colour when using a light or heavy hydrocarbon. The great difficulty in testing for gas seemed to him to be the recognized fact, that under certain conditions it was necessary to be able to see in a pit low percentages of gas. He was strongly convinced that occasions did arise when it was necessary to see low percentages of gas, and he did not think that it was possible to do so with any ordinary lamp in use at the present day. The lamp that Mr. Atkinson had exhibited in the earlier part of the discussion was one which he (the speaker) should condemn in the strongest possible terms. It was an excellent appliance for showing a cap where no gas existed; in fact, he was able to see with it a slight cap in the very room in which they were seated. When the small tube was drawn up over the wick, combustion was partly checked, and unburnt gases escaped from the wick and formed the cap over the lamp-flame. At the same time, it exaggerated the cap, because it enabled one to work in an atmosphere mixed with gas with a higher flame than a standard flame would be; so that on both those grounds it was an

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unreliable lamp to use in the mine. He was tolerably certain that if small quantities of gas were to be detected, it would have to be done by the use of two lamps, one for the examiner to see his way and the other to detect gas. The Wolf benzene lamp had given good results, but not for very low percentages. He (the speaker) had been working for some time on the possibility of making a safety-lamp that could be used practically and safely in the pit, which would always maintain a standard height of flame. Up to the present he had not been quite successful, but he hoped that in time he might overcome the difficulties which he had encountered.

A Member said that the Clowes lamp combined the two requirements, as one had there a lamp which could be used for both purposes, although with great care.
Prof. Louis said that he would not like to put a Clowes lamp in the hands of an ordinary deputy. It was, in fact, two lamps in one, and so far came partly within the definition that he had previously given, but he looked upon it as a dangerous lamp except in skilled hands. If one wanted to use one lamp only, he was certain that such a lamp must be fitted with some self-igniting apparatus, in order to take away the fear of the deputy losing his light. He believed that if that were done, it might to a certain extent get over the difficulty, although even then he did not admit that such a lamp would be suitable for detecting very small quantities of gas. A point to which he wanted to call the attention of the members was the enormous difference in the power of different people in seeing gas. He had been in the pit, for instance, with Prof. Cadman, and had found that he (Prof. Cadman) was able to see gas with absolute certainty where he (Prof. Louis) and others present could not see gas at all. He had frequently found this to be the case, and he believed that most of the members would bear him out in the statement that one's power of seeing a gas-cap became less as one got older. He knew he could not see a cap as well as he could 10 years ago. He had tried partly to overcome that difficulty by following out, and he hoped he might say improving on, the old suggestion of Mr. Steavenson. He had used blue lenses which cut off the rays of white light and magnified the cap when there was one. In his own case, he had found the device helpful; many others had also found it useful though not all. A man might be an excellent person in every way for the post of gas-examiner excepting that his sight might be such that he was physically unfit to see caps where others could: and he thought that seeing a cap should form part of the examination through which any deputy was put before he was placed in a position where he was called upon to look for it. It was not a matter of "being a fool," but that he was physically unable to see a cap that other people could see. The question was one that bristled with difficulties at every point, and he thought that it was only by elaborate investigations, such as those described in the papers before them, that they could hope to throw any light on the subject. All of them, however, fully appreciated the immense difference between testing for gas in a laboratory and doing so in a pit amongst dust and dirt, under the conditions with which they were all familiar underground.

Dr. James S.Dixon (Glasgow) said that there was a point that he would like to bring before the notice of Sir Henry Cunynghame. They all knew, in the case of a virgin coal-field when shafts were newly sunk, of the great difficulty of contending with gas before a proper current of air could be got into action between the two shafts. In cases of that kind, it would be absolutely necessary to have an exception to any rule that dealt with a standard of ventilation. In numerous cases within his own experience, the quantity of gas met with had been enormous. He knew of one case where, when driving between two shafts, for a short time they had to dip their lamps into buckets of water when they became hot, owing to the gas burning inside. In a case of that kind, it was absolutely necessary to make the connexion between the two shafts at once, otherwise one would have to wait for several years to allow the gas to escape. The amount of gas far exceeded 3 per cent., so that the Home Office would have to make some exception in such cases.

Mr. Simon Tate (Trimdon Grange) asked at what place in the mine would the standard of ventilation be taken? Would it be taken in the main return, as if so it would be a very serious matter for many collieries, because the only way in which they could tap the gas from the goaves was to allow it to come.
along that return. No man in the world could judge the amount that was coming out; one
could not tell whether there were 10,000 or 50,000 feet of air in such a place. He had
known of 50,000 feet of air being contaminated and made inflammable with one little fall in
the goaf, and that state of affairs had lasted for days. If the pit in question had had to be
laid off because the air in the return was foul, it would have had to stand for many years.
A standard of ventilation, therefore in the returns was, in his opinion, futile. If the standard
was fixed for a man's working-place, that might do, but it was not practicable to reduce the
amount of gas to a percentage that was not discernible by any ordinary miner. The quantity
must be discernible to any ordinary man before it could be recognized or dealt with. Probably his own experience in testing for gas was somewhat extensive, but he would not
like to say that a place had more or less than 2 per cent. at any time. He questioned very
much whether a man could tell by means of an ordinary lamp whether anything less than 2
per cent. was present. He might mention a recent instance when he was testing with some
very eminent men in the industry in a return airway, and the amount of gas was made out to
be 1, 1 ¼, and some said 1 1/2 per cent. When the air was analysed, however, there was
no gas at all. He remembered an overman once making a test for gas with the old spirit-
lamp, and the lamp was tried in the overman's cabin at the bottom of the shaft, and the
overman said: "It is a beautiful cap." Then the lamp was taken in-bye, one could tell very
well that there was 2 ½ per cent. on the lamp. The overman knew as well as he (Mr. Tate)
did what quantity there was in the place. As a matter of fact, however, these small quantities
were not what one wanted to find out; what one wished to ascertain was the presence of
dangerous quantities. A member had said that no man would fire a shot where there was
coal-dust. In his (the speaker's) opinion coal-dust constituted the greatest danger with which
they had to contend at present. He did not think that any man was so foolish as to fire shots
where there was gas, but he believed that there were hundreds of men who did not know the
danger of coal-dust. It was not because they did not desire to know, but because they could
not see the danger of it. Dust in itself was innocent enough to look at, and it was only under
certain circumstances that it fired. Every

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member of any experience present in the room had seen thousands of shots fired without
any disastrous results; for it was only at odd times, when everything was favourable for an
explosion, that coal-dust explosion occurred. To fix a standard of ventilation because of
these accidents was, however, he thought, a mistake. he was quite sure that in the County
of Durham there was no fireman, deputy, or stoneman who would fire a shot where there
was any gas at all present, and it was a reflection upon the engineers, managers, and
firemen of the district to impute such recklessness to them. In all his experience—and he
had as much experience as anyone—he had never been able to trace an explosion to where
a shot had been fired. They might have had suspicions, but they could never say definitely
that such was the case. Human nature was the same all over the world, and he questioned
whether any man would fire shots where he could see a cap on his safety-lamp, and he
could see a cap with 2 ½ per cent. of gas.

Mr. T. E. Forster (Newcastle-upon-Tyne) said that there was only one point that he
would like to mention to Sir Henry Cunynghame, and that was that before The Institution
of Mining Engineers could give any advice or information the members should know more
definitely what it was that the Homo Office proposed to do. How did they propose to make
the test? Was it to be made with a safety-lamp? If so, it seemed to him that mining engineers would have to find some better way of testing with lamps than that which appeared at present to be in vogue. They had all heard the papers read that morning, and had listened to the remarks upon them, and the conclusion at which he imagined they had arrived was that until they had a better method of testing for gas, it would be quite unwise to try and regulate the mines in the way suggested. They would not only require to have a standard of ventilation, but a standard of testing, and a standard man who could do the test. He supposed that probably they would keep a man at the Home Office of the proper age who had nothing wrong with his eyesight, and who could be lent out by the Government to test their mines. Until something was done to define more closely the lines, he thought that it would be quite a mistake to fix a standard which should be followed in gas-testing. He agreed with Mr. Steavenson’s

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remark, that they ought to give to the past generation some credit for having thought of things which had now come prominently before them. The reason that no standard of air or gas was fixed in the past was because it was seen then, as it was seen by many people now, that it would be foolish to lay down any hard-and-fast rule. He had been in other parts of the world where they had standards of ventilation, and the ventilation there was not so good as in British collieries.

Mr. Steavenson said that his standard would be that if there was any cap at all to be seen, all shot-firing should be stopped. When coal-dust was added to the gas, no one could tell how small a cap might be dangerous.

Mr. W. H. Pickering (H.M. Inspector of Mines, Doncaster) said that he only rose for the purpose of correcting a remark made by Mr. Tate to the effect that no man would fire shots where he saw gas. He was bound to confess that in his younger days he had seen shots fired in places where gas was indicated, and he would like to say that he was at present investigating a case where a shot was fired under such circumstances.

Mr. Tate said that he was speaking of the County of Durham when he made the statement.

Mr. W. H. Pickering said he had even seen, in his younger days, shots fired where there was gas in the County of Durham. With regard to a standard of ventilation, he would say nothing, because some of the speakers had expressed his own view, that before a standard of ventilation was fixed the opinions and views of all those who were qualified to speak on the subject should be ascertained.

Mr. J. G. Weeks (Bedlington) said that so far as Northumberland was concerned, none of their deputies would ever think of firing a shot in a place if there was any visible signs of gas indicative of danger. He did not think that a standard, if adopted, ought to be less than 3 per cent. What struck him most was the absurdity of suggesting that a whole district should be laid idle because a little gas was found to be present in one particular place. If gas was found in any one place, then it was only necessary to fence off and lay that particular place idle. If
there was to be any standard of ventilation, it should be confined to the place where gas was actually found, and not extended to the adjoining places where there was no indication of gas. The adjoining places were perfectly safe, so far as firing shots was concerned, even if there was gas to the extent of 3 per cent. found in such a fenced-off place.

Prof. John Cadman (The University, Birmingham) congratulated the authors on their excellent papers and on the admirable photographs which they had produced. It had been put forward by a great many mining engineers that 3 per cent. was the limit which one could see, and these beautiful photographs, he hoped, would convince them that much less could be seen. As to the photographs being educational evidence, that was to say, evidence by which to teach deputies, he was rather sceptical. It was necessary in that case to show the colour and the various zones in the caps. It was obvious that in order to obtain the best evidence of fire-damp, one must get rid of the luminous light, and the lamp which Mr. Atkinson had shown that day was a very simple and ready means of doing it. If deputies' lamps were fitted with a contrivance of the sort (which was very simple), and were blackened so that they did not reflect, it was quite possible to get a non-luminous flame as described by the authors. He did not quite agree, however, with the authors of the paper in their references to the comparison between coal-gas and marsh-gas. If they only referred to the intensity of the flame, he was at one with them. The heights were the same, but, so far as his experience with Birmingham coal-gas was concerned, there was a difference in respect of the colour and intensity of the cap. For educational purposes in demonstrating to deputies, that was a very important point.

With reference to Mr. Blackett's remarks, he was rather inclined to think that the question of the standard did resolve itself into one standard, for, when all was said and done, they must get down to the bed-rock of the whole question, namely: what were the conditions under which they were prepared to leave the workman with a safety-lamp? The question of firing shots in itself did not, he thought, come into the question at all, for nobody would fire shots in the presence of coal-dust, nor would they fire shots in the presence of gas. The question was at what point were workmen to be withdrawn? What was the limit, and to what point were they to be permitted to remain at work in the presence of firedamp? He thought that it resolved itself into two points: first, what could be seen and, second, what was the effect on the safety-lamp burning continually in percentages of fire-damp? If a safety-lamp was permitted to burn in a 3-per cent. mixture, the lamp became excessively hot, and those who had seen lamps burning in a 3 per cent. mixture knew that such a lamp was almost unfit to handle. Was that a satisfactory condition under which workmen should be allowed to carry on mining operations? Certainly, if one had to go into such an atmosphere in case of emergency, it was safe enough to take in a lamp, provided that the person who carried it understood all about it, and was competent to take care of himself and his lamp; but, with the lamp in the hands of an ordinary workman, something lower than that percentage was required.

With reference to the paper by Prof. Thompson, he (the speaker) had been doing a considerable amount of work himself on the question of the education of officials with reference to fire-damp caps, and he had experienced many of the difficulties to which Prof. Thompson had referred. He had found that by putting a lamp in a box in a gaseous mixture, the mixture did not remain constant, and the method was not altogether satisfactory. Again, one was looking through a glass window, and the conditions were very different from the actual conditions of a mine. For preliminary demonstration it was, of course, admirable, but
for final demonstration it was hardly like the real thing. He had recently fitted up a portion of
the experimental mine at Birmingham, which allowed the atmosphere to be charged with 1,
2, or 3 per cent. of gas, and students and others were permitted to sit in the roadway and
make their observations actually under conditions similar to those in the mine.

Dr. J. S. Haldane (London) wrote that, although unable to be present at the meeting,
he had, by the courtesy of the authors, been enabled to examine their photographs, by
which he was greatly impressed. He considered that Messrs. Whalley and Tweedie's paper
marked a very distinct advance in the scientific treatment of the whole subject, and
contained a great deal of new and useful information.

He was particularly struck by the close correspondence between the caps on the reduced
flame as photographed and as seen by the naked eye. The photographs seemed to show no
more of the caps than could be seen. In looking at the cap shown by the 1½ per cent. of
fire-damp on an ordinary oil flame, one was apt to imagine that although the tip was actually
invisible, it must be present, and would be seen if the eye were delicate enough. He would
like to ask the authors whether, with long exposure of the photographic plate, a tip could not
be brought out. The photographs of long caps on a full flame were of special interest to him
as a physiologist. The eye could only perceive percentage differences in luminosity, and only
down to about 1 per cent.; hence the cap on a full flame with 1 or 2 per cent. of fire-damp
was invisible. On the other hand, the intensity of the light falling on one part of a
photographic plate was without influence on the effect produced by light falling on another
part. In other words, there was no "dazzling" of the photographic plate; hence the cap on the
full flame could be photographed.

The data showing the relation between the height of the flame and the height of the
cap were especially instructive; also the experiments on the influence of the illuminant on the
height of the cap. He would like, however, to ask the authors whether the percentage of gas
at which the tip of the cap became visible varied appreciably with different illuminants. For
instance, was a tip distinctly visible in less than 2 per cent. of gas with a reduced naphtha
flame? As the percentage of gas up to about 3 per cent. could be judged, and so much by
the height of cap as by the visibility of its tip and its luminosity, this question was important.

From the clear account which the authors gave of "fuel-caps," it seemed to follow that
for everyday testing underground it was better to use an illuminant which was as little volatile
as possible, consistently with keeping the wick reasonably free from clogging.

The authors' photographs, and the lantern-slides made from them, would be
extremely useful for instructing deputies and others in testing for gas, and he hoped that they
would arrange to make sets of slides available for that most important purpose.

Mr. W. Walker (H.M. Inspector of Mines, Derby) wrote that he thought Messrs.
Whalley and Tweedie were to be congratulated on, and thanked for, bringing before the
notice of the members of the Institution the results of their experiments on the detection of
caps on the flames of safety-lamps. At the present time, nothing was of greater importance,
seeing that the question of the standardization of ventilation in all mines had been so
prominently brought forward, by many witnesses, before the Royal Commission on Mines,
and also at the meeting between the Commission and the Mining Association of Great
Britain. The value of the paper to the persons most concerned, namely, the deputy and shot-
firer, who made the actual examination of the working-places for the presence of gas, under
the requirements of the Coal Mines Regulation Act and Special Rules, was very great, but if it was not brought to their special notice by the owners, agents, or managers, many of them would never hear of it. The paper should be specially explained to the deputies and shot-firers, or they ought, without exception, to be sent to the various universities or mining schools to see similar experiments made. In the course of his official duties, he (Mr. Walker) had watched carefully how the deputies and other officials proceeded to examine places for gas, and only in a very few instances had the flame of the lamp been lowered as far as it should be in order to get rid of the white light. In fact, such tests would not show 4 per cent. of gas, as the cap would be masked by the luminosity of the white light. There was, no doubt, considerable risk of losing the light altogether if it was lowered to such an extent as would enable one to detect 1 ½ or 2 per cent. of gas, and if the men were working alone, it might be taken as certain that they would not run any such risk. To obviate this, he would suggest that either the deputy should carry two lamps or that he should be accompanied by an assistant, who should always be present when examinations for gas were being made. If the latter course were adopted, the deputy would be likely to make a much more searching examination, as not only would he know that there was a second light present, in the event of his own being put out, but the presence of the second man would be a check on the first, and, at the same time, the assistant

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would be receiving a valuable training which it was not now possible for him to get. The paper and photographs showed how important it was in order to get accurate results, that the wick should be properly trimmed and the light lowered to such point that the luminosity of the white light would not mask the cap if gas were present.

The importance of having careful lampmen and the lamps and gauzes carefully examined, as mentioned by Prof. Thompson, could not be overrated. At many collieries safety-lamps, before being taken into the mines, were tested by being placed in gas, and were invariably extinguished. At a colliery in Yorkshire, a deputy was seriously burned by an explosion of gas in his lamp when examining the workings in the mine. This lamp had been tested in gas at the lamp-cabin on the surface, before being taken into the mine, prior to the occurrence of the accident. Before proceeding to investigate the circumstances of the occurrence (that is, after the accident had taken place), the lamp was electrically relighted, without being opened, and again put into the same gas-testing box in the lamp-cabin; and, although subsequent examination of the lamp showed that there was a hole of considerable size in the top of a single gauze, the flame was extinguished, and the lamp in all respects (for the reasons explained by Prof. Thompson in his paper) behaved as if it were in perfect condition. Gas-testing arrangements could never supersede careful examination of all parts of a safety-lamp, but gas-testing was, if properly applied, a valuable adjunct.

The question of arriving at a satisfactory standardization of the ventilation of a mine bristled with difficulties. It had been suggested that a certain percentage of gas in the main ventilating current should be taken. This, he (Mr. Walker) presumed, meant the main return, as it was hardly likely that gas would be found in the main intake. That being so, it should be remembered that there would be a strong temptation on the part of the officials to keep the returns ventilated by passing air from the intake to the separation-doors between the intake and return airways. Such a proceeding would mean that the ventilation of the faces and ripping lips would suffer: they, in his opinion, were of the greatest importance--and the quantity of air should not be reduced at that part of the mine.

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The safest and only satisfactory standard to establish would be that no man should be allowed to work in any place, except for the purpose of repairs or of removing accumulations of gas where there was more than 2 to 2 ½ per cent. of fire-damp present; and that no shot should be fired, under any circumstances, where the slightest trace of gas could be detected.

Prof. W. Galloway (Cardiff) wrote that the following observations might perhaps be of interest as a contribution to the discussion on Messrs. Whalley and Tweedie's paper: —

1. Although a flat wick might sometimes be used, faute de mieux, a round wick which gave a symmetrical flame and cap was always preferable.

2. The wick should present a smooth, rounded, black surface, quite free from minute projecting fibres, the glow of which distracted the eye and slightly coloured what the authors of the paper had called the "fuel-cap" (hydrogen flame?). The latter was very easily distinguishable, from even an incipient fire-damp cap, by a practised eye.

3. As great care was required to be exercised in drawing down the wick, in order to obtain the small dark blue hemispherical flame about ¼ inch in diameter by 1/8 inch high, with a speck of yellow in its centre, which was the necessary condition when an ordinary safety-lamp burning colza oil was employed, it would be better to furnish a testing-lamp of that description with a screw arrangement such as was used in lamps burning benzine and similar illuminants, otherwise the flame was very apt to be accidentally extinguished and loss of time to ensue.

4. After the lamp had been burning for some time, and a crust had begun to form upon the wick, it was impossible to clean and smooth the top of the latter and press back recalcitrant fibres into it in an efficient manner by means of an ordinary pricker. For this reason he (the writer) had a small ball-and-socket joint made in the brass ring above the glass of a Clanny lamp, with the pricker projecting downwards through a hole in the ball, at the time when he had occasion to make numerous observations of the state of the air in the fiery mines of South Wales, namely, in the second half of the eighth decade of last century. By this means he was able, at all times, to clean and trim the wick as thoroughly as if the upper part of the lamp itself had been removed. This arrangement could not be conveniently applied to bonneted lamps.

5. In advocating the use of a standard testing-lamp,* the writer had suggested the use of one burning benzene, for the following reasons, namely: (1) a crust did not form on the wick and therefore, no cleaning and trimming was required just before a test was going to be made; (2) the wick was lowered with a screw and, therefore, there was not the same danger of extinguishing the flame as with a pricker; (3) the fire-damp cap began to appear sooner, and increased in height more rapidly than with a lamp burning colza or other similar oil; and (4) the lamp gave a better light than the last-named when the flames of both were of normal height.

The following observations made by the writer in a district of longwall workings in the Two-feet Nine Seam in Pentre Colliery, Rhondda Valley, on September 28th, 1877, might not be without interest in this connexion. They were copied from one of a number of original note-books containing many similar details:

South split: 42 working-places, 84 men. The air was travelling partly in the roadways, partly in the faces, but was brought up to the faces from the roadways as
required for dilution of the current at the face, and was finally guided into the return airway after passing the last face.

Caps: 10th face, 1/8 inch; 20th, 1/8 inch; 30th, 3/16 to 1/4 inch; 33rd, 1/4 inch; 37th, 1/4 to 3/8 inch; 40th, 3/8 inch; 40th, 3/8 inch; 45th, 1/2 inch. The area at the point where the air was measured in the return was 35.75 square feet; the velocity of the air, 383 feet, and its volume 13,692.25 cubic feet per minute.

According to the scale employed,† a cap of 1/8 inch represented 2 per cent., and one of 1/2 inch nearly 4 per cent. of fire-damp.

Mr. W. H. Hepplewhite (H.M. Inspector of Mines, Nottingham) wrote that individuals whose duty it was to make an inspection of a district, especially if far in-by, had occasionally en route to test for small percentages of gas on a lowered oil-wick, and the difficulty experienced in obtaining a clean blue light with which to make the test—often ended in failure.

* Practical Coal-mining, 1907, divisional volume v., pages 77 and 83.

Safety-lamps burning a suitable oil very soon began to form a crust on the wick, and when the operator wished to make his first test with a small flame, he probably found that the crust was not sufficiently hard to fall away entirely, and that the ordinary pricker provided either failed to clear the crust or extinguished the light.

He (the writer) had made numerous experiments with various patterns of prickers and snuffers, and the only one to remove completely all the crust and leave a clean wick with the flame burning was in the shape of a bow with a thin wire across. (Arranged as a bow-string.) The suitable size of pricker for most lamps was 1 inch each way.

[Diagrams: Fig. 1.—Front and Side Views of Improved Pricker. Fig. 2.—Front and Side Views of Combined Flat- and Round-wick Tubes.]

The arch of the bow consisted of two wires, one of which formed the shaft for raising and lowering the wick, whilst the other was shorter and bent, so as to form the pricker (Fig. 1). Some of the prickers that he had made were of thin iron wire and arranged to start on the snuff in the contrary way from the ordinary pricker. The snuffer pushed the light out as it advanced, and it was only occasionally that the light would jump the sniffer and re-light the extinguished wick. On the contrary, the wire being thin he found that with ordinary care it took the crust clean away and never extinguished the light.

It was desirable that officials, when making an examination of a mine previous to the arrival of the first shift, should make a few tests with a lowered flame of the safety-lamp carried by

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them. As they often travelled alone, and as there were probably no workmen at the faces, if an official lost his light he was placed in a, very awkward position. It was possibly the fear of
being placed in this position that deterred an official from interfering, as he might think, unnecessarily with his light.

He (the writer) would draw the attention of the members to a device which would, he thought, give confidence to officials who were expected to make tests for gas-caps with a lowered wick (Figs. 2 and 3). On the opposite side to the pricker-hole of an ordinary flat-wick tube there was attached a half-round tube that would take wick a quarter of an inch in diameter (Fig. 2). The tops of both tubes were not at the same level, the half-round tube being 1/4 inch lower than the flat-wick tube. There was a slit in the half-round tube to correspond with that of the flat tube, so that the pricker, which was provided with a double head (Fig. 3), could manipulate either wick in turn.

[Diagram: Fig. 3.—Special Pricker, to which the Bow of Fig. 1 could also be Attached.]

The small tube he would name the "pilot light." Before commencing operations on the flat wick, the pilot wick was pushed up and lighted at the flat wick. A light having been secured on the pilot, the flat wick could be treated to obtain the clear blue light. This having been accomplished to the satisfaction of the operator, the pilot wick was then drawn down and extinguished, and the observation made in confidence.

It might happen that the flat wick could not be thoroughly cleared of the crust, and then the pilot light could be used for making the test. The writer preferred the flat wick to make the test, although a satisfactory test could be made with the round wick. He thought that the circulation of air through the lamp had been reduced to a minimum, when the large flame was suddenly lowered to a small one with comparatively low temperature, and especially so if the temperature of the ventilating current was high; but the blue flame with a flat wick was larger than with a round wick and ought to help to sustain the circulation and draw in the surrounding atmosphere.

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The wick must be absolutely cleared of the crust for accurate testing, if the percentage of gas were small.

With regard to the pattern of lamp to be used to obtain the most satisfactory result, he preferred one in which the air was fed under the glass.

It seemed to him that the time was not far distant when officials making examinations under the Coal Mines Regulation Act would be compelled to carry a safety-lamp with a suitable appliance for the detection of small percentages of gas, and for these to be duly recorded in the report-book.

Mr. E. Bessell Whalley (Rotherham) said that the greater part of the discussion needed no reply from him, because it related to a standard of ventilation, which was not the subject of the paper. The members would, however, be extremely interested in hearing what Sir Henry Cunynghame had to say upon the question of a standard.

In reply to Mr. A. L. Steavenson, he said that the apparatus described depended upon the rate of diffusion of gases, and water-vapour might have the same effect as firedamp. He (Mr. Whalley) had used various tints of coloured glass: but, although the glass cut off some of the luminous rays, one lost as much as one gained by looking through it, and, on the whole, one was better off without it.

In reply to what some members had said about the camera seeing more than the human eye, the greatest care had been taken to produce photographs which by careful comparison showed exactly what was seen by the observers, except in the case of the caps over full flames, where the camera was purposely used to depict more than the eye could
easily see. It was possible, as Dr. Haldane suggested, by giving prolonged exposures, to photograph a complete cap with a tip in some cases where only the lower part of a cap was visible to the human eye.

If Mr. J.B. Atkinson would refer to the paper, he would see that Section (3) (see page 106) dealt specially with the subject of a standard testing-flame, and that Fig. 2 (Plate XVII.) referred to on page 107, was a photograph of a standard flame the exact height of which depends upon the lamp and illuminant used.

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The lamp Mr. Atkinson produced was very similar to one in use at Altofts Collieries, but the burnished reflector behind the flame was detrimental when testing for gas.

In reply to Mr. Charles Chandley, he said that it was certainly not suggested that mining officials need be photographers any more than that they should manufacture their own lamps, but that it would be helpful to them if photographs were supplied for their information and guidance.

In reply to Prof. Henry Louis, he (Mr. Whalley) could not detect the difference between the caps produced by methane and those produced by Leeds coal-gas, although he had looked at them carefully side by side in experimental chambers; and if a man was capable of appreciating the slight difference in colour or size, he would certainly be capable of seeing the cap produced by a small percentage of gas which could be detected by the careful use of ordinary safety-lamps. He (Mr. Whalley) had had considerable experience in the use of the Clowes and other special types of lamps. Some of them gave excellent results, but some practice with them was necessary, and the same amount of care and practice would enable an ordinary man to detect small percentages with an ordinary safety-lamp.

With respect to the point raised by Dr. J. S. Haldane, some illuminants did give a complete cap visible to the eye with smaller percentages of gas than others, and for this reason a naphtha which was not excessively volatile was found most suitable by the writers. This point was confirmed by the decision arrived at by the Prussian Commission in their report upon the detection of fire-damp.*

The fuel-cap was, as the name implied, burning fuel, and not the hydrogen zone of flame as referred to by Prof. W. Galloway. The flat wick was preferred to a round one by the writers, for the reasons given in the paper. Colza oil was found to be unsatisfactory, especially after the lamp had been burning some time; and, although a pricker such as that described by Mr. W. H. Hepplewhite would, no doubt, be an improvement on the ordinary wire, it would not trim the wick well enough. When naphtha was used, the wick could be carefully cut and trimmed before the lamp was lighted, so that the reduced flame extended right across the wick-tube; and, as no crust formed on the wick the reduced flame did not alter when the lamp had been burning for some time, as happened when colza was used. Mr. Hepplewhite preferred a lamp into which the air was fed below the glass, but it was not certain whether this had an appreciable effect in testing for gas. The writers found that in a Clowes chamber, lamps showed no difference of cap, whether the whole lamp or the oil-vessel only was used.

He (Mr. Whalley) considered that those officials whose duty it was to test for gas should have lamps fitted with internal igniters, and he held that otherwise they could hardly be expected to reduce the lamp-flame so as to make the best possible examination. He felt certain, however, that most officials regularly detected less than 3 per cent., and probably what they took for 3 per cent. was in reality considerably less.

He also considered that safety-lamps should be tested, and only permitted lamps allowed to be used in mines, as was the case with explosives.

He thanked the members for the way in which they had received the paper.

Prof. G. R. Thompson (The University, Leeds) said that Prof. Cadman thought that to look through two glasses in the cap-testing chamber was very unsatisfactory. The larger chambers were intended to overcome that supposed difficulty, and he had made them larger and left out struts in the front part of the supporting frame so that a man could get inside the chamber and avoid, at any rate, the original wall of the chamber. He had found that the objection was purely academic, and if he had to put in chambers again, he should put in small ones, which lie regarded as more satisfactory. Speaking of the use of marsh-gas and coal-gas, Prof. Cadman seemed to draw a great distinction between the two, and to suggest that marsh-gas was the only thing that should be shown to deputies or to anyone else. He (Prof. Thompson) totally disagreed with such a contention. Under present conditions, the preparation of marsh-gas was a rather tedious process, and, not only that, the material was costly. He did not see that there was sufficient advantage to be gained by departing from coal-gas and supplying marsh-gas. He was certain that the difficulty of using the large chamber mentioned

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Prof. Cadman would be so great that it would be comparatively seldom used, and then under disadvantageous conditions. With regard to the cap, the method that he had adopted was not to use 1 per cent. of coal-gas, but to use one-seventh of what was just an explosive mixture. He did not think that gas-testing was so rigidly accurate and that the tests could be reproduced so truly that further refinement was necessary. He could bear out what Mr. Whalley had said, that in passing from the coal-gas chamber to the Clowes chamber supplied with marsh gas artificially prepared from aluminium carbide, he could not distinguish between the caps for corresponding percentages; and if the eye distinction would not enable him, who had been comparatively well trained to distinguish them, he thought that it would not allow the ordinary deputy with much less training to do it. Replying to a question, he also said that he had had considerable experience in comparing his own eyesight with other people’s -- that was, so far as seeing caps was concerned— and he found that he could see a cap more readily than an untrained man could.

The next point mentioned by Prof. Cadman was the luminous speck in the flame. Prof. Cadman had said that it was utterly out of the question to have any luminosity in the flame whatever, but he (Prof. Thompson) thought that the most advantageous condition for testing was to have a very slight luminosity, because in that case one got a bigger flame; but when the flame was raised so as to get more than a grey luminosity, the luminous part would, as Mr. Whalley had said, break through the blue zone, and become brightly luminous. When a testing-flame was gradually put up, the flame very rapidly outclassed the cap in luminosity, and the cap became invisible; and, in spite of the statements that 2 ½ per cent. of gas could be seen by anyone, he was of opinion that neither 2 ½ nor 3 ½ per cent. would be detected by a man who did not know how to look very carefully indeed into the lamp and into the gauze above. If he did that, however, he would then detect 2 ½ or 3 per cent. with a slightly larger light, but if he got a flame that was very distinctly luminous, he
would not be able to do so with an ordinary testing-lamp, although possibly he might with a shield.

Prof. Louis had been kind enough to praise the cap-testing chambers, and had asked him why he had used coal-gas in the

[160] chambers and petrol for experimenting with high velocity. The great convenience of using coal-gas was that he had simply to turn a tap, put in a switch, and the thing worked; it did not take 2 minutes to start working with any percentage. The reasons why he proposed to use petrol or benzol for the velocity test were as follows:—It was well known that the composition of coal-gas varied very much, and (in spite of Mr. Whalley’s statement as to what he had found) he had observed that he could use coal-gas for cap-testing in the Clowes’ chamber, and get very different results from those given by marsh-gas. Coal-gas also contained hydrogen, and he considered that there was a probability of the hydrogen burning on the gauze, heating the lamp up too much, and making the test unfair, so that he thought that a hydrocarbon would be better for testing purposes. He also found that he could put in a much cheaper appliance using a volatile oil, although one rather dearer to work.

It had been stated that photography was of no use, as it saw what the eye did not see. He might say that, so far as the caps were concerned, his own eyes had seen what the photographs showed.

The lamp exhibited by Mr. Atkinson was particularly interesting: in any form of lamp where there was a leakage of oil from the side, and particularly of volatile oil, a cap could be got—for example, a lamp fitted with a flat wick, and burning paraffin, would often, on the flame being pulled down for gas-testing, give a small light burning over one part of the wick only. The edges of the outer mantle of this flame were bent upwards, and were continued for a short distance, forming the base of a very bright, although incomplete, fuel-cap. The vapour giving rise to this cap was derived from the surface of the hot wick adjacent to the flame. He believed it was on record that men had been called out of the pit because the deputy thought the whole intake foul, and by using very volatile oils such an occurrence might easily happen.

There was just another point, and that was the effect of a lamp burning in a 3-per cent. mixture; if that lamp were dropped, he should say that there would be no effect whatever. A lamp burning in a 3-per cent. mixture would get rather hot, but that would be the only disadvantage; the flame, of course, could not pass out.

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Mr- Whalley said that with reference to what had been said about the camera showing more than the eye could see, that was certainly so: but he and Mr. Tweedie had taken care not to produce more than the eye could see, excepting in the case of the full-flame cap. With respect to the cap that could be seen without any gas being present, they had photographed that cap also; and he had had the experience himself of the whole of the men being turned out of a colliery because a cap, due to a badly-fitted lamp, could be seen in an intake airway where there was no gas at all!

The President (Mr. J. B. Simpson) moved a hearty vote of thanks to the writers of the two papers. They had raised a discussion which would be of great use to all engaged in mining, and he hoped that the Home Office would pay some regard to the observations that had been made on both sides.

The vote was put to the meeting and carried unanimously.
The following paper by Mr. W. O. Wood on "An Account of the Method employed in Stopping an Extensive Leak, under High Pressure, in the Tubbing of the East Pit, Murton Colliery, 1907," was read by Mr. E. Seymour Wood:—

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AN ACCOUNT OF THE METHOD EMPLOYED IN STOPPING AN EXTENSIVE LEAK, UNDER HIGH PRESSURE, IN THE TUBBING OF THE EAST PIT, MURTON COLLERY, 1907.

By W. O. WOOD.

It is no easy undertaking to stop a leak in the tubbing in a working shaft, when the point of leakage is 420 feet from the surface, and the quantity of water escaping 150 gallons per minute under a pressure of 105 pounds per square inch. It may therefore be interesting, and probably useful, to the members of the Institution to have a description of the method employed under such circumstances at the East Pit, Murton Colliery.

This shaft was sunk in the year 1838. The tubbing having become weak and leaky, it was found necessary to re-tub it in 1891. Fig. 1 (Plate XIX.) is a vertical section of the shaft and of the old and new tubbing. The old sand-crib bed, 270 feet from the top of the tubbing, is situated immediately below the sand-bed at the base of the Magnesian Limestone. This was "fore-set" by a similar crib in the new tubbing, the space between the old and the new tubbing being filled in with concrete to a height of 12 feet above the crib.

Some time after the new tubbing was put in, a leakage occurred at the joint, A (Fig. 1, Plate XIX.), between the tubbing and the sand-crib. This was wedged and made tight; but successive wedging—which was required to stop the leakage—indicated that the lower portion of the tubbing was settling, thus causing a parting at that particular joint. The cause of this is no doubt due to the existence of a large cast-iron bunton, B (Fig. 1. Plate XIX.), about 60 feet above the sand-crib, which formerly served to support the cistern of the top set of pumps, and is "pocketed" into the old tubbing. When the shaft was re-tubbed, this was allowed to remain undisturbed, and it was built into the new tubbing. This bunton prevented the settling of the upper portion of the new tubbing, and the joint eventually

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opened from 1 ½ to 2 inches, with the result that the wooden sheeting frequently blew out, causing serious inrushes of water into the shaft: indeed, it was found impossible to maintain the in its place until a special contrivance was used for the purpose.

A cast-iron ring (Figs. 2, 3, and 4, Plate XIX.) was designed, consisting of segments bolted together. Every alternate joint was fitted with a right- and a left-hand screwed bolt, for the purpose of expanding the ring: and the outside of the ring was recessed to receive—first a steel plate ¼ inch thick, and then a strip of rubber ¾ inch thick. The ring, when fitted up in position in front of the leaking joint, was expanded by the right- and left-hand screwed bolts in each segment, which, acting on the steel liner, pressed the rubber strip tightly over the leaking joint. This had the effect of considerably reducing the leakage, but, owing to the heavy pressure, the erosive action of the water gradually caused the leakage to increase, until at the time of the operations about to be described there was a feeder of 150 gallons per minute flowing into the shaft.

The volume of water was not of material importance, as it was all used as feed-water for twenty steam boilers underground, required for driving the hauling and pumping-engines.
As it had, however, been arranged to replace steam by electrical haulage, the boilers would have to be discarded, and the water would then have to be pumped at considerable expense. It became necessary therefore to stop the leakage before the boilers were dispensed with. To accomplish this without stopping the pit in a coal-drawing shaft, working double shift and running practically night and day, was a difficult problem.

The writer deemed to try the "Portier" method, which consisted in forcing Portland cement behind the tubbing. This system had been employed successfully in France and Belgium. In those cases, however, the leakages dealt with had been smaller and the pressure of water less, the highest being 60 pounds per square inch.

Mr. Henri Portier was retained to superintend the operation. Full particulars were supplied to him, and he prepared plans of the necessary equipment, which are described in Figs. 5 to 9 (Plate XIX.).

A belt of tubbing 30 feet above the leaking joint was selected,

and five brass cocks, 5/8 inch in diameter, were inserted in the plug-holes, at about equal distances apart (Fig. 5, Plate XIX.) Each tap was connected with a range of pipes, C, ¾ inch in diameter, which were run from the taps up to the surface, terminating with a funnel, G, on a platform, D (Fig. 7, Plate XIX.). Each range of pipes was connected with a hopper, E to contain sand and gravel, fitted with a valve, F, to regulate the flow of the sand and gravel into the funnel, G. A pipe, H, connected each range of shaft-piping with a water-tank of 45 gallons capacity.

For the purpose of relieving the pressure on the tubbing while operations were in progress, another set of cocks, 5/8 inch in diameter, was inserted in the tubbing, 51 feet above the sand-crib, and therefore 31 feet above the range already described, each tap being connected with a range of pipes, I, J, K, L, M (Fig. 5, Plate XIX.).

Mr. Portier with his assistant arrived on September 6th, and, after inspecting the arrangements, he expressed himself perfectly satisfied with the manner in which his instructions had been carried out, and arranged to commence operations the following morning.

Several tons of carefully hand-sieved sea-sand had been prepared, dried, and put under cover, together with a quantity of crushed brick and gravel, which had been passed through an 1/8 inch sieve. The following is a record of the operations: —

September 7th, 1907.
9.20 a.m.—Commenced to run sand and gravel from the hoppers, through the funnels into each pipe: a good volume of water was kept flowing from each tank, the sand and gravel being thus carried down the pipes to the space behind the tubbing.
11.0 a.m.—Commenced to inject gravel.
12.0 noon.—All pipes being blocked with the gravel, they were disconnected at the bottom and washed out.
2.45 p.m.—Recommenced injecting gravel.
2.50 p.m.—Pipes Nos. 4 and 5 blocked, Nos. 1, 2, and 3 working.
3.0 to 5.30 p.m.—Injecting gravel very slowly, the pipes frequently becoming blocked, and having to be disconnected and washed out. About 1 ½ tons of sand and gravel were injected.
5.58 p.m.—Commenced to inject cement by mixing it in the tanks with water to the consistency of cream, and running it down the pipes.
8.45 p.m.—Ceased operations, after having injected 5 tons of cement.
During the night the down pipes were disconnected from the injector-cocks and connected to the cocks above, which had been used for relief purposes.

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September 8th, 1907.

9.15 a.m. to 12.0 noon.—Injecting cement without cessation, 7 ½ tons being sent down the pipes during this period.

12.0 noon.—Ceased operations, and, upon examination of the joint, no improvement was found; but there was sufficient evidence to show that both the gravel and cement had escaped through the joint, apparently as quickly as they had been injected, and had run into the bottom of the pit, whence they had to be pumped to the surface, with a great risk of blocking the pumps. As the leak showed no diminution, operations were, therefore, discontinued, the experiment having up to this point proved a failure.

A few hours after the cessation of the operations, it was observed that there was a serious increase in the leakage: the feeder of water, on being measured, was found to have increased from 150 to 300 gallons per minute, the cause, undoubtedly, being the erosive action of the sand, gravel, and cement forced through the sheeting composing the joint. This serious leakage demanded urgent attention, and it was obvious that, if it was to be stopped by the injection-process, it would be necessary to use much coarser material, which would not pass through the cracks in the concrete between the two tubbings nor through the apertures in the joint, but would be retained and form a bed for the finer material and cement.

There was no time to replace the ¾ inch pipes and the 5/8 inch taps with larger pipes and taps, nor did it appear practicable to do so. After anxious deliberation, a novel method was devised to meet the case. The ¾ inch pipes were allowed to remain as they were, four of the 5/8 inch injection-taps were removed, and four 1 ¼ inch brass valves (Fig. 10, Plate XIX.) with full-way bore were attached by tapped bolts to the tubbing, the bore being exactly in front of a plug, which was then bored out and the valve closed.

What may be called a "hydraulic injector," was then fitted to each of the four valves (Fig. 11, Plate XIX.). A tube, 1 ¼ inches in diameter, with a T-piece at the other end, was screwed into the valve, N, the T-piece being connected by a tap, O, to one of the ¾ inch pipes leading to the platform on the surface.

Cartridges (Fig. 12, Plate XIX.), 4 inches in length by 1 inch in diameter, were then prepared, the cases being made of stout brown paper; a leaden bullet, 1 inch in diameter, formed the nose, and the body was filled with bullets 1/4 inch in diameter.

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The method of injecting the cartridges was as follows:— Valve P was opened, and a cartridge placed in the tube; valve V was then closed, and valve N opened. Tap O was now opened quickly; the pressure of water from the surface (200 pounds per square inch) injected the cartridge into the space behind the new tubbing, when it burst with the impact against the old tubbing; the contents were precipitated on to the concrete lining above the crib, the small bullets filling up the cracks and openings, as shown in Fig. 13 (Plate XIX.). During the week-ends of September 14th and 15th and September 21st and 22nd, 1,300 cartridges were injected, with the result that the leakage was reduced from 300 to 125 gallons per minute, proving that the leaden bullets were doing exactly what was intended.
Two ranges of pipes, 1 ½ inches in diameter, were then laid on from the surface and connected at the bottom to valves, N, N (Fig. 10, Plate XIX.), on the east and west sides of the shaft, and connected at the top to the tank shown in Figs. 7, 8, and 9 (Plate XIX.).

On September 29th, at 4 a.m., the injection, through the 1 ½ inch pipes, of gravel of 1/8 inch to ¼ inch in diameter was commenced, being assisted by a good flow of water from the tanks, with the result that by 8 o'clock the leakage was perceptibly less. At 10.30 a.m. the pipes were connected to the north and south sides of the shaft; the leak continuing to diminish, the flow of gravel was stopped, and the injection of sand and cement commenced. At 2.30 p.m. the cement was mixed in the tanks with water, and allowed to gravitate down the two 1 ½ inch pipes. The result was encouraging: the leakage continued to diminish steadily, and in 12 hours, namely, at 2.30 the next morning, the following material had been injected:

<table>
<thead>
<tr>
<th>Material</th>
<th>Tons.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel, 1/8 to ¼ inch</td>
<td>3 ½</td>
</tr>
<tr>
<td>Coarse sand</td>
<td>3 ¼</td>
</tr>
<tr>
<td>Portland cement</td>
<td>7 ¾</td>
</tr>
<tr>
<td>Total</td>
<td>14 ½</td>
</tr>
</tbody>
</table>

It was now found that the leakage had entirely ceased, only a little moisture exuding from it; and in a few days the joint was found to be absolutely tight, and has remained so ever since.

[Plate XIX., Figs. 1 – 13, to Illustrate Mr. W. O. Wood’s paper on stopping a leak at Murton Colliery]

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Mr. S. Hare (Bishop Auckland) said that all those who were interested in deep shafts with water under pressure behind metal tubbing would appreciate the importance of Mr. Wood’s paper as a valuable contribution to mining literature. To himself it was especially interesting, seeing that the operations in connexion with the stoppage of the leak were carried out at the time when he was acting as manager of the colliery.

It was satisfactory to think that the result of these operations, following the successful fore-setting of the tubbing in the Middle Pit, must have resulted in removing the great anxiety of the management of the colliery in connexion with the condition of those important shafts.

In Mr. Wood’s account of the operations relating to the stoppage of the leak, his statement that “after anxious deliberation, a novel method was devised to meet the case” required some explanation. It might be inferred from it that Mr. Portier had invented or assisted in inventing the “hydraulic injector,” whereas it was devised by the speaker, and the plan of it produced only after Mr. Portier and his Belgian assistant had left—Mr. Portier’s system up to that time having proved a failure. It was only fair to add that the work was carried out in a very able manner by the resident engineer of the colliery, Mr. J. Plummer.

Although he did not wish to underrate the Portier system, which was an excellent one in every respect, yet he was of the opinion that under difficult conditions similar to those at Murton it would always prove a failure, if his (the speaker’s) system of injecting leaden bullets through the tubbing plug-holes was not first adopted.

Mr. J. J. Prest (Horden Collieries) congratulated the author of the paper on carrying out successfully a very difficult operation; but he thought that it should be placed on record
that the Portier system in this case had been absolutely unsuccessful: in fact, anybody who had had similar experience of dealing with leakages of this kind might have anticipated such a result. Eventually, however, the local staff of engineers succeeded in entirely stopping this dangerous leakage by means of a unique piece of apparatus designed and manufactured on the spot. There was another important point in connexion with the stopping of leakages of a similar description, and that was the question of using internally-flanged tubbing. So far as the North of England was concerned, mining engineers were accustomed to use externally-flanged tubbing, but if internally-flanged tubbing were used, serious leakages of the description described by Mr. Wood would never occur. By internally-flanged tubbing, he meant the so-called "German" style of tubbing.

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) referred to a statement in the paper to the effect that "When the shaft was re-tubbed, this was allowed to remain undisturbed, and it was built into the new tubbing." Did he understand Mr. Wood to mean that the leaving in of this old bunton-tubbing was the cause of the leakage?

Mr. W. C. Blackett (Sacriston) asked why Mr. Portier had not used larger gravel to fill in the crack.

Mr. John Gerrard (H.M. Inspector of Mines, Worsley) asked whether, if larger pipes had been used, larger gravel that would not pass out through the tubbing could not have been introduced into the crevices.

Mr. T. E. Forster (Newcastle-upon-Tyne) asked whether the place shown in Fig. 13 (Plate XIX.) was the only one where the leakage occurred, and was that place immediately underneath the cast-iron buntons, or did the leakage take place all round the shaft? With reference to what was called "German" tubbing, mentioned by Mr. Prest, he might mention that it had been used 20 years ago in this country. He quite agreed that there was much to be said in its favour, not only for preventing leakages, but for preventing the tubbing from shifting. A case had occurred at Chilton Colliery on which they had worked for several months. There were three sections of tubbing, and as fast as one was put right another went wrong. The end was that the whole of the tubbing had to be ringed. The rings were put in for 15 to 20 fathoms, which made the whole tubbing perfectly tight; but, if that tubbing had been internally flanged, it would probably have stood all right.

Mr. Simon Tate (Trimdon Grange) said that the only novelty consisted in the leaden bullets. He had used successfully 2 to 2½ inch pipes for injecting cement, etc., but had never known leaden bullets to be employed.

Mr. J G. Weeks (Bedlington Collieries) said that Mr. Wood spoke of the shaft having been re-tubbed. What was the space between the new and the old tubbing, and was the leakage at the joints, or did it arise through corrosion in other parts than the joints? He had had a somewhat similar case from corrosion in the middle of a piece of tubbing in which the shaft had to be re-tubbed exactly the same depth down, under a pressure of water of 70 pounds
to the square inch; but he had got over the difficulty by undersetting the foundation rings, then tapering the new tubbing, and bringing it up to the spot before the temporary iron rings were taken off.

Mr. C. C. Leach (Seghill Colliery) asked whether the twenty underground boilers had anything to do with the tubbing leaking.

Mr. W. O. Wood said that with reference to the question: Why did the tubbing leak? the underground boilers had nothing to do with the cause, because the shaft was a downcast one. He did not quite grasp the question raised by Mr. Weeks. The shaft was re-lined, and the space between the two tubbings was from 4 to 5 inches. The only leakage was immediately at the bottom of the sand-crib, and it was fairly equal all round. It was shown in Fig. 1 (Plate XIX.) immediately above the sand-crib at the point A. The leakage was caused, he believed, by the bunton, which was pocketed into the old tubbing, and the tubbing below had sunk, or rather given way. This bunton had prevented the settling of the upper portion of the new tubbing, and the joint eventually opened from 1 ½ to 2 inches in consequence. He did not know that there was any other cause or reason to be given for it, and he would recommend anyone who had to deal with a similar case to take out the old bunton.

With regard to the remark that was made as to the employment of larger tubes, Mr. Portier's system undoubtedly failed because of the small diameter of the tubes that were used; they would not carry down gravel large enough to be retained behind the sheeting. Neither the gravel nor the cement was retained, which, as explained in the paper, was washed through so quickly as it was put in. If there had been time to have

put in larger tubes, there would have been no need to have resorted to the injector. The injector was an exceedingly useful expedient, and no doubt it contributed very largely to the result. He willingly acknowledged Mr. Hare's and Mr. Raffle's services in the matter, but had not thought that it would be necessary to refer to them. He wished both Mr. Raffle and Mr. Hare to have their proper share in whatever credit there was in the device.

It was impossible to wedge the tubbing up, as the joint below the opening was 30 fathoms down, and it was tight—nearly metal to metal; there was, therefore, no chance of getting wedges in anywhere.

The President (Mr. J. B. Simpson) proposed a vote of thanks to Mr. Wood for his interesting paper, which was unanimously accorded.

The following paper on "Sinking through Sand at Newbiggin Colliery," by Messrs. E. M. Bainbridge, Jun., and Walter M. Redfearn, was read by Mr. Bainbridge:---

SINKING THROUGH SAND AT NEWBIGGIN COLLIERY.
By E. M. BAINBRIDGE, Jun. and WALTER M. REDFEARN.

The above colliery is situated about 3 miles to the north-east of the Cambois Colliery of the Cowpen Coal Company, Limited, about 1 ½ miles to the south-east of the Woodhorn Colliery of the Ashington Coal Company, Limited, and about ½ mile inland from the beach at Newbiggin Village.
The shafts are being sunk on the extreme west of the royalty acquired by the present company (the Newbiggin Colliery Company, Limited), and the royalty consists almost entirely of the coal under Newbiggin Moor and sea-coal, and is bounded on the northern and western sides by the Ashington Coal Company's royalty, and on the southern side by the Cowpen Coal Company's royalty. Two shafts are in process of sinking at present, with a possibility of a third shaft being sunk at a later date. The position of the shafts are as shown in Fig. 1 (Plate XX.). The site on which the shafts are being sunk is known locally as "The Carrs"; it consists of low-lying land, the highest point of which is only about 10 feet above sea-level, and is supposed to be the former course of the river Lyne, with which it probably formed an estuary. A series of borings proved the existence of a peat-bog underlying The Carrs, this bog being about 24 feet thick in the middle and running out on each side, with about 12 inches of soil overlying the whole.

Owing to the difficulty of securing efficient foundations for the buildings and plant in this bog, it was decided to sink the shafts on the extreme western side of The Carrs, and erect the buildings and plant clear altogether of the bog. The following is a precis of the top (alluvial) strata sunk through to the first stone, which was encountered at a depth of about 76 feet from the surface:

<table>
<thead>
<tr>
<th>Thickness of Strata.</th>
<th>Ft.</th>
<th>Ins.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>—</td>
<td>6</td>
</tr>
<tr>
<td>Yellow clay</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Peat (bog)</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Blue clay, with stones</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Sand</td>
<td>—</td>
<td>6</td>
</tr>
<tr>
<td>Mottled clay</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Gravelly clay and sand-pockets</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Sand, with water</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Strong sandy blue-clay, with stones</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>Coarse sand, with stones, heavily watered</td>
<td>19</td>
<td>3</td>
</tr>
<tr>
<td>Coarse freestone, depth from the surface</td>
<td>76</td>
<td>3</td>
</tr>
</tbody>
</table>

A bore-hole had previously been put down at a distance of about 600 feet from the site of the shafts (Fig. 1, Plate XX.), and as only 5 feet of dry sand, lying close to the surface, was proved, sinking was commenced in No. 2 shaft in the ordinary way, the first sod being cut on March 9th, 1908. Sand was encountered at a depth of about 14 feet; and, after sinking 11 feet in this stratum, it was decided to put down a borehole adjacent to the shaft, to prove the underlying ground and locate the stone-head, which was ascertained to be at a depth of about 76 feet. Meanwhile as No. 1 shaft was being sunk, and had also reached similar ground; it was decided, therefore, to stop further operations at No. 2 shaft, and to endeavour to pile through the sand at No. 1 shaft. The piling process proving unsuccessful, it was ultimately decided to adopt the drop-shaft system of sinking, as applied by Messrs. Haniel & Lueg. This decision was come to after seeing the above process in operation at Astley Colliery, near Manchester.

Preparations for sinking by the drop-shaft method were commenced on November 20th, 1908, by stripping No. 2 shaft of the sheeting, shaft-rings, etc., and filling up the same with clay to within 10 feet of the surface.
An excavation 40 feet square and 10 feet deep was then made on the site of the shaft (the original centre of the shaft being maintained), for the purpose of containing a concrete block of sufficient strength and base area to support the brickwork-mass necessary to provide resistance to the "pushing-down" operation. Figs. 2 and 3 (Plate XX.) represent the concrete block. It was 5 ½ feet in depth, and had a circular opening in the middle coincident with the proposed shaft. The concrete block was strongly reinforced by a series of steel bars, 1 ¼ inches in diameter (Figs. 4 and 5, Plate XX.), suitably bent and laid across the excavation. Each bar was spaced about 12 inches apart, and laid in an easterly and westerly direction, a thickness

of 3 inches of concrete intervening between these bars and the bottom of the excavation. Another series of similar bars, spaced in a similar manner, but laid in a northerly and southerly direction, was placed across the first series of bars, thus forming a kind of basket or network. The points of intersection of this network were then firmly tied with wire, and vertical tie-bars (Fig. 6, Plate XX.), ½ inch in diameter, were fastened at every alternate point of intersection. A thickness of 15 inches of concrete, consisting of 3 parts of whinstone chips, 2 parts of sand, and 1 part of cement, was then laid in, and well rammed around the bars. A series of lacing bars, ½ inch in diameter and spaced about 24 inches apart, was then laid on the top of this layer of concrete, also in a northerly and southerly direction, and was crossed in an easterly and westerly direction by another series of similar bars, the ½ inch vertical ties being fastened by wire to the points of intersection of these lacing-bars. Another 15-inch layer of concrete was then laid in, followed by a further series of lacing-bars (fixed to the vertical ties by wiring), until a thickness of 3 ½ feet was reached. At this thickness the anchor-ring was placed in position, and accurately set on a level bed to the correct centre of the shaft. A better position for the anchor-ring would, of course, have been on the underside of the concrete block; but, as this would have meant considerable delay, it was decided to place it as shown and described. The concreting and the insertion of the lacing-bars was again carried out, the anchor-ring being specially reinforced by bars, ¾ inch in diameter (Fig. 7, Plate XX.), bent over the same, until a thickness of 5 ½ feet was attained. The appearance of the reinforcing system before concreting is shown in Fig. 28.

The anchor-ring is shown in detail in Figs. 8 to 11 (Plate XX.), and in position in Fig. 12 (Plate XX.), which is a section through No. 2 shaft. It consists of a box-casting, in twelve segments, which, being bolted together, form a circular curb or ring. In the middle of each segment, and on the inside edge, a pocket is cast to receive the T-shaped ends of the guide-bolts (Figs. 8 to 11, Plate XX.). These guide-bolts (twelve in number) are 4 inches square, and connect the anchor-ring with the pressure-ring, thus transmitting the reaction of the hydraulic jacks to the anchor-ring and at the same time acting as guides for the tubing.
Although somewhat delayed by frost and bad weather, the excavation and concrete block were completed by January 16th, 1909, the concrete block itself having been cast in 10 working days. The brick pillar was commenced on January 20th, 1909, the bricklayers working from 6 a.m. to 10 p.m.

The brick pillar is shown in Fig. 12 (Plate XXI.), and was built of shaft-lumps laid in cement; although again heavily handicapped by adverse weather and frost, it was completed (together with the top walls) on February 19th. The pillar is 33 feet square for the first 5 feet, the remainder being 32 feet square.

The top of the pillar is 25 feet above the surface-level of the Carrs, and will be the permanent banking-level of the shaft, and it has been arranged that it shall form the foundation for the permanent headgear.

The pressure-ring (Figs. 13 to 15, Plate XXI.) was then laid on the top of the brick pillar, and, after being accurately set to the centre of the shaft and carefully levelled, cement grouting was run well under the bed. The pressure-ring consists of a strong, well-ribbed casting, in twelve segments, bolted together so as to form a ring. The bed of the ring projects over the inside of the circular opening of the brick pillar; it is machined truly level, and efficiently provided with slotted holes for the purpose of attaching the hydraulic jacks. The segments are each provided with two holes strongly bossed and cast with the ribs of the casting, for the purpose of receiving the upper ends of the guide- and anchor-bolts, and have screwed ends with nuts. The position of the pressure-ring is shown in Fig. 12 (Plate XXI.) and Fig. 30.

From the foregoing description it will be clearly understood that, by means of the twelve guide-bolts and (in a lesser degree) the twelve anchor-bolts, the pressure-ring is rigidly fixed to the anchor ring, which in turn is loaded with the superimposed brick pillar. This mass thus forms the resistance necessary to counteract the action of the hydraulic jacks in forcing down the tubbing.

The brickwork was completed by the erection of the walls (Fig. 12, Plate XXI., and Fig. 29) on the top of the brickwork pillar. These walls were built up on three sides to a height of 17 feet, the fourth side being left open for the purpose of delivering the tubbing to the shaft. A circular crane-track (Fig. 12, Plate XXI.) was fixed over the shaft. On this track an electric crane, of 2 tons lifting capacity and having separate motors for travelling and lifting, was mounted for the purpose of handling the tubbing segments, and is shown in Fig. 12 (Plate XXI.) and Fig. 30. Timbers were built in the top of the walls, and formed the soles for the temporary headgear, in addition to providing for the suspension of the circular crane-track. The temporary banking-platform was laid on these timbers, and a travelling bridge provided.

The tubbing is pushed down by ten hydraulic jacks, fixed in an inverted position and fastened to the pressure-ring, as shown in Fig. 12 (Plate XXI.). These jacks were, at first, spaced equidistant; but the spacing was ultimately altered, for reasons which will be made clear in the latter portion of this paper. The rams of the jacks are each about 6 3/8 inches in...
diameter, and have an effective area under pressure of about 32 square inches. The bottom end of each ram is fixed into a shoe, which is so arranged that it adjusts itself to the tubbing. This is necessary, in case the tubbing does not travel in an exactly vertical direction, when, of course, the flange of the tubbing would not be in a horizontal plane.

A ring-main of copper tubing supplies the jacks with pressure-water from a pressure-pump, the jacks having their valve-gears so arranged that any jack can be put into or out of action independently. The maximum working pressure used was 5 tons per square inch (the pressure being registered by a pressure-gauge placed at bank in full view of the man operating the jacks), and was supplied by a horizontal duplex direct-acting hydraulic pump.

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The pressure-pump had steam cylinders 8 inches in diameter 7 inches stroke, with four rams, each 5/8 inch in diameter. The steam pressure was reduced to 80 pounds per square inch for the purpose of driving the pump. No accumulator was used, the pump working directly on to the jacks, and water under a slight head was supplied to the suction end of the pump.

The cutting-shoe is shown in Figs. 10 to 18 (Plate XXI.), and consists of twelve segments of cast-steel, 2 ¼ inches thick and 3 feet 3 ½ inches deep. The cutting-edge is formed at an angle of 45 degrees, and the extreme point is rounded to a radius of 1/8 inch. The vertical joint of each segment is bolted together by seven 1 7/16 inch turned and fitted bolts. Coned lead-washers, fitted into internally-coned wrought-iron washers, are fixed on the bolts, one on each side of the flanges, so that when tightened up a watertight joint is made. The joint between each vertical flange is made by the insertion of leaden sheeting, 3/32 inch thick. All the flanges being machined, the addition of the lead, when tightened up and caulked home, makes the joint thoroughly watertight. The horizontal joints are made in a similar manner to that described for the vertical joints. A rib is also cast on the inside face and near the cutting-edge, for the purpose of strength, and to form a means of attachment for the matching-piece (after the sand has been sunk through), and is provided with holes for that purpose.

The cutting-shoe is recessed behind so as to receive a mild steel band, which is also in twelve segments, the joints of these breaking joint with the cutting-shoe segment joints. This band is fixed to the cutting-shoe by means of screws, 1 inch in diameter, tapped into the band and fixed from the inside through clearance holes in the cutting-shoe. The band is intended to strengthen the cutting-shoe against a bursting action (as opposed to the normal collapsing action of the ground on the cutting-edge) such as might take place when the progress of the cutting-shoe is resisted by rounded boulders, etc. In order to clear a way for the tubbing which follows it, the bottom ends of the cutting-shoe segments are made 0.5 inch larger in diameter than the top (flange) ends.

The tubbing is shown Figs. 19 to 21 (Plate XXI.), and is of cast-iron, 2 ¼ inches thick, consisting of twelve segments to the circle, each segment being 4 feet 11 1/16 inches deep. All joints (vertical and horizontal) are machined and fixed together in a similar manner to that described for the cutting-edge. The first four rings of tubbing, together with the cutting-edge, have turned and fitted bolts, 1 7/16 inches in diameter—the remainder of the tubbing being bolted with similar bolts, but in clearance holes.

As the depth of each ring of tubbing was 4 feet 11.4375 1/16 inches, whilst the full stroke of the jacks was only 22 inches, two complete rings of tubbing, termed “making-up
rings," each about 20 inches deep, were provided. When the jack-rams had completed their full stroke, these making-up rings were placed in turn between the ordinary tubbing and the rams, and pushed down until the next ordinary ring of tubbing could be got in. The guide-bolts were fixed truly vertical, and to such a radius that the clearance between the outside of the tubbing and the inside face of each guide-bolt would be about 1 inch.

On March 17th, 1909, everything was ready for laying the cutting-edge and building up the first rings of tubbing in the shaft. Deals were laid perfectly level on the bottom of the shaft, close together and pointing towards the centre of the shaft. Each set of deals which were common to each cutting-edge segment was battened together by a deal laid transversely on the top of the inner ends of these radial deals. The segments of the cutting-edge were now placed in position on the radial deals, one by one, and bolted together, each being supported by a raking-shore driven under the top flange of the segment and the lower end nailed to the batten common to that segment (Figs. 22 and 23, Plate XXI.). The ordinary segments were then built up on the cutting-edge, the joints of each ring being staggered, and care was taken to keep each ring central in relation to the guide-bolts, until sufficient tubbing had been built up to bring the same within range of the jacks.

The jacks were then fixed in position, the cutting-edge was released, and the actual operation of pushing down the tubbing was commenced on March 24th, 1909. The winding-rope was attached by means of chains to the bottoms of all the raking-shores, thus pulling all out simultaneously, with the result that the inner ends of the radial deals tipped up, and were forced out by the weight of the tubbing on the outer ends. The distance travelled by the tubbing before it was found necessary to apply pressure was about 10 feet. Pressure was applied and tubbing built on, until the cutting-edge had been pushed down to a depth of about 18 feet below the bottom of the shaft (ten jacks at 5 tons per square inch being the final pressure used), when it was found necessary to excavate the inside of the shaft as the tubbing could be pushed no farther.

The excavation was carried out by the usual methods, until the top of the sand was reached. The shaft was then filled up with water to a level of about 10 feet higher than the surface-level of The Carrs (Fig. 12, Plate XXI.), and the sand was excavated by means of a Priestman double-purchase single-chain grab, of 29 cubic feet capacity (Fig. 12, Plate XXI., and Figs. 30 and 31), plated up so as to work efficiently under water. At about 39 feet from the surface very strong blue clay of a leathery nature was reached with the grab, the cutting-edge then being 9 feet in advance of the grabbed bottom. This clay was so strong and tough that the progress of the cutting-edge was practically at a standstill, and the grab made hardly any impression on the bottom.

On the morning of April 6th, 1909, the tubbing suddenly appeared to be making such quick progress that an examination was made of the brickwork pillar, with the result that the pillar was found to be lifting, and the tubbing had not really moved. Pressure was at once taken off the jacks; but, owing to the fact that a new ring of making-up segments had just been inserted, without taking the pressure off all the jacks, three segments of the pressure-ring were broken. It may be explained here that, owing to the toughness of the ground that was being passed through, the pressure was kept on continuously, and the making-up segments were inserted segment by segment, the pressure being taken off one jack only at a time.

The brickwork (which was cracked horizontally about 2 feet below ground-level) and the pressure-ring were repaired, the former being also tied by additional bolts, as may be seen in Fig. 30, and clay and spoil heaped up against the outside of the brick pillar in order
to obtain additional resistance to counteract the action of the jacks. The maximum pressure
was reduced to 4 tons per square inch, and the jacks were also rearranged so as to place
each jack adjacent to a guide-bolt, in place of the original equidistant spacings. The above
repairs were completed by April 16th, 1909, and it was then

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decided, on account of the inefficient working of the grab in the tough clay, to drain the shaft
and sink by the usual methods. In the meantime, careful observation had been kept of the
level of the brick pillar, and it was found that it had subsided about 2 inches on the eastern
side. The eastern side being adjacent to the bog was therefore the "soft" side, and this
probably accounts for the depression, which steadily increased, until at the end of the
sinking the difference of level between the western and the eastern side was as much as 18
inches.

[Photograph: Fig. 30.—Showing Position of Pressure-ring and Method of Repairing Cracked
Segments.]

The method adopted of draining the shaft and putting the men in to excavate was
soon proved to be a mistaken policy, as on April 20th, 1909, an inrush of sand and water
took place, followed by an increased subsidence of the block towards the east, although the
cutting-edge was still 10 feet in advance of the sinking-bottom. It was decided to fill the shaft
again with water and to persevere with the grabbing despite the slow progress made, and on
May 21st, 1909, the cutting-edge had reached the stone. The shaft was then cleared of
water, and it was found that the feeder amounted to about 900 gallons per minute.

The stone was sheared in advance, so as to allow the tubbing to

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be pushed well in (several small inrushes of sand taking place during this process) until the
stone was found sufficiently good to allow the curb to be laid and this was done at a depth of
16 feet below the bottom of the sand.

The finished size of both shafts is 18 feet, and the inside diameter of the sand-
tubbing was made 20 feet, to allow for possible deviation from the vertical. Fig. 27 (Plate
XXI.) illustrates the method of completing the bottom of the tubbing.

[Photograph: Fig. 31.—Single-Chain Double-purchase Grab.]

The curb is of the ordinary type, and was laid on a level bed. On the top of the curb an
ordinary ring of tubbing was fixed, the top flange of which was, of course, level.

To the bottom of the cutting-edge a matching-piece was attached (Figs. 24 to 26,
Plate XXI.), with \( \frac{3}{4} \) inch sheeting between the bevelled faces of the cutting-edge and the
matching-piece; and, after bolting up, this was wedged tight with tubbing wedges. As the
bottom of the cutting-edge (and therefore the matching-piece) was out of level (due to the
deviation from the perpendicular of the tubbing, whilst the tubbing on top of the curb was set
level), it was necessary to close up with a ring of segments in which the complete ring was
made level.

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It may be remarked that the permanent buildings, which are almost all within a short
distance of the shaft, show no sign whatever of any damage, neither are there any signs of
surface subsidence to be seen.

Preparations are now being made for sinking a third shaft (to be known as No. 1) by
the same process; and, in view of the experience gained in sinking No. 2 shaft, the following
modifications have been decided upon: —

1. In order to minimize the depression of the pillar towards the eastern side, the
   concrete block is being cast 50 feet square in place of 40 feet, and the brickwork pillar made
   heavier on the western side.

2. In order to guard against the lifting of the pillar, the anchor-ring has been fixed in
   the bottom of the concrete block, so that this additional weight (of concrete) is added to the
   brickwork. A more massive brickwork pillar has also been built.

3. An improved high-purchase grab has been specially designed to cope more
efficiently with the tough blue clay.

In conclusion, it may be stated that the tubbing and plant were supplied by Messrs.
Haniel & Lueg, and the benefit of their extensive experience in this method of sinking was
placed at the writers' disposal.

Mr. J. J. Prest (Horden Collieries) said that the value of the paper would have been
increased if the authors, who were, he believed, in charge of the sinking operations at
Newbiggin Colliery, had stated the cost of sinking by the drop-shaft method employed by
Messrs. Haniel & Lueg of Dusseldorf.

The total depth of the surface-sand and clay to the stone-head was stated to be only
76 ¼ feet, and the authors mentioned that at about 39 feet from the surface the clay was so
strong and tough that the progress of the cutting-edge was practically at a standstill and the
grab made hardly any impression on the bottom. The comparatively strong nature of the
ground was also indicated when the authors stated that, on account of the inefficient working
of the grab in the tough clay, it was decided to drain the shafts and sink by the usual
methods. Bearing in mind the fact that the first sod for this shaft was cut on

[Plate XX., Figs. 1 – 11, and Plate XXI., Figs. 12 – 27—To Illustrate Sinking at Newbiggin
Colliery.]

March 9th, 1908, it would certainly have been of educational value if the authors had stated
the total cost, including standing charges, material, and wages, of sinking through these few
fathoms of surface-clays and sand.

For the information of the authors and others in charge of similar undertakings, it
might be well to remind them that over 60 years ago the shafts at Framwellgate Moor
Colliery were successfully sunk through 144 feet of sand, gravel, and clay forming the Team
Valley Wash, by local workmen under the supervision of competent local sinking engineers.
Norwood New Pit was sunk, in 1851, within 60 feet of the River Team, through 17 fathoms of
exactly similar ground to that encountered at Newbiggin, in 6 weeks; and, in 1906, a shaft at
Bowburn Colliery was sunk by local engineers and contractors, through 156 ¾ feet of similar
ground, containing a considerable quantity of water, in a period of 9 weeks, and the whole
work was successfully completed at a minimum cost.

Mr. T. E. Forster (Newcastle-upon-Tyne) said that the members were much indebted
to Mr. Bainbridge and Mr. Redfearn for their paper. There might be one or two points which
needed further explanation, and one of these was the question which had puzzled Mr. Prest. One reason why the drop-shaft method of sinking was employed was that there were a number of buildings surrounding the shaft which were known to be standing on sand, and if any sand had been let into the shaft, it would have caused a subsidence of the surface, and lead to the demolition of the buildings.

It might be as well to draw attention to the necessity of proving the deposits beforehand when one was going to sink in such a manner. He believed that Messrs. Haniel & Lueg had previously done a great deal of sinking through sand, and the difficulties in this case showed the necessity of proving the deposits before sinking was commenced. With the experience gained in sinking the first shaft, they had decided to sink the second shaft with a larger block and anchor-ring. Perhaps Mr. Bainbridge would tell them how much he had got out of plumb.

Mr. E. M. Bainbridge, Jun. (Newbiggin Colliery), said, in answer to Mr. Prest, that it was rather difficult to state the cost, but the price of the material alone was about £4,000, and he should think that the whole cost of the sinking would come to rather less than £8,000. That was for one shaft. As to why the buildings were there, the reason was that a bore-hole was put down to a depth of about 420 feet some time before the pit was started; this bore-hole was only 1,800 feet from the site of the shafts, and it had shown no sand. The sand, therefore was unexpected, and it was decided to put up the permanent buildings first and then sink.

Mr. Simon Tate (Trimdon Grange) said that it would be interesting to know why the piling first failed.

Mr. J. G. Weeks (Bedlington Collieries) agreed with Mr. Tate, and said it would also be interesting to have some account of the pile-sinking which had failed. With regard to putting the bore-hole down, that was all very well in its way, but he recommended putting down more than one. He took the precaution in a recent sinking of putting a bore-hole down in the centre of the shaft. An experienced sinker had reported to him that the stone-head was reached at a depth of 16 feet. He (Mr. Weeks) commenced to sink, but he found, when he had sunk the pit 16 feet, he got sand and gravel, and he was fortunate in having only to go down 29 feet before he reached the stone-head. It had therefore struck him that he was perhaps taking matters rather easily by having only one bore-hole, and he would recommend two holes at least on the site of the shaft. The man had evidently made a mistake: he had reached something hard, and concluded that it was the stone-head.

Mr. Walter M. Redfearn (Newbiggin Colliery) said, in reply to Mr. Prest, that although the first sod of No. 2 shaft was cut on March 9th, 1908, the sinking was only carried on for a few days. This preliminary sinking was the means of first bringing to their knowledge the fact that dangerous running sands were close to the surface. The shaft was thereupon filled up to within 10 feet of the surface, and was then laid idle for some months. Actual operations for the preparation of the site of No. 2 shaft for sinking through the sand were commenced on November 20th, 1908, as stated in the paper. With regard to Mr. Prest's remarks respecting Framwellgate Moor, Norwood, and Bowburn Collieries, he (Mr. Redfearn) ventured to think that the circumstances as compared with Newbiggin
were entirely different. In the cases mentioned, sinking was carried out with temporary plant and buildings, and surface subsidence was a comparatively trivial factor. On the contrary the case of Newbiggin, surface subsidence was the all-important factor, as they had (not expecting to find any exceptional difficulties) already erected almost the whole of their permanent surface plant and buildings. This necessitated careful consideration, and the process had justified its adoption by the fact that no subsidence of any kind whatever had occurred.

He might mention that, in addition to the extensive experience of Messrs Haniel & Lueg in this particular class of sinking the bulk of the plant necessary for the carrying out of the work was hired from them, thus saving the colliery company considerable expense. This might be taken as an additional reason why the assistance of foreign engineers was requisitioned, as it was found impossible to obtain the plant on the same terms in England.

He agreed with Mr. T. E. Forster as to the necessity of proving ground before sinking. In their own case the bore-hole did not give them the same strata as those which were found when sinking. The hole was at a distance of 600 feet from the site of the shafts; and it would, no doubt, have been a much wiser course to have first put down a bore-hole—or, better still, two, as recommended by Mr. Weeks—near the site of the shafts before commencing any other operations. The tubbing was found to be 19 ½ inches out of plumb.

In reply to Mr. Tate's question why the piling had failed in the first instance, it was decided to pile No.1 shaft with interlocking steel piles. The piles were of channel-section, and an interlock was formed by the aid of Z-bars. The piles were driven in a square of 80 feet, and it was expected that the interlock would be kept whilst they were being driven. However, when the top clay was being driven through the boulders forced the interlocks out, and consequently when sinking was proceeded with only a few piles were found to be in interlock. These were insufficient to keep the sand back.

Mr. Weeks' suggestion as to putting bore-holes in the centre of shafts did not commend itself to the speaker. His firm impression was that all bore-holes (except holes which were being bored a few feet in advance, whilst sinking, for precautionary reasons) should be bored clear of the actual site of the shafts.

Should a stratum containing water under pressure be "sandwiched" between two impermeable strata, then a bore-hole in the bottom of the shaft would possibly convert what would be otherwise a dry sinking (until the stratum containing water was reached) into a wet sinking, with all the attendant complications of pumps, etc., and result, of course, in a slower speed of sinking.

Mr. Bainbridge and he would be pleased to act on Mr. Weeks' suggestion, and give a paper on the piling operations at Newbiggin at some future date.

The President (Mr. J. B. Simpson), in proposing a vote of thanks to the writers of the paper, said that when the other shaft was down they would perhaps be able to give the members further particulars, as well as some idea of the cost that had been incurred in carrying on the operation.

The vote was agreed to unanimously.
DISCUSSION OF MR. ROBERT NELSON'S PAPER ON "ELECTRICITY IN COAL-MINES."

Mr. Edward Barrs (Newcastle-upon-Tyne) wrote that Mr. Nelson's paper formulated very clearly the points of difference between surface and mining work and the special precautions necessary in the latter case. Mr. Nelson advocated lead-covered cables, especially where General Rule No. 8 applied, for the reason that, in the event of a fall crushing the cable and causing an arc inside, the leaden covering must be burned through before a flash could escape, thus allowing the protective devices time to operate.

There was a feeling amongst colliery engineers that lead-covered cables were not as reliable in a mine as vulcanized-bitumen cables. It had been pointed out that the purely chemical action of pit-water on lead was very slow, except in rare cases, but that electrolytic and galvanic action were often very rapid. Electrolytic action, so far as it was due to the leakage of the network, would be minimized by a sensitive system of leakage protection. If the waterproofing of the lead, effected by the jute separation, were permanent, there would be no fear of electrolysis.

But it did not seem possible to ensure this permanently; and once the waterproofing was destroyed, the lead and iron would form a galvanic couple and cause the destruction of the armouring. Putting aside other points which had been raised, the general opinion, also, seemed to be that lead-covered cables, even when armoured, were not so capable of withstanding falls as vulcanized-bitumen cables, on account, perhaps, of the rigidity. However much the above defects might have been exaggerated in the past, the fact remained that vulcanized bitumen was more or less free from them. The argument seemed, finally, to amount to this, that when a cable was injured by a fall a lead-covered cable was less liable to cause a flash outside than an ordinary vulcanized-bitumen cable; but, on the other hand, it was more liable to damage from this source, in addition to defects in other directions. Prevention was always better than cure, and that was one reason for using vulcanized-bitumen cables, provided that they could be made safe when an accident occurred.

Mr. Nelson had recommended a copper sheath below the armouring of vulcanized-bitumen cables, a plan which had, the writer believed, been used with success in South Wales. Only those parts of the cable where explosion was to be feared need be sheathed, and the extra cost might not form a very large proportion of the whole. The use of vulcanized bitumen was becoming general in collieries, and he thought that, so far as lead-covered cables were concerned, Mr. Nelson was ploughing a lonely furrow.

Efficient earthing of motor-frames and armouring was really important, and, as Mr. Nelson had pointed out, one could only be sure of an earth at the shaft-bottom or at bank; still, it would be an additional safeguard to instal earth-plates at other points where there was a likelihood of a good earth. He (Mr. Barrs) would also suggest the advisability of testing earth-plates regularly; with two earth-plates, a test of the kind could very easily be made.

The ideal system of protection would render motors and cables mutually independent of faults; a breakdown or overload on a motor should isolate the motor alone, and a cable breakdown only the section of cable at fault. Generally speaking, there was no need to protect a cable against overload, provided that it was protected against faults to
earth and between phases. The motor-overload devices protected the motors against accidental overloading, and if it was necessary for some reason to

overrun a cable, it was done deliberately and with a knowledge of the risks entailed.

Experience at the surface showed that the "balanced" system fulfilled these conditions, and if an automatic duplicate was required, it was the only system available; but the cost of pilot-cables, current-transformers, and relays was high. Further, it remained to be seen whether a small pilot-cable could be kept in perfect order under existing conditions in a mine: as it must be borne in mind that a fault in the pilot-cable would interrupt the supply just as much as if the fault had occurred in the main cable that it controlled.

Mr. Nelson proposed to protect cables from the distribution centre on the "leakage" system, and referred to one method of doing that; another consisted in taking advantage of the leakage current flowing in the armouring and utilizing it to close a relay and open a switch. Both these had the advantage, in common with the balanced system, of an instantaneous isolation of the leakage, but did not protect against a fault between the phases. In the absence of experimental evidence, it was difficult to say whether it would be safe to wait until the fault extended to the armouring and cut off the supply. It might be necessary to add overload protection. Where one cable from the distribution centre fed one motor, this overload device might be used for the motor-overload device, treating the cable and the motor as one unit; but where several motors were fed from one cable, each would have its own overload device: thus one returned to the old question of overload protective devices in series, and their lack of discrimination. This might, to some extent, be remedied by setting the cable overload to operate only on a very bad short; and if, in addition, the main cable to the distribution centre were protected on the "balanced" system, an excellent method of isolating faulty apparatus would result.

The discussion of protective gear led one to imagine that faults were constantly occurring, and that no system, except the most perfect one, was of any use. Fortunately, this was not the case, and provided that precautions were taken to guard against explosion and shock, mine-owners often preferred to risk an occasional shut-down in order to save capital.

With regard to districts which do not come under Rule No. 8, it did not seem so necessary to provide special forms of protection, as the earthed armouring would normally prevent shock; and

he should like to ask Mr. Nelson whether he would consider time limit overload protection sufficiently safe as far as the main distribution centre? The rapidity of isolation of "leakage" protection would, probably, isolate a fault to earth on the distribution cables before the overload had time to operate, and only a fault between phases would be liable to interrupt the supply.

Mr F. E. Armstrong (Liverpool) wrote that in discussions on the use of electrical apparatus in mines subject to accumulations of fire-damp, it had always appeared to him that an essential difference between a safety-lamp and a piece of electrical apparatus had not been sufficiently insisted upon.

A safety-lamp when taken into the mine was liable to go into any part of it; it had to go into those parts in which accumulations of gas were most likely to exist, and was thrust into holes in the roof and back in the gob to test for gas, and if defective was liable to cause an explosion the first time that gas was found. A piece of electrical apparatus was never
portable in the same sense as a lamp. It was a fixture, in every well-regulated mine, in a place in which an explosive mixture was most unlikely to be found. The standard of safety, therefore, to be reasonably required from electrical apparatus was not so high as that demanded from a safety-lamp.

A motor which was totally enclosed was objectionable, and in large sizes impracticable, with reasonable cost and efficiency; and if it was insisted that haulage motors, for instance, on roads on which explosive mixtures were unknown, must be totally enclosed, a very serious and unnecessary blow would be struck at electrical development in mines. In the vast majority of mines, the prospect of an explosive mixture coming into contact with such a motor without adequate warning was so remote as to be negligible, and the fact that safety-lamps only were used in the neighbourhood did not make it less so.

The only effect of making the same rule apply in the case of electrical apparatus as with safety lamps would be that where safety lamps were now used all over the pit, they would in future be used at the face and in the returns only.

With regard to the use of armoured cables underground, Mr. Nelson, in his reply to his critics, appeared to miss the main point of their criticism. No one denied that, given an efficiently earthed armouring, the armoured cable was the safest. But by what test were mining engineers to recognize an efficient earth? And would anyone guarantee that the earth, when made, would at all times remain efficient, and that every bond in the armouring from every motor to the earth-plate would always be and remain electrically sound? Such an assumption must appear to those to whom the inevitable conditions in many pits were familiar to be utterly unjustifiable. As soon as the efficient earth disappeared, as it would on occasions, a most dangerous condition ensued. Any damage to the cable which brought the armour into contact with the conductor, or any failure of insulation on any motor or switch-gear in connexion with it, immediately rendered the entire "earthed" system of armouring motor-frames, haulage ropes, etc., alive, and liable not only to give fatal shocks to anyone touching it, but to produce sparking and arcing, with all their attendant dangers of fire and explosion.

DISCUSSION OF MR. JOHN KIRSOOP, JUN.'S, PAPER ON "COAL-SHIPMENT AND THE LAYING-OUT OF STAITHE HEADS, WITH SPECIAL REFERENCE TO ANTI-BREAKAGE APPLIANCES."*

Sir Thomas Wrightson, Bart. (Thornaby-on-Tees), wrote that the statements made by the author, that "the North-Eastern Railway Company have recently erected, for experimental purposes, a belt for the shipment of coal," and that "The adoption of such a method in this country is entirely a new feature in the shipment of coal,"† etc., did not agree with those on pages 227 and 231, where the Wrightson coal-shipper was described. In addition, reference was made to a former description of the shipper in Mr. John Morison's paper on "Coal-shipment by Belts,"‡ which was communicated to the members as far back as 1898.

It would be seen from that description of the Wrightson coal-shipper, as then made, that three different belts were used, namely: (1) The ordinary plate conveying-belt from the hopper to the jib, (2) the Kock curved-plate belt on the jib, and (3) the Wrightson vertical anti-breakage belt; and these belts had been in constant use since 1899.

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† Ibid., page 644.
‡ Ibid., 1898, vol. xv., page 67.

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On pages 231 to 233 the two Grimsby coal-shippers were described by the author, the three descriptions of belts mentioned above being used; and, in addition, Marcus conveyors were also employed. These two shippers had been in constant use since August, 1907.

Automatic continuous weighing-machines had been applied successfully for many years to plate conveying-belts by the Blake Dennison Weighing Machine Company, and the makers guaranteed their accuracy to within ½ per cent.

In addition to the notes on end-tip wagons with moving shoots, described by Mr. Kirsopp on page 162, it might be mentioned that a very successful arrangement could be seen at work at the Powell Duffryn Company's loading wharf at Southampton. By the arrangement in question, coal was loaded into barges at any height of the tide. The rising or falling of the pontoons controlled the level of the shoot, and the balance-weights of the shoot automatically controlled the tipping of the wagon. This work was designed and erected in 1904 by Messrs. Head, Wrightson, & Company, Limited.

Two very effective loading arrangements with incline, skips, and movable shoots (Japanese method) had been made by the same company for the shipment of coal at Miike Harbour. They were first erected at the works of the manufacturers, and afterwards re-erected in Japan by native workmen, in 1908, without a hitch. They were now in constant use, the output from each of the shippers being 500 tons per hour.

Mr. William Taylor Heslop (Hatting Spruit, Natal) wrote that papers like Mr. Kirsopp's possessed exceptional interest to members residing abroad, inasmuch as they furnished a practical compendium on special subjects, and were of great value for reference purposes.

As a supplement to Mr. Kirsopp's paper, the following views (Figs.1, 2, and 3) [following pages] and particulars of the coaling plant at Durban, Natal, might be of interest. The plant consisted of an electrically-driven side-car dumping machine, which tipped trucks of up to 35 tons in weight into a receiving hopper. From the receiving hopper the coal was loaded into a series of 6-ton buckets on a flat trolley. The trolleys containing the buckets were shunted by the yard engine to a cantilever transporter,

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[Photograph: Fig. 1--- General view of Coaling Appliances at Durban, Natal.]

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[Photographs: Fig. 2.--- The McMylarSide Dumper, Fig. 3--- View of Transporters and Storage Bins, Durban, Natal.]

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where the buckets were hooked, elevated, and conveyed horizontally either to the bins, of 10,000 tons capacity, or to the steamer's bunkers or hold. The bins in turn were discharged by bottom doors into the buckets again, which were then shunted by locomotive to the transporter.
The two sets of transporters working simultaneously had loaded coal at the rate of 507 tons per hour. The provision of storage of coal in bins had been severely criticized on account of breakage of coal, but it enabled the port practically to guarantee bunker-coal to any steamer coming in; and with collieries 240 miles from the port, and connected therewith by only a mountain railway, this was a point of considerable importance.

The plant was designed to deal with bunker-coal in particular, and the transporters had sufficient over-reach to deliver coal to any part of a steamer's deck. The transporters could be moved along the wharf to discharge into separate steamers, or both into the same steamer.

Dr. James S. Dixon (Glasgow) proposed a vote of thanks to the President and Council of The North of England Institute of Mining and Mechanical Engineers for the arrangements made in connexion with the meeting and for the use of their rooms. The Institution had been under many obligations to the North of England Institute in the past, and the excellent arrangements made for the comfort of the members had resulted in the meeting being most successful.

Mr. W. G. Phillips (Atherstone), in seconding the resolution, said that the meeting was the most interesting one that he had had the pleasure of attending. The papers were not only good, but they had been listened to by a full meeting, and the criticisms upon them had been vigorous and valuable.

Mr. T. E. Forster (Newcastle-upon-Tyne), on behalf of The North of England Institute of Mining and Mechanical Engineers, thanked the members for the vote. The North of England Institute had always been glad to welcome the members of The Institution to Newcastle in the past, and would still be more pleased to see them in the future. He hoped that the present meeting would not be the last by many.

Mr. John Gerrard (H.M. Inspector of Mines, Worsley) proposed a vote of thanks to the owners of collieries and works which were to be visited. The members were greatly indebted to them for the opportunity of making such interesting inspections.

Mr. John Ashworth (Manchester) seconded the resolution, which was cordially approved.

Mr. W. H. Pickering (H.M. Inspector of Mines, Doncaster) proposed a very hearty vote of thanks to the President for his services in the chair. Wherever the name of Mr. Simpson was known, it was always received with honour. It had been a great pleasure and privilege to the members to sit under his guidance that day, and he was sure that all of them, not only mining engineers in the North of England, but throughout the English-speaking world, would join in congratulating Mr. Simpson on his having attained the highest honour which could fall to the lot of a mining engineer.

Mr. J. W. Fryar (Eastwood Collieries) seconded the vote of thanks, which was unanimously approved.

The President (Mr. J. B. Simpson) thanked the members for their kind vote of thanks. He thought that they might congratulate themselves upon having had a very satisfactory meeting. It was rather curious that they should be fighting again the battle of the lamps. He
believed that the first time that the question of lamps was raised was in the year 1812, when, as the result of a meeting, a society was formed after an explosion which took place at the Felling. Great good had resulted from that meeting, because, about 2 or 3 years afterwards, the safety-lamp was introduced by Sir Humphry Davy and George Stephenson.

The following notes record some of the features of interest seen by visitors to collieries, works, etc., which were, by kind permission of the owners, open for inspection during the course of the meeting, on September 15th, 16th, and 17th, 1909: —

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THE NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY COMPANY, LIMITED.
CARVILLE POWER-STATION.

This station, which has a total capacity of 56,000 horsepower in plant installed, consists of the engine-house and three boiler-houses placed at right-angles thereto. Each boiler-house is complete in itself, with coal-bunkers, boilers, mechanical stokers, economizers, induced-draught fans, feed-pumps, ash-conveyors, etc. Coal is brought in by overhead sidings, and water for condensing is pumped to the station from a pump-house at the river-side. With the exception of the feed-pumps, all the auxiliary machinery is electrically driven.

Boiler-houses,—No. 1 boiler-house contains ten Babcock and Wilcox marine-type water-tube boilers, each having a heating surface of 4,500 square feet, capable of evaporating 20,000 pounds of water per hour at a pressure of 200 pounds per square inch superheated 150° Fahr. Two economizers of 480 pipes each are placed in the main flues to the chimney.

Nos. 2 and 3 boiler-houses each contain eight Stirling water-tube boilers, each having a heating surface of 6,380 square feet, and capable of evaporating 33,000 pounds of water per hour at a pressure of 200 pounds per square inch superheated 150° Fahr. In these boiler-houses each boiler is fitted with its own economizer of 120 pipes.

All the boilers are fitted with chain-grate stokers, which are fed with coal direct from overhead bunkers, the grate area being 120 square feet for the Babcock-and-Wilcox boilers and 140 square feet for the Stirling boilers. The coal-bunkers of each boiler-house will contain about 800 tons.

The draught is on the induced system, and is maintained by means of Sirocco fans driven by electric motors. The ashes pass from the grates into hoppers, which deliver them direct on to longitudinal tray-conveyors running in tunnels under the boilers. They are thence delivered into skips, and hoisted up an inclined way to be finally dumped direct into railway wagons. The chimneys are 14 feet in diameter and 120 feet high.

Engine-house.—The engine-house is 236 feet long by 65 feet wide, and contains eight Parsons turbo-alternators of 7,000 horsepower each. The condensers and air-pumps...
are situated below each machine. The alternators run at 1,200 revolutions per minute, and
generate three-phase current at 6,000 volts and a periodicity of 40 complete cycles per
second. Each alternator supplies current at a reduced voltage (by means of a transformer) to
its own auxiliaries, which include air-pump, circulating pump, ventilating fan, and exhaust-
valve motor, and also to the corresponding auxiliaries for the boilers supplying the steam.

Switch-gear.—Adjoining the eastern side of the engine-house, and open to it, are
placed the bus-bars and switch-gear, which occupy four galleries. The main switches, which
are each in a concrete cell, are of the remote-control type, operated by electric motors. The
dimensions of the switches are 4 feet by 2 feet 9 inches by 9 feet high. The switches are
each capable of controlling circuits normally carrying 10,000 horsepower, and there are, in
all, 47 switches. There is also an auxiliary board (situated between the operation offices and
the main building) of the ironclad type, which contains eight switches, each capable of
controlling circuits of 3,000 horsepower.

Control-room.—The whole system is operated and controlled from the control-room
by the "system engineer," who is in direct telephonic communication with each sub-station in
the area, which now covers some 700 square miles. The control-room contains a large
diagram of the whole system, and upon it a record is kept of the position of all switches.

Adjacent to the control-room are the operation offices and telephone exchange, from
which the large private telephone system of the company is operated.

Step-up Substation.—In the sub-station near the control-room are installed two large
step-up transformers for raising the pressure from 6,000 to 20,000 volts for transmission to
the extreme north and south of the area. The transformers are of the oil-immersed air-cooled
type, each of 3,300 electric horsepower. There are in all eight transformers of this size on
the system.

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Step-down Sub-station.—At the northern end of the power station there is a step-
down sub-station of 4,000 horsepower capacity, which supplies current to adjacent works.

Circulating-water Pump-house.—The pump-house consists of a corrugated-iron
building resting on a concrete chamber, 72 by 16 by 30 feet deep, the bottom of which is
below the level of the lowest tide, to enable the pumps to be drowned at all states of the
tide. Along one side of the pump-chamber is a canal, from which the pumps draw their
water, and across this screens are placed to trap any refuse and foreign material; strums are
also fixed in front of the penstocks provided between the pumps and the canal. The pumps,
seven in number, are of the centrifugal type, with vertical shafts, and are each capable of
delivering into the 48-inch mains 400,000 gallons of water per hour at any state of the tide;
they are driven by three-phase electric motors, each of 150 horsepower. Space is available
for two additional pumps. The whole of the circulating-water system is arranged to work as a
syphon. In the old pump-house on the jetty, which now acts as a stand-by, are installed two
Gwynne pumps of 800,000 gallons capacity each and two vertical-shaft Mather-and-Platt
pumps of 400,000 gallons capacity.

North-Eastern Railway Sub-station.—This is one of several sub-stations located at
various points for supplying current to the electrified line of the North-Eastern Railway. The
building contains three rotary converters, each capable of a continuous output of 1,100
horsepower. Conversion is effected from 6,000 volts three-phase to 600 volts direct current.
The sub-station also contains two small motor-generators for lighting purposes and traction in the yard.

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THE HARTON COAL COMPANY, LIMITED.

The total horsepower installed at all the collieries of The Harton Coal Company is as follows:

<table>
<thead>
<tr>
<th>Colliery</th>
<th>Horsepower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boldon</td>
<td>1,892</td>
</tr>
<tr>
<td>Harton</td>
<td>2,445</td>
</tr>
<tr>
<td>St. Hilda</td>
<td>1,820</td>
</tr>
<tr>
<td>Whitburn</td>
<td>2,413</td>
</tr>
<tr>
<td>Total</td>
<td>8,570</td>
</tr>
</tbody>
</table>

Situation.—This colliery, situated in the borough of South Shields, near Tyne Dock railway-station, is the property of The Harton Coal Company, Limited, who are also the owners of the St. Hilda, Boldon, and Whitburn Collieries. The whole of the appliances at the colliery are worked entirely by electricity, no steam power being used for any purpose.

Shafts.—The existing shaft acts as the downcast to the St. Hilda Colliery. The new shaft now being sunk will become the upcast for Harton Colliery; and the new shaft which is being sunk at Westoe will be the upcast for St. Hilda Colliery. The existing shaft is 14 feet in diameter, and is sunk to the Bensham Seam, a depth of 1,284 feet from the surface. The new shaft is to have a finished diameter of 10 feet, and it is intended to sink it also to the Bensham Seam.

Seams.—The seams at present being worked are the Bensham and Hutton, the output of the colliery being about 1,200 tons per day of 10 hours. The electrical winding engine, which has just been erected, is, however, designed to deal with an output of 240 tons per hour.

Winding Engines.—The motor is of 800 brake-horsepower normal capacity, with a maximum output, when starting, of 1,700 horsepower at 5,500 volts. The motor works at a speed of 518 revolutions per minute, and is coupled direct to the winding drum, which is 14 feet in diameter by 8 feet in width. The brakes on the drum are operated by means of compressed air at a pressure of 60 pounds, and can be applied in three ways, namely: (1) By the winding engineman, by means of an operating lever; (2) automatically by the depth-indicator, in the event of an overwind; and (3) by an auxiliary magnet, in case of failure of the electrical energy.

Round winding-ropes are used, 5 7/8 inches in circumference, made of best extra improved plough steel, with a breaking-strain of about 145 tons. The balance-rope is flat, 8 ½ inches in width, and weighs about 4 ¾ tons, which is 1 ¼ tons heavier than the winding-rope. The engine draws coals from the Bensham Seam level.

Cages.—The cages in use have four decks, and carry two tubs on each deck; each deck is fitted with the Winter patent tub-stopping device.
The total weight on the loaded rope at starting, including the rope, cage, tubs, coal, etc., is 14 ¾ tons; The net weight of the coal raised at each wind is 4 ¼ tons. The time occupied per wind is 48 seconds. The guides are of pitch-pine.

Underground Hauling Engines.—The following engines are placed underground, and are electrically driven:

There are two principal haulage engines, one in the Bensham and one in the Hutton Seam, which are worked on the main-and-tail system. Each is driven by a 250/600-horsepower motor, working under 2,600 volts at 230 revolutions per minute.

[Diagram: Fig. 1.—Plan showing Engine-planes, etc., in Hutton Seam, Harton Colliery. Scale, 1 mile to 2 inches.]

The drums of the engines are each 6 feet in diameter on the trod, and are geared at 4 ¼ to 1. The speed of the set (of tubs) is about 10 miles per hour.

The sidings for these haulages are situated 1,050 feet from the shafts, and two small haulage gears are used to bring the coals from them to the insetting station.

There are also several auxiliary haulages: one in the Hutton Seam is driven by a 60-horsepower motor at 2,700 volts. It is placed 7/8 mile from the shaft, and brings tubs from the different flats to the main hauler; and the speed of the set is 6 miles per hour. In the New Hutton Seam, there is a small endless-rope gear, driven by a 15-horsepower motor at 600 volts; and the speed of the set is 1 ½ miles per hour.

At the top of the staple is a small main-and-tail haulage gear, the motor being of 15 horsepower at 600 volts, and the speed of the set 5 miles per hour.

In the Hutton Seam, South-east District, is a main-and-tail haulage gear, driven by a 60-horsepower motor at 2,000 volts. It is situated 1 ¾ miles from the shaft, and the speed of the set is 6 miles per hour.

There are exactly similar haulage gears in the South Winnings and Holder House in the Bensham Seam Districts.

In the Southwest Cross-cuts District is a small endless-rope gear, driven by a 15-horsepower motor at 600 volts, the speed of the set being 1 ½ miles per hour.

In the North Drift District a small main-drum gear is installed, the motor being of 15 horsepower at 600 volts.

These auxiliary haulages haul the coals from the flats to

[Diagram: Fig. 2, showing engine planes in the Bensham Seam, Harton Colliery at a scale of 1 mile to 2 inches.]

The hauling-engine roads, so as to avoid the use of driving ponies: only four ponies are employed in the pit.

Figs. 1 and 2 are plans respectively of the engine-planes in the Hutton and Bensham Seams.
Underground Winding Engine.—A small electrical winding gear is installed, winding coals from the New Hutton Seam to the Bensham Seam level, a distance of 132 feet. This is worked by a 35-horsepower motor at 600 volts, and winds one tub at each lift.

Pumping Engines.—The whole of the water is pumped from the face by means of small electrically-driven pumps, and is raised from the Bensham Seam to bank by a Sulzer four-stage high-lift centrifugal pump of a capacity of 1,000 gallons per minute, against a head of 1,380 feet when working at 2,300 revolutions per minute. The pump is direct coupled to a 650-horsepower Brown-Boveri motor, working at 2,700 volts.

A spare and stand-by pumping plant is also installed, consisting of a motor of 140 horsepower, working at 480 revolutions per minute at 2,600 volts; and a horizontal three-throw pump, with three rams, each 9 inches in diameter with 18-inch stroke, making 24 revolutions per minute, and capable of pumping 300 gallons per minute against a vertical head of 1,300 feet.

Heapstead, Pulley-frames, Pulleys, etc.—The headgears and pulley-frames are constructed of steel, being of the lattice-girder pattern, and have been recently erected. The pulleys are made of cast-iron, and are 10 feet in diameter, the pulley centres being 102 feet from the surface.

Gravitation Roads, etc.—Creepers and gravitation roads are employed on the surface to conduct the tubs from the shaft-mouth to the tipplers leading to the screens; the empty tubs afterwards gravitate back to the cage. A similar arrangement is in operation at the bottom of each shaft. The tubs on all four decks of the cage are simultaneously discharged, no movement of the cage being necessary when it has been brought to a standstill. The motors driving the creepers are of 7 ½ horsepower, and work at 1,120 revolutions per minute at 600 volts.

Coal-cleaning Belts.—These consist of three main belts, 5 feet wide, formed of steel plates, varying in length from

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48 ¼ to 63 ¼ feet by 4 feet. The subsidiary belts for nuts and small-coal are 3 feet wide by 52 feet and 46 feet in length respectively. The two motors driving the screening appliances are each of 35 horsepower, and work at 480 revolutions per minute at 600 volts.

Safety-lamp Room.—The lamp room is of a suitable capacity for cleaning, examining, repairing, and storing upwards of 850 safety-lamps; these are electrically lighted, and magnetically locked, by means of patent devices.

Granary. The motor driving the granary plant is of 15 horsepower, and the horse-food for the whole of the company's collieries is suitably crushed, chopped, mixed, and cleaned at Harton Colliery.

Harton Sinking.
The following are particulars of the electric sinking engine and plant: —

- Weight of kibble and stones: 3 tons.
- Weight of rope (1,300 feet): 15 hundredweight.
- Maximum speed of rope: 1,000 feet per minute.
The drum is 6 feet in diameter over the barrel, 5 ¼ feet wide, and runs at 51 revolutions per minute when at full speed.

The rope is 2 ¾ inches in circumference, and is of best plough steel.

The brakes are of the post type, and are operated by compressed air at a pressure of 50 to 60 pounds. They are applied by the driver by means of a lever, act automatically in case of failure of supply, and can also be operated by means of a foot-lever by the driver.

The drum is geared at 7 ½ to 1; the gearing is steel, and the teeth are machine-cut and double helical in shape. The pinion-wheel has 18 teeth of 2-inch pitch, and a 12-inch face: the spur-wheel has 134 teeth, and has the same pitch and face.

The motor is wound for 2,600 volts, at 40 cycles, and 390 revolutions per minute; it develops 240 brake-horsepower normally and 450 brake-horsepower in starting. The gear and motor are mounted on the same bed-plate. The controller is of the liquid type, with circulating pump and electrically-controlled reversing-switch.

The total horsepower of the motors installed is 1,645, exclusive, of the winding-motor, which is rated at 800 brake-horsepower normal and 1,700 in starting.

Ventilation.—The colliery is at present ventilated by means a Capell fan, 11 feet in diameter by 7 feet in width (erected at St. Hilda Colliery), which is direct driven by means of a 300-horsepower Siemens-Schuckert motor, wound for 5,500 volts at 260 revolutions per minute. With the fan running at that speed, 210,760 cubic; feet of air per minute are produced at a water gauge of 5 inches. A motor of the same make is installed on the other side of the fan-shaft as a stand-by in case of breakdown, this motor being rated at 400 horsepower and running at 295 revolutions per minute; at this speed the fan will give 250,000 cubic feet of air at a water-gauge of 6 ½ inches.

An additional ventilating plant is also provided, consisting of a Walker Indestructible fan, 26 feet in diameter by 8 feet in width, which is driven by compound horizontal engines, having a high-pressure cylinder 22 inches in diameter and a low-pressure cylinder 38 inches in diameter, with a stroke of 48 inches. Eleven cotton ropes connect the engine with the fan pulley. With the engine running at 45 revolutions per minute, and the fan at 110 revolutions, 207,000 cubic feet of air per minute are produced at a water-gauge of 5 inches.

NEWBIGGIN COLLIERY COMPANY, LIMITED.

Newbiggin Colliery.

Sinkings.—This colliery (which is in process of sinking) is situated on the Northumberland coast, about 3 miles north of Blyth. The laying-out of the work was commenced in February, 1908, and the buildings competed to date comprise the boiler-house, two winding-engine houses, the power-house, and workshops, all of which are equipped with machinery and plant. There are two shafts in process of sinking. No. 2 shaft is at present about 116 feet deep from the surface, and is now passing through freestone, having been sunk recently through the sand. The freestone is giving off feeders of about 700 gallons per minute, and is being unwatered by two high-lift turbine sinking pumps. A description of the sinking is

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contained in Messrs. Bainbridge and Redfearn's paper.* A third shaft is at present in process of being equipped for sinking through the sand. Both shafts, when finished, will be 18 feet in diameter.

Steam Plant.—Steam is supplied at a pressure of 160 pounds per square inch by means of four Lancashire boilers, each 8 ½ feet in diameter by 30 feet in length, housed in a steel framework structure, the sides and roof of which are covered with corrugated sheeting. The chimney has an internal diameter of 6 feet, and is 100 feet high. The boilers are fired by Erith underfeed stokers, and forced draught is supplied by a fan driven by a high-speed engine, the air being conveyed by means of a culvert underneath the stoker-hole floor and distributed to each boiler by separate pipes from the culvert. The feed-water heater is situated close to the power-house; the exhaust steam from the engines in this house is taken through the heater, and a temperature of 180° Fahr. is attained. The feed-pumps, to be described later, are situated in the power-house. Two of the boilers are connected to superheaters, and the steam mains are so arranged that the degree of superheat in the steam from any or all of the boilers can be controlled. The steam from each boiler is led into a steam drum, 3 feet in diameter by 30 feet long, which lies transversely across the range of boilers. From this steam drum, mains are arranged so as to pass the steam through the superheaters or, alternatively, direct into the main steam range.

Two low-service pumps are also installed in the annex to the boiler-house for the purpose of maintaining the water-service of the colliery, and pump into a tank situated adjacent to the boiler-house.

Steam is conveyed by means of mild-steel pipes with welded flanges, and Ferranti-Hopkinson valves are used throughout. The steam main is 12 inches in diameter for the first portion (until beyond the winding engine supply-pipes) and 10 inches in diameter for the remaining portion. A stuffing-box expansion-joint is fixed at the point where the steam main enters the power-house.

Winding Engines.—The two winding engines are housed in brick Houses, 37 feet square inside measurement, and are exactly alike. They are simple non-condensing engines, with cylinders 20 inches diameter by 40 inches stroke. When arranged for coal winding they will each have two drums, 10 feet in diameter but at present each engine is working with one drum for sinking purposes. Reversing gear of the latest type and steam brakes are provided.

Power-house.—The power-house contains the electrical plant, air-compressor, and feed-pumps; it is built of brick, covers a floor-area of about 3,510 square feet, and in plan is shaped like the letter L. This house (which is at present unfinished) will ultimately contain, in addition to the machinery above-mentioned, the fan engines and an electrician's workshop. The western wall of the power-house is roughly built, and intended to be pulled down for future extension.

The electrical plant consists of two 250-kilowatt three-phase generators, together with two 18-kilowatt continuous-current generators, and a switchboard. The two 250-kilowatt generators supply three-phase current at 600 volts, which is used for power purposes, the exciting current being obtained from the 18-kilowatt continuous-current
generators. The 250-kilowatt machines are driven by totally-enclosed compound high-speed engines, with cylinders measuring 15.5 by 20 inches with a 10-inch stroke, and run at 343 revolutions per minute. The 18-kilowatt generators supply continuous current at 220 volts, and are used for the purpose of supplying the exciting current for the three-phase machines, in addition to supplying the colliery lighting. They are driven by open-type single-cylinder high-speed engines, 10 inches in diameter with a 7-inch stroke, and run at 325 revolutions per minute. The switchboard is of black enamelled slate, and composes panels for each 250-kilowatt generator and each 18-kilowatt generator, and a distributing panel fitted with synchronizer and leakage indicator.

The air-compressor is a compound two-stage machine, with steam cylinders measuring 12 and 20 inches with 16-inch stroke, and air cylinders measuring 11 and 18 inches, and supplies air at a pressure of 80 pounds per square inch. It is to be used for the purpose of supplying air to the rock-drills for shaft-sinking, the capacity being about 700 cubic feet of free air per minute.

The air is stored in a vertical air-receiver, 5 feet in diameter by 25 feet in length (situated behind the power-house), from which it is conveyed to the shafts.

The boiler feed-pumps (also situated in the power-house) are two in number, and are of the Evans compound beam type, measuring 6 by 10 by 5½ inches, with a 12-inch stroke. The feed-water is taken from the feed-heater, and forced along a feed-main to the boilers.

A 5-ton travelling crane is fixed in the power-house for overhauling purposes.

All the exhaust steam from the above-described engines in the power-house is taken into an exhaust-steam main, which is laid in a trench outside the building. A portion of the exhaust steam from this main is diverted through the feed-heater, the remainder being allowed to escape into the atmosphere. All the winding-engine exhaust mains are also arranged with a view to being ultimately connected with the above exhaust main, so that exhaust-steam turbines may be laid down when further extensions of electrical plant become necessary.

Workshops.---The shops comprise fitting, smiths’, and joiners' shops, together with stores and enginewrights' offices, etc. They are grouped together so as to form a block building, and are entirely lighted from the roof, without lateral windows. The machinery in the shops comprises the following:----Fitting shop: 10-inch S.S.S. lathe, radial drilling machine, screwing machine, planing machine, slotting machine, cold-iron saw, and emery grinders; smiths' shop: 10-cwt. steam-hammer, punching and shearing machine, and grindstone; joiners' shop: bench-saw, band-saw, and general joiner.

The shafting is almost entirely arranged underground, and is driven from a 55-horsepower motor, situated in a motor-room under the shop offices. The blowing-fan for the smiths' fires is also situated in this room. Clutches are so arranged that any of the shops can be worked independently and without running all the shafting. The enginewrights’ office is elevated about 5 feet above the shop floor-level, and the windows are so arranged that a full and comprehensive view of all the shops can be obtained from this office. The fitting shop is also provided with a 5-ton overhead travelling crane, running the whole length of the shop.

In addition to the stores in the shop building, fireproof stores (in a separate building) have been erected for storing lubricating oils, waste, and other inflammable materials.
THE ROMANO-BRITISH SITE OF CORSTOPITUM, CORBRIDGE, NORTHUMBERLAND.*

Introduction.-The Roman Corstopitum, although it is situated about 2 ½ miles to the south of the line of the Murus, owes its importance to, and no doubt acted as a supply base for, the soldiers who garrisoned the wall. It lies immediately to the west of the village of Corbridge, on the northern bank of the Tyne, at the point where a Roman bridge---half a mile west of that now in use---carried Dere or Watling Street across the river.

The area of the site, according to an outline survey made by MacLauchlan, in the early fifties, covers not less than 22 acres, about one-third of the area of York, and it is by no means certain that MacLauchlan did not largely underestimate its extent. The operations during the past 2 years have been conducted under the personal supervision of the executive committee of the Corbridge Excavation Fund, and notwithstanding denudation, the pilfering mediaeval builder, and the latter-day Goths, who have plundered and used the site as a quarry, satisfactory progress has been made. By the aid of the foundations which have been uncovered, an idea of the plan of the place, the direction of the streets, and the character of the buildings, has been disclosed. They incline to the arrangements common to a civil community, combined with features that are more definitely military. They suggest, indeed, a site with a considerable cosmopolitan population, enjoying a certain amount of wealth and luxury, although evidence of the vicissitudes undergone by its people is visible in marks of destruction and repair upon many of its buildings.

Up to the present nothing has been found that can be definitely described as indicating formal castrametation, although some pieces of wall, 6 feet in thickness, seem too massive for purely civil buildings; and it is possible that further excavation may link them up, and prove that some kind of fort or citadel existed near the centre of the town. Trial-trenches to ascertain whether a wall enclosed the site have proved so far unsuccessful; but a mound with a rubble core and a ditch were discovered in 1906 to the south side of it, on the brow of the natural slope which falls to the low marshy land, and the river beyond. In Roman times the surface was no doubt much steeper, and the river also flowed considerably to the north of its present course.

The site being in close proximity to the great wall on the north, and protected by the river on the south, a stone-walled enclosure was possibly deemed unnecessary.

The Granaries.---The two granaries are of substantial and damp-proof construction, and are larger than, but otherwise similar to, those found in Roman camps. That these buildings were used as store-places for grain is demonstrated by the recent discovery of wheat in this type of building at Ribchester and elsewhere, and by an inscription found at Corbridge in 1908. The remains of pillared porticos have been found outside the south front of the granaries during the present season.

The western granary was erected first. It measures on the interior 92 ½ by 23 ½ feet, and is enclosed with massive walls strengthened on three sides by stout buttresses, the southern end towards the road being occupied by the entrance door and loading platform. The walling is of rubble-concrete, faced on both sides with good ashlar masonry in courses.


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The floor, with the object of keeping the goods stored thereon free from damp, was constructed about 2 feet 4 inches above the ground-level, and was formed by flags 4 inches thick, carried on seven parallel dwarf walls placed longitudinally, the channels formed between them being supplied with an effective current of fresh air by cross-channels placed opposite to the ventilating openings in the outer walls. At a subsequent date these channels were filled in with large cobbles, and a second floor erected thereon; but in this case the floor was carried by six longitudinal walls, the flags as before spanning the intervening space and being supported on a scarcement or offset provided for the purpose on the main walls. The ventilation openings in the outer walls were altered to suit the levels. As these exist in a more perfect state of preservation in the eastern granary, they are described below. Within the door at the southern end of the granary are some descending steps, which may have been introduced at a period before the floor was raised to the same level as that of the eastern granary (which has only one floor), the reason for the second alteration probably being that it was found more convenient for the floors of both buildings to be at the same height. Without the door was a mass of masonry, presumably a loading platform, but of later date than the original building.

The eastern granary measures on the interior 86 by 25 ½ feet, and is shorter but wider than its neighbour. It was divided down the middle by a series of pillars, the base-stones of which remain. The walls exist at a greater elevation, and in a more complete condition, than in the western granary. They are similar in construction, excepting that the buttresses are nearer together. The floor is supported by eight dwarf walls with longitudinal and transverse channels fed with fresh air from openings 10 to 12 inches wide, placed between each buttress. In two instances these openings, with widely-splayed jambs to the interior, are comparatively complete; they are about 2 feet in height, and have been divided by chamfered mullions let into sinkings in the sill and lintel. One of the mullions is in situ, and forms a unique feature in Romano-British work. A few lengths of a weathered plinth occur in situ at the north-eastern angle of the building, and are of larger section than fragments of the similar moulding found in the western granary. The occurrence of a row of piers down the centre of the building is uncommon. Whether they were carried up in stone or wood does not appear, excepting that there is no apparent preparation for wooden posts on the existing stone courses. By the provision of these pillars, the span was reduced to 12 feet; and, if constructed of stone, they would be sufficiently strong to support a barrel-vault; but as there is no evidence of arch-stones or tile-slabs to suggest such a means of covering the area, it may be assumed that the pillars indicate the existence of an upper storey or some form of loft or storage in the roof-space.

The Fountain.--This structure is on the north side of the street, and was discovered in 1907 and re-opened in 1908. It comprises a podium or platform raised 2 feet above the first-period street-level. It has a frontage of 19 feet, and is six-sided, two, the eastern and western, being about 8 feet, and the northern and canted sides about 7 ½ feet in length. On each side it is flanked by large square pedestals, and in front of it is a trough or cistern. The podium was enclosed by a low screen having a moulded base-course, grooved on the top to receive sculptured panels separated by projecting pilasters. Possibly, from a mask or other feature in the panels, the water spurted into the trough below, from which the populace drew
their supplies of water. Its position is an encroachment upon the width of the north-and-south street, and the detached wall, which passes along the north of the podium, was apparently erected as a retaining-wall merely, when the level of the street was raised at a later date. On the upper surface of the flooring-flags and structural stones the usual dovetailed sinkings occur, commonly surmised to have been filled with iron or leaden cramps for binding the stones together. As no distinct evidence of either material appeared on the visible stones, an examination was made of the lower courses, which had not previously been exposed, and it was found that these contained no trace of metal, but had apparently been filled with cement. During the present season traces of an aqueduct, leading to the fountain, have been found.

The "Forum."---The fourth building is situated to the east of the fountain. It is of exceptional dimensions, and built of excellent masonry. The structure seems to have been, perhaps, a market-place or large stores, and comprises a number of apartments arranged about a quadrangle. The western range was completely excavated, but only a portion of the northern and southern ranges. On the exterior the western wall, without apparent door opening, extends from south to north 221 feet, and on the interior the quadrangle in the same direction measures 168 feet; the northern and southern exterior walls were traced to the extent of 100 feet; and, until the completion of the investigations, it is not possible to say whether the space enclosed is square or oblong. The various chambers measure on an average 20 by 17 feet; they are divided by walls at right-angles to the exterior, returned a short distance on either side towards the quadrangle in the shape of the letter T. The space between each T-piece is 13 feet, and is the only opening into the chamber. There is no indication of any provision for the attachment of doors or windows.

The great western wall rests on a broad foundation, 4 feet 3 inches wide by 14 inches in height, over which is a course with a bold torus moulding to the exterior. Above this course the walling is 2 ½ feet thick, every stone being the full width of the wall and laid in courses 12 to 15 inches high, dressed on both faces in heavy "rustic" fashion within a chiselled margin. The cross walls, 24 inches thick, are similarly dressed on both faces, and here again every stone spans the full width of the wall.

Floors occur at two if not three levels; the lowest is composed of crushed chippings and fine gravel, another, 2 feet above it, is of flags bedded on small cobbles. At one point a number of arch-stones were strewn about. They belonged to an arch (or arches) of 13 feet span, a dimension identical with the width of the openings into the various courts. Unfortunately, the voussoirs are only 18 inches on the soffit, whereas the jambs of the openings are 30 inches; and it is therefore improbable that they occupied the position that the span would otherwise indicate.

Within the area of the quadrangle are the remains of several rubble-walls enclosing shallow trough-like structures of poor masonry; also two parallel walls, 19 feet apart, set in strong cement, which appear contemporary with or earlier than the massive walls of the main building. These walls once had embedded in their thickness wooden uprights, placed quite near to the inner face of the walls, and protected by a thick layer of wall-plaster, which is stained yellow. The floor-space between the walls has been cemented, and has a fan to the south. It is not yet possible to demonstrate whether the whole of this work may have been used for some simple trade, kneading-troughs, or washing-places. Two series of post-holes occur on the east side of the central rectangular area, and penetrate the sandy sub-soil about 2 feet. An iron pole-shoe and several querns were among the minor finds, whilst in
one of the courts were a number of stone ballista shot. The area also yielded two early Anglo-Saxon cruciform fibulae, found with coloured beads.

Near one of the western courts, a heap of small coal was found, lying on a floor of fourth-century date.

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Coins.--Of the noteworthy finds, the most remarkable is that of the hoard of gold coins--forty-eight in number--enclosed, together with a gold ring, in a piece of lead, and secreted 18 inches below the present ground-level in a building of late date. The coins include examples of the reigns of Valentinian I. (4), Valens (2), Gratian (16), Valentinian II. (8), Theodosius (5), and Magnus Maximus (13). According to Mr. H. H. E. Craster, M.A., they may be ranged between the inclusive dates 370-385 A.D. The coins have been deposited in a bank pending litigation.

The buildings explored during the present season are less substantial and important than those found in 1908. They include another granary or store-house which was ruined at an early date, as a clay-embankment, carrying an aqueduct, has been carried across the site, probably in the fourth century. Farther north is a small bath-house, with a hypocaust and two apses.

A new temporary museum has been erected, in which many of the most interesting objects found since the commencement of the excavations may be inspected.

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THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

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GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,

FEBRUARY 12TH, 1910.

MR. T. E. FORSTER, PRESIDENT, IN THE CHAIR.

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The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on January 29th and that day.

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

HONORARY MEMBERS----
Dr. William Henry Hadow, Principal, Armstrong College, Newcastle-upon-Tyne.
Mr. William Mundell Thornton, Professor of Electrical Engineering, Armstrong College, Newcastle-upon-Tyne.

MEMBERS-----
Mr. William Bilton Coxon, Mining Engineer, Seaton Hill, Boosbeck, Yorkshire.
Mr. Matthew Cullen, Colliery Manager, Transvaal Clydesdale Collieries, Springs, Transvaal.
Mr. Stewart Maclntosh, Mechanical Engineer, 26, Sandringham Terrace, Benton, Newcastle-upon-Tyne.
Mr. Thomas Tate Minns, Colliery Manager, Binchester Blocks, Bishop Auckland.
Mr. Reginald George Pearson, Mining Engineer, Luderitzbucht, Angra Paquena, German South-West Africa.
Mr. William Ramsay, Colliery Manager, Bentinck House, Pegswood, Morpeth.
Mr. Walter Maurice Redfearn, Mechanical Engineer, Bowers Rigg, Newbiggin-by-the-Sea, Northumberland.
Mr. Thomas Cuthbert Whitfield, Colliery Manager, Trimdon Grange Colliery, County Durham.

ASSOCIATE MEMBERS------
Mr. Frederick Elford Gulley, 4, Park Terrace, North Shields.
Mr. Francis Hoste-Turner, 164, Rye Hill, Newcastle-upon-Tyne.
Mr. Ford Stafford Jopling, Jun., 8, Thornhill Terrace, Sunderland.
Mr. Robert Oliver Patterson, Thorneyholme, Wylam, Northumberland.

ASSOCIATE----
Mr. Arthur Magnus Spence, Back-overman, Park Cottages, Langley Park, Durham.

SUBSCRIBERS-

DISCUSSION OF MR. T. L. ELWEN'S PAPER ON "SOME RESULTS OF EXPERIMENTS MADE TO TEST THE EFFECT OF SPRAYERS UPON THE MOISTURE OF MAIN ROADS AT BRANDON COLLIERY."

Mr. T. L. Elwen (Brandon Colliery) said that, acting upon the suggestions made at the last meeting, he would like to submit the following additional particulars asked for:-

<table>
<thead>
<tr>
<th>Distance from Downcast Shaft.</th>
<th>Number of Sprayers in Operation</th>
<th>Velocity of Air-current</th>
<th>Pressure of Water.</th>
<th>Quantity of Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet.</td>
<td></td>
<td>Feet per minute.</td>
<td>Pounds per square inch.</td>
<td>Cubic feet per minute.</td>
</tr>
<tr>
<td>In the shaft</td>
<td>2</td>
<td>533</td>
<td>146</td>
<td>82,000</td>
</tr>
<tr>
<td>2,016</td>
<td>4</td>
<td>450</td>
<td>165</td>
<td>36,000</td>
</tr>
<tr>
<td>3,498</td>
<td>3</td>
<td>554</td>
<td>136</td>
<td>36,000</td>
</tr>
<tr>
<td>5,049</td>
<td>2</td>
<td>522</td>
<td>112</td>
<td>24,000</td>
</tr>
<tr>
<td>6,897</td>
<td>2</td>
<td>157</td>
<td>108</td>
<td>9,000</td>
</tr>
</tbody>
</table>

Assuming the velocity of the air-current to be 500 feet per minute, and the sectional area of the airway 50 square feet, a set of three sprayers at the commencement and a similar number at a further distance of 150 feet, would suffice to keep 300 feet of roadway in a damp condition.

DISCUSSION OF MR. JOHN CUMMINGS' PAPER ON "SINKING THE JOHN SHAFT AT HAMSTERLEY COLLIERY, THROUGH SAND AND GRAVEL, BY MEANS OF UNDERHANGING TUBBING."

Mr. H. W. G. Halbaum (Horden) wrote congratulating Mr. Cummings on the excellent work that he had accomplished, and upon the public spirit he had displayed in communicating to the Institute so lucid an account of his work. It was always refreshing to discover a man at once sufficiently able and courageous to act upon his own initiative and succeed in the face of old traditions and established custom. The work done by the author of the paper afforded (in this country) a distinct advance on the older methods, and it was pleasing to know that at last men were really beginning to wonder whether the old-fashioned tubbing plate, with flanges on its convex surface, was not unnecessarily clumsy, distinctly ill-designed, mechanically unsymmetrical, and altogether unworthy of modern scientific principles.

Against the greater initial cost of the machined tubbing, suspended in the shaft, as compared with the first cost of the unmachined article built up from a foundation curb, the author had set the saving effected by being enabled to dispense with the otherwise necessary temporary shaft-linings. But, in addition to that economy, he might very justly have claimed the economy effected in the cost of pumping— an economy distinctly due to the exuding surface of the newly-exposed strata being more promptly dammed off by the continual advance of the suspended tubbing with its cement backing, and the consequent earlier plugging-off of the successive feeders. The following sentence in the paper was sufficiently suggestive:—

"It was noticed regularly, while the men were sinking and putting in the segments, the shaft sides being then more or less open, that the quantity of water increased considerably, and the pump was kept going at its fullest capacity to enable work to be carried on in the pit-bottom; but, after each course was completed and the bolts tightened up, the quantity was greatly reduced, especially after the grouting was put in."†

Had Mr. Cummings adopted the usual type of tubbing with external flanges, he would have been obliged to go down to the stone-head before he could have put in any tubbing at all. One could not help wondering how much pumping he had saved by forsaking the old paths.

In his final paragraph, the author had stated that there were three difficulties which, in local cases, might arise to prevent others from adopting the system which had yielded him his well-deserved success. One would be well-advised, however, to look twice at those difficulties before running away from them. With a little ingenuity, such as the author himself had evinced, they would seldom be found insuperable. With regard to the first, for example, the weakness of the foundation irresistibly suggested the coincident strength of the side pressure, and in the strength of the one might very possibly be found some compensation for the weakness of the other. Referring to the second difficulty, if the pressure was found to be high, that would be probably due to the depth being considerable; if so, the same depth

† Ibid., page 328.
which intensified the pressure behind the tubbing would also increase the intensity of pressure at the bottom of the rising-main. The second difficulty, therefore, would generally resolve itself into the question of the best method whereby the power in the main could be utilized against the power behind the tubbing. The third difficulty might, in some cases, be very great, but he (Mr. Halbaum) hardly gathered why it should be supposed to react in a special degree against the system of suspended tubbing. If, in the particular case of suspended tubbing, the conditions of a sinking created a serious situation from the standpoint of Mr. Cummings' third-named difficulty, would the trouble be in any degree relieved by reverting to the usual system of externally-flanged tubbing built up from a solid stratum? He (Mr. Halbaum) believed that on the Continent (where it was usual to employ internally-flanged tubbing) it had been found necessary in a few instances to insert a false bottom in the shaft for the time being; and, as a last resource, Mr. Cummings' third difficulty could always be met by a temporary false bottom, either of metal or cement, at the base of the tubbing. That might, or might not, be less costly than the temporary linings saved by the method of suspended tubbing; in any case, it would probably be the less of two evils. The alternative might be the adoption of a more expensive mode of sinking, or it might even mean the abandonment of the enterprise. One thing seemed very sure, namely, that if the user of internally-flanged tubbing failed, there would be small prospect of the success of anyone who adopted the older type of plate, which had its ribs and flanges cast on the convex surface.

He (Mr. Halbaum) might mention that he had devoted some little time in a careful consideration of the case for inside flanges, and he ventured to predict that the internally-flanged plate would rapidly grow in popular favour. Furthermore he felt very sure that the system of lining shafts by the method of underhanging tubbing had a great future before it; and therefore he was very pleased, without being at all surprised that Mr. Cummings had come off with flying colours at his first attempt to put in practice modern ideas in that direction.

Prof. Henry Louis (Armstrong College, Newcastle-upon-Tyne) said that he would like to make one or two remarks with reference, not to the underhanging tubbing, but to the closely germane subject of tubbing flanged internally. At the last meeting, when the paper was under discussion, the fact was commented upon that Mr. Cummings had gone to Germany for his tubbing, and the question was raised as to whether such tubbing could not be obtained in this country. He (Prof. Louis) believed that he had stated then—if not, he wished to mention it now—that he knew one works in the County of Durham where such tubbing was made, and since then he had seen other tubbing which was manufactured quite close at hand. He had been privileged to see some sinkings at Elswick, where they had been sinking a number of gun-pits through the sludge of the Tyne to a depth of about 50 feet. These were 19 feet in diameter, and had been sunk, not by underhanging tubbing, but by the drop-shaft system—forcing down by weights from above—with which method engineers were perfectly familiar. An important point was that this tubbing was made in segments of unusual size; the shaft was 19 feet in diameter, and there were six segments of tubbing round the shaft, in about 10-foot lengths. The plates were 6 feet deep, and had been planed and turned up on the machinery at the Elswick Works, some of the fine horizontal lathes there being admirably fitted for the work. It was also interesting to call attention to the fact that they had developed a form of joint
which was distinctly more mechanically perfect than the German sheet-lead joint. The joint was of lead-wire; a groove was cut into the joints and seams of the tubbing, into which \( \frac{1}{2} \) inch lead-wire with a scarf-joint was laid, the vertical wires coming clear in front of the horizontal wires, so that there was no question of leakage at the overlap. The joint was so good that it enabled them to do away with the lead-washers used by German engineers. The bolts were accurately machined to a proper radius at the inside of the head; the bolt-holes were bored out to a tight fit, and turned up at the ends, so that the bolts could be put on close against the flange without the use of lead washers. The pits, although liable to a good deal of water-pressure, were perfectly dry and sound inside. He (Prof. Louis) thought that this information was worth putting on record.

The Chairman (Mr. T. E. Forster) said that it would appear that it would now be possible to obtain easily tubbing of this description in Great Britain. It might perhaps be of interest to mention that some internally-flanged tubbing was put in at Cowpen Colliery some 20 years ago; it was still there, and had done good service. It was not machined, but it was very carefully put together, and a water-tight joint thus obtained. Internally-flanged tubbing had also been used at Whitburn Colliery. It had a lead-joint, and he believed that it was made at the Elswick Works. Such tubbing had been used on many occasions, but not with the water-tight joints.

Mr. John Cummings (Hamsterley Colliery) remarked that he had tried to get the tubbing in England, but many of the tubbing makers did not know exactly what it was that was wanted. Since then, however, one or two firms had commenced manufacturing that type of tubbing.

Mr. Halbaum, in speaking of the economy effected in the cost of pumping, had mentioned a point which was one of the chief factors in deciding upon the method of sinking adopted. In view of the fact that the power at the writer’s disposal for the purpose of the sinking was limited (without expensive additions to existing plant), and also bearing in mind that the shaft was to be sunk through the sands and gravels of an ancient river bed, and the consequent wear and probable trouble with impellors of centrifugal pumps when dealing with gritty water, the desire

Was to save as much pumping as possible. As to the actual economy effected, it would be very difficult to say; but it might be mentioned that during the time that the tubbing was being put in the feeders were about 200 gallons per minute, and then only intermittently: but when sinking immediately below the tubbing the quantity pumped was 800 gallons per minute.

With regard to Mr. Halbaum’s remarks on the injection of cement against pressure, this difficulty had been overcome by using the power due to a column of water equal to the depth of shaft and in various other ways. The securing of the bottom joint while grouting was more difficult, but could also be overcome.

In reference to the question as to whether the tubbing used might have been obtained in England, he might mention that at that date six English firms were asked to quote for the work, and although some of them could supply internally-flanged tubbing, none of them could supply the specially designed and machined tubbing required for the work in the time specified, whilst the German firm were able to deliver almost immediately. Since then he had been privileged to see the gun-pits of Sir W. G. Armstrong, Whitworth, & Company, Limited, at the Elswick Works, mentioned by Prof. Louis, and confessed that the
tubbing there used, with the addition of grouting-holes and external ribs, would have answered the purpose quite well, provided that the segments were made of suitable sizes.

Mr. Charles Arthur Crofton read the following paper on "Fence-gates for Winding-shaft Cages" :-

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FENCE-GATES FOR WINDING-SHAFT CAGES.
By CHARLES ARTHUR CROFTON.

Introduction.—After a fatal accident, observations are frequently made by the coroner, the jurymen, or H.M. Inspector of Mines, suggesting that improvements might be made whereby the danger would be avoided or lessened. In the case of a fatal accident caused by the tilting of a cage whilst running in the shaft, the coroner's recommendation, endorsed by H. M. Inspector of Mines, was "that gates should be on each cage when men ascend or descend." This incident induced the writer to give some consideration to the subject, and he is of opinion that gates could be attached to all cages at a small expense, thus assuring the safety of the workmen, whilst not affecting the output. He purposes, therefore, bringing before the notice of the members one or two methods of attaching gates to cages which he has devised, and would recommend that they be adopted, in conjunction with the existing cage-snecks, when drawing coals. It is not an uncommon experience to have tubs insecurely snecked, a danger which would be entirely avoided if this recommendation were acted upon. The designs that the writer submits are (1) a collapsable gate for cages with one or more decks; (2) a rigid gate, working on a fixed bottom pivot or hinge, for cages with one or more decks; and (3) a false-bottom or telescopic-frame gate for cages with one deck only.

(1) Collapsible Gate for Cages with one or more Decks.—The object of this type of gate (Figs. 1 to 5, Plate I.) is to allow the gate to collapse into the minimum of space available in the case of complicated headgears and onsets. If possible, the gate should be so constructed that in case the cage is signalled away without its being closed, no fouling will take place during its-journey in the shaft.

Figs. 1, 2, and 3 (Plate I.) show a gate constructed of flat iron bars, built up in such a manner as to allow of both a horizontal and a vertical motion. The vertical bars, A, B, and C, are 1 ¼ inches wide by 3/8 inch thick, and are riveted 9 inches apart to the horizontal bars, D and E (which are 1 ¾ inches wide by 7/16 inch thick), with loose rivets 5/8 inch in diameter, so as to allow the gate to collapse into the desired form. The vertical bars are placed on the inside of the horizontal bars in case of an undue stress being thrown on them, when the rivet heads would not be strained, as would be the case were they fixed on the outside. The horizontal bars are spaced 24 inches apart, the lower bar being 6 inches from the bottom of the cage-deck, making the total height of the gate 33 ½ inches. The whole gate swings horizontally upon a pivot, F, 3/4 inch in diameter, to which the horizontal bars are attached by loose rivets, G and H, 3/4 inch in diameter, thus allowing of the vertical movement. The top horizontal bar has a hand-hole, I, 4 inches by 1 ½ , to allow of the lifting of the gate. When the gate is closed, the ends of the horizontal bars rest in slots, J and K, being kept in this position by catches, L and M. To open the gate, it is lifted clear of the catches, and is moved first in a horizontal
and then in a vertical direction, in which latter position it is retained by the shackle, N, until the cage is ready for moving away, when the gate is closed. The weight of the gate will allow any average person to manipulate it with ease; and if anyone wishes to get out at any offset in the shaft, it is only necessary for him to lift the gate vertically to the cage-hoops and to walk out.

Figs. 4 and 5 (Plate I.) show the details of the slots, J and K.

(2) Rigid Gate for Cages with one or more Decks.—This gate (Figs. 6 to 9, Plate I.) is of a somewhat similar type to the collapsable gate, and is recommended when space is not a serious consideration. It must, however, be closed before any movement of the cage takes place, otherwise it will foul obstacles while the cage is running in the shaft.

In this gate the vertical bars, A, B, and C (Figs. 6 to 8, Plate I.), are riveted with fixed joints to the horizontal bars, D and , and the whole gate swings vertically on only one pivot or axis, which is ¾ inch in diameter. On the hinged end of the gate there is attached an additional vertical bar, G, 1 ¾ inches by 3/8 inch, for the purpose of stiffening the structure. There is, moreover, an additional hand-hole, I, provided in the lower horizontal bar, to which is also attached a stop-piece, H, 2 ½ inches by ½ inch by ½ inch, which prevents the gate, when opened, from going too far through the slot, N. In all other particulars it is identical with the collapsible gate already described. As its general construction is very simple, it is not likely to get out of order.

Fig. 9 (Plate I.) shows the details of the slot, N.

(3) False-bottom or Telescopic-frame Gate for Cages with one Deck only.—In this type of gate (Figs. 10 to 12, Plate I.), a framework, attached to the gate by pins, A and B (Fig. 10), 7/8 inch in diameter, is constructed under the cage in such a manner that when the cage is lowered to the bottom of the shaft, the framework comes into contact with the beating-beams, the result being the vertical lifting of the gate, which, of course, gives access to the inside of the cage. The gate slides in slots provided at each side of the cage. When the cage is lifted, the gate, by its own weight, automatically closes itself. At the bank-level the opening and closing of the gate is also automatic. A lever, H (Fig. 12, Plate I.), is pivoted at its centre to the side of the cage, the lower end being attached to the bottom of the gate. When the cage ascends, the free end of the lever engages with a fixed sheave, I, at bank, the depression of the one end of the lever lifting the gate attached to the opposite end.

When the cage is lowered away, the gate, as when at the bottom of the shaft, automatically closes itself. The framework below the cage is constructed of flat iron bars, C and D (Figs. 10 and 12, Plate I.), 2 inches by ¾ inch, fixed securely and rigidly together by bars, E and F, of a similar section, and by bars, G, 2 inches by ¾ inch, which ensure the proper gauge of the bars C and D. The gate itself is made up of an expanded-metal panel, in the centre of which is a small door, to allow of access to offsets in the shaft. This small door, which is constructed of flat iron bars, 1 ½ inches by 3/8 inch, opens inwards on hinges, and is so hung as to close of its own accord. It is kept in this position by a self-closing latch, which locks into a flat iron bar, 1 inch by ½ inch. The small door may, if preferred, be constructed in halves, so as to take up less room in the cage when opened. When the gate is opened, the height from the floor of the cage to the bottom of

[Plate I, Figs. 1-12, Illustrating Fence-gates for Winding-shaft Cages.]
the gate is 35 ½ inches. Fig. 11 (Plate I.) shows the gate open, and Fig 12 (Plate I.) the mode of working; the lever which opens the gate at bank.

Since writing the above description, particulars of a fatal accident, whereby a young boy lost his life through falling from an ascending cage, has come under the writer’s notice. The boy was not missed by the other occupants until the cage was practically at bank, and whether, therefore, he had overbalanced himself or had had a fit is not known. Had gates been fitted to the cage, this accident could not have happened.

The Chairman (Mr. T. E. Forster) said that they were very much obliged to Mr. Crofton for bringing the subject before them. It was thought by some that gates should be attached to all cages, and, if one had to provide gates, the best possible gate should be fixed.

Mr. C. C. Leach (Seghill Colliery), referring to the false-bottom or telescopic-frame gate (Figs. 10 to 12, Plate I.), asked how a tub could be got out at an inset half-way down the shaft, as there was only a little door that could be opened. Gates seemed very nice things until they were tried; but he thought that there were a great many dangers connected with them, as if they were in use people would rely upon them, and they would have more accidents. In pits like his own, where they had very little room, he very much doubted whether it would be possible to fix fence-gates.

The Chairman asked the author whether any of the gates described had been in use, or whether as yet he had just got out the plans. He did not think that gates were usually necessary in Northumberland and Durham; but, in pits where winding was carried on at greater speed, he thought that they should be installed. The whole question had been under consideration by the Home Office, and a report had been issued in connexion with the matter.*

*Report of a Committee appointed by the Royal Commission on Mines to Inquire into the Causes of and Means of Preventing Accidents from Falls of Ground, Underground Haulage, and in Shafts, 1909 [Cd. 4821], page 29.

Mr. C. Arthur Crofton (Wansbeck Colliery, Morpeth), in reply to Mr. Leach, said that in the case of winding from a seam which was half-way down the shaft, or in any position except at the bottom, other gates than the false-bottom or telescopic type would be used, probably the collapsable gate (Figs.1 to 5, Plate I.). In the case, however, of an odd tub or two in the week, containing, say, timber for repairs, etc., the false-bottom or telescopic gate could be used, by attaching crooks, JJ, on to the cage-hoop, to come under the frame of the gate when the gate was up, and thus to prevent it from falling down for that wind; or by providing pins, KK, on the cage-hoop to enter the gate-frame, both of which arrangements were shown in Fig. 11 (Plate I.).

In reply to Mr. Forster, the gates were not yet in use, but he hoped shortly to have them tried in actual practice.

The Chairman proposed a vote of thanks to Mr. Crofton., which was carried.
Mr. E. A. Hailwood read the following paper on "The Cunynghame-Cadman Gas-detecting Device:" —

THE CUNYNGHAME-CADMAN GAS-DETECTING DEVICE.
By E. A. HAILWOOD.

In the lamp-house of very many pits there will be found quite an assortment of firemen's lamps, which have been obtained on various occasions since the opening-out of the pit, and yet the tests for gas in such pits are generally carried out by means of a lamp either identical with or differing very slightly from that used by the collier. This would seem to prove the want of a good firemen's lamp, as the non-use of those already at hand would apparently demonstrate that they are in some way unsuitable.

It has been proved that there are lamps capable of detecting very small percentages of gas, such for instance as the hydrogen lamp, but the comparatively small use of this type would seem to show that either the country is not yet ripe for the same, or that the firemen or officials have some objection to it.

Mining men are, therefore, faced with the fact that, generally speaking, the testing for gas is carried out with the ordinary oil-lamp, and apparently some considerable time would elapse before a lamp embodying any radical change would be accepted and generally employed.

It is universally admitted that the necessity for having to lower the flame to a non-luminous point in order to measure or detect the gas-cap is a serious disadvantage, by reason of the great risk of losing the light when the flame has been so reduced; and it seems very probable that a fireman, when some distance from a re-lighting station, will hesitate to carry out a test for fear of losing his light, and of not being able to complete his duties in the usual time. The omission of such tests may therefore be an indirect cause of a subsequent calamity.

Any device which would enable firemen to conduct tests rapidly with a greatly reduced risk of losing the light, would therefore be a great boon to the mining community; and the

one recently brought out by Sir Henry Cunynghame, of the Home Office, and Prof. John Cadman, of the University Birmingham, seems to the writer to fulfil this condition.

The device merely consists of a piece of asbestos-sheeting steeped in a strong solution of carbonate of soda preferably twice dipped (a little hydrochloric acid added to the soda solution improves the same). This sheet of asbestos is secured in a suitable holder in such a manner that it may be moved into the lamp-flame whilst the flame is still comparatively big.

It is found that good results are obtained if the asbestos be about 1/5 inch above the wick, the asbestos entering the flame about two-thirds of the thickness of the same. A slight fuzzy yellow or orange halo will then appear round the flame towards the upper part of the asbestos, this halo no doubt being from the oil. If methane be present, a yellowish conical cap will appear above the halo, the length and distinctness of the cap varying according to the percentage of methane present.

Experiments are now being carried out by Prof. Cadman with a view to fixing standards in connexion with the yellow cap; but whether such standards be fixed or not, a lamp fitted with this simple device will no doubt be of great utility in enabling a fireman to
discover quickly the presence of gas, seeing that during his journey round the mine he can frequently, with only a moment’s hesitation, turn the asbestos into the flame and note whether or not the yellow cap be present. If there be no yellow cap, he would instantly move the asbestos from the wick and proceed on his journey without having run the risk of losing his light, as would be the case under the old method. If, however during the test the yellow cap be discerned, he could then do what he now regularly should do, namely, lower his flame and ascertain the percentage of the blue cap, in the usual way.

Fig. 1 depicts one form of lamp with the detecting device moved to one side, and clear of the wick. Fig. 2 shows another form of lamp, in which the device is shown in the working position.

In the adaptation of the device to the safety-lamp (Fig. 1), the asbestos holder, b, is made capable of horizontal adjustment without the need for clipping the asbestos, a; and a tubular rod, d, in which the carrier holder is inserted, may be raised or lowered into any desired position, and will maintain such position by reason of a flat spring arranged between the spindle and the tube through which the rod slides. This allows of the asbestos, when not in use, being well lowered so as to throw as little shadow as possible.

In order to maintain a perfectly clear flame, a snuffer, c, is provided, which may be passed completely across the wick. This prevents stray parts of the wick rom causing a jagged edged testing-flame, and assists greatly m obtaining a good conical gas-cap.

To change the wick, the wick-tube is arranged to slide in or out from the upper part of the burner. With this lamp, therefore, there is comparatively little likelihood of the asbestos being damaged in the ordinary manipulation in the lamp-house, as there is no need to remove the brass thumb-screw to get the burner out, the oil being forced into the lamp through a spring valve on the upper part of the lamp-vessel.

To assist in reading the gas-caps, a perpendicular scale (Fig. 2) has been attached to the snuffer-pin in such a way that during a test it may be turned into position quite close to the burner, and the height of the cap readily read; whereas when not needed for testing purposes, it may be turned away from the burner, and does not therefore draw the flame or cause it to smoke, as would be the case if it were permanently fixed alongside the burner.

The asbestos will, with reasonable care, remain active for a considerable time, as under one test a lamp with the indicator in the flame has been used continuously for a week, and at the end of such time the flame-colouring properties did not appear to have been affected.

If, therefore, the indicator be dipped in soda solution, or a new holder (costing a few pence) be attached to the lamp at the commencement of every week, it should enable the indicator to be kept in a thoroughly efficient state.
It appears possible to detect very small percentages of gas with the device, and Prof, Cadman states that ½ per cent. can be easily detected.

From the construction of the device, it will be seen that there is really very little divergence from the collier's lamp now in general use, and there is every reason to believe that it will meet the requirements of the most conservative fireman.

To demonstrate (on the surface) the utility of the device, one end of a small indiarubber tube, which has been attached to any ordinary gas-jet, may be brought to a position about 1 inch below the air-intake of the lamp, and sufficient gas permitted to enter the lamp to make the yellow cap quite distinct.

Mr. E. A. Hailwood (Morley, near Leeds), after reading the paper, experimentally illustrated it with two lamps of the same make placed in a chamber filled with a gas mixture, the flame of one being lowered to practically a non-luminous point to show the blue cap, while the flame of the other was allowed to remain at the ordinary height, but with the detector inserted in the flame,

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thereby showing the corresponding yellow cap for the selfsame percentage of gas. This test was carried out first with the electric lights extinguished and then with all the lights switched in circuit. The remarkable distinctness of the yellow cap as compared with the blue cap under both tests was greatly appreciated.

In reply to questions put by Mr. J. H. Merivale (Acklington), Prof. Henry Louis (Armstrong College, Newcastle-upon-Tyne), and Mr. C. P. Almond (New Seaham), Mr. Hailwood said that the price of a single complete lamp was 11s., and the idea had not been patented. The lamp would stand a fairly large percentage of gas, without being put out.

The Chairman (Mr. T. E. Forster) said that this very interesting subject was one following up papers which were read at the Newcastle-upon-Tyne meeting of The Institution of Mining Engineers,* the apparatus having been devised very shortly afterwards. He proposed a vote of thanks to Mr. Hailwood for his interesting paper and demonstrations.

The vote of thanks was carried unanimously.

The following paper, by Mr. William Morley Egglestone, on "The Geology of the Little Whin Sill, Weardale, County Durham," was taken as read :-


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THE GEOLOGY OF THE LITTLE WHIN SILL, WEARDALE, COUNTY DURHAM.
By WILLIAM MORLEY EGGLESTONE.

Introduction.—Among the most interesting geological phenomena, in connexion with igneous rocks in Britain, are the Cleveland Dyke and the Great Whin Sill in the North of England. The Cleveland Dyke, as it runs its course across the country lying between the mouth of the Tees to the vale of the Eden, traverses, according to Sir Archibald Geikie, a
greater variety of sedimentary formations than any other basaltic dyke in England. Its general trend is west 15 degrees north, and it touches the Carboniferous, Permian, Triassic, and Jurassic formations; it varies in width from 15 to 100 feet, and runs for at least 110 miles (although often not reaching the surface); but the above-named authority is inclined to think that the last visible portion of this Dyke, near Carlisle, may be connected with the dyke that runs out into the Firth of Clyde, near Prestwick, covering a further distance of about 80 miles. Sir Archibald Geikie concludes that "if we consider this extension as a part of the great North of England dyke, then the total length of this remarkable geological feature will be about 190 miles."* In any case, the Cleveland Dyke is the longest in Britain.

The other remarkable geological feature in the North of England, the Great Whin Sill, is very much in evidence in Teesdale; it is exposed at Burtrereford, in Weardale, and is traceable from the Pennine escarpment along its outcrop almost to the northern limits of Northumberland, a distance little short of 100 miles. This typical intrusive sheet varies in thickness from a few feet to 241 ½ feet in Weardale, and has a subterranean area of at least 400 square miles. Sir Archibald Geikie, however, considers that 1,000 square miles would probably be below the truth in respect to its underground area at the period when it was


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intruded amongst the Carboniferous Limestone Series of rocks, and points out that the Great Whin Sill is the most extensive manifestation of a subterranean intrusion of igneous rock in the British Isles later than the Dalradian sills of Scotland.

The object of the present paper is to consider the geology of the Little Whin Sill of Weardale, a minor example of intrusive rock when compared with the two prominent displays before mentioned, yet, in a way, equally interesting as a local geological feature as it is evidently of the same age and origin as its big brother, the Great Whin Sill. It is, as yet, unknown in any other locality in the North of England.

Plate II. is a sketch map of Weardale, showing the Little and Great Whin Sills and lead-mines.

The Carboniferous System.—In England, the upper series of the Carboniferous System, the Coal-Measures, are found chiefly in synclinal detached basins or coal-fields, whilst the Lower Limestone Group forms the axial Pennine Chain or range of hills running from Northumberland along the moorland ridges between Alston and Weardale to Derbyshire. To this anticline is due the dip to the north-east (otherwise the rise to the south-west) of the Weardale rocks.

The Carboniferous System, which sometimes reaches to a thickness of 20,000 feet, is divided into its larger groups by Sir Archibald Geikie and others as follows: —
Briefly we have (1) Coal-Measures, (2) Millstone Grit, and (3) Carboniferous Limestone Series.

Prof. G. A. L. Lebour, in his paper "On the Limits of the Yoredale Series in the North of England,"* says that in the north-western parts of Yorkshire the term is convenient, but quite incapable of being used much farther north, either stratigraphically or palaeontologically, and (in his Outlines of the Geology of Northumberland and Durham) suggests for this northern type of rocks the name "Bernician" Beds.*

Westgarth Forster, in 1821, characterized the strata of the North of England lead-mining districts of Alston, Weardale, and the neighbouring dales, as the "Lead-Measures," in the same way as the rocks stratigraphically above are denominated the "Coal-Measures." "Lead-Measures" is the common name used by the local lead-miners.

The Weardale Rocks.—Amongst the Weardale strata (made up of limestones, sandstones, grits, and shales, or plate, with small seams of "craw" coal) have been intruded two igneous sheets, the Great Whin Sill and the Little Whin Sill. The following limestones have been proved in mining operations, and they are exposed in the natural sections in the various tributary burns or streams, as well as in the main valley of the River Wear: —

1. Fell Top Limestone. 7. Five-yard Limestone.
3. Little Limestone. 9. Cockle-shell Limestone.
5. Four-fathom Limestone. 11. Tyne Bottom Limestone.

In studying the geology of the igneous and other rocks of Weardale, it would help the student if he made himself acquainted with the local strata of the dale, and as a guide the

<table>
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<tr>
<th>Coal Measures</th>
<th>Upper Red Sandstones with Spirorbis limestone (not present the northern counties).</th>
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<td></td>
<td>Middle or chief coal-bearing measures.</td>
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<td></td>
<td>Lower Coal-Measures or Gannister group. Millstone Grit</td>
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<tr>
<td>Millstone Grit</td>
<td>Grits, flagstones, and shales, with a little coal.</td>
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<tr>
<td>Carboniferous</td>
<td>Yoredale Group of shales and grits, with limestones.</td>
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<tr>
<td>Limestones</td>
<td>Thick (Scaur or Main) Limestone of England, with sandstones and coals in Northumberland and Scotland.</td>
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<td></td>
<td>Lower Limestone Shales (Calciferous Sandstones of Scotland = Tuedian of Northumberland)</td>
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<tr>
<td>Bernician Series of Northumberland</td>
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stratigraphical horizon of the Great or Main Limestone provides a useful key to these Weardale rocks.

At the wooden bridge which crosses the Wear at Broadwood Lodge, at the eastern end of the village of Frosterley, this limestone forms the bed of the river, and its outcrop is traceable along both sides of the valley and around the moorland slopes at the head of the tributary "hopes" of Burnhope and Killhope. This bed-rock at Broadwood Lodge is 530 feet above sea-level, and at Wearhead, 12 miles westward, the bed of the river is 1,090 feet above sea-level, giving a rise of 560 feet, or 46 feet per mile. As the strata which crop out in the dale have a rise south-westwards

* Second edition, 1886, page 60.

[235] greater than that of the Wear, it will be found that the outcrop of the Main Limestone along the sides of the valley rises higher and higher with one fairly general gradient (excepting a modification caused by the Burtreeford Fault, which cuts the rocks across from north to south at Burtreeford) until, in the western part of the parish of Stanhope, the Great Limestone is exposed in situations 1,980 feet above sea-level, as, for instance, near Lodge Gill Mine, at Burnhope. It will be seen that this guiding limestone from Broadwood runs like a blue ribbon all round the edges of pasture and moor of the dale in the west, closing across the Wear at Broadwood Lodge in the east.

From this key to the Weardale rocks the student can trace in ascending order the coal sills and Little Limestone and the Crag Limestone, in the Stanhope and Frosterley district, to the Fell Top Limestone and all the associated sandstones, shales, small seams of "craw" coal, upwards to the Millstone Grits. In descending order (below the Main Limestone) can be traced in the mine shafts and in glens and hopes a small limestone, the Four-fathom Limestone, the Three-yard and Five-yard Limestones, the Scar Limestone, the Cockle-shell Limestone, the Single Post Limestone, the Tyne Bottom Limestone (exposed in Burnhope), and the Jew Limestone, which has been sunk into in the Slitt mine. This brief view of the local rocks will help the geological student to locate the horizons of the igneous sheets, the Great and Little Whin Sills.

The Horizon of the Whin Sills in Weardale.—The horizon of the smaller intrusive sheet of igneous rock (which lies between the "posts" of the Three-yard Limestone) has been completely cut through by glacial action, by the River Wear, and by other associated erosive agencies. Immediately west of Stanhope, above and below the rib-arched stone bridge, the rock is well exposed on both sides, and forms, perhaps, the most beautiful bit of rock, river, and woodland scenery in Weardale. Westwards, the outcrop of the Little Whin Sill may be traced along each side of the valley for 3 or more miles, and then the sheet disappears.

The Great Whin Sill is exposed as a boss at Burtreeford, near

**"Post" is the local name for beds or layers. This limestone is often called the "Three-post Limestone."

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Cowshill, but it shows no extended outcrop in Weardale. It has however, been sunk through at two of the Weardale lead-mines (Burtreeford and Slitt), being under the Tyne Bottom Limestone at the Slitt Mine, and under the Single Post Limestone and above the Tyne
Bottom Limestone at the Burtree Pasture Mine, where it proved to be, when sunk through in 1857, not less than 241 1/2 feet thick, this being the greatest thickness of this igneous sheet known to the writer. The same horizon is shown in the bed of Killhope burn, where this basalt is being quarried near Cowshill.*

The Little Whin Sill has not been found to be more than 30 feet thick, and it has not been proved to change its horizon, which is between the upper post and the two lower posts of the Three-yard Limestone. According to Westgarth Forster, the Little Whin Sill in the River Wear, west of Stanhope, is considered to be the same as the Great Whin Sill.† In 1830, however, the late Sir Walter C. Trevelyan, Bart., corrected this.‡ In examining the Little Whin Sill, the student must bear in mind that its horizon is stratigraphically 350 feet higher than that of the Great Whin Sill at the Slitt Mine, near Westgate, Weardale, and that in this mine shaft, which cuts through the Three-yard Limestone, the Little Whin Sill is wanting; and it does not occur in an exposed section of the Three-yard Limestone in Middlehope Burn, at a short distance down stream from the Slitt Mine.

Are the Whin Sills Contemporaneous?—The question whether the Whin Sills are contemporaneous might, the author thinks, be answered in the affirmative. If the two whin sills in Weardale were formed at the same time, and from the same source, then the Great Whin Sill may have intruded itself amongst the local strata at a point 350 feet stratigraphically below the horizon of its contemporaneous Little Whin Sill. On the other hand, if the


† A Treatise on a Section of the Strata from Newcastle-upon-Tyne to the Mountain of Cross Fell, in Cumberland ; with Remarks on Mineral Veins in General, by Westgarth Forster, second edition, 1821, page 112; and third edition, 1883, page 61.


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two sills were the result of surface volcanic outbursts, then the age of the two sills would differ in accordance with the period of time required to lay down the 350 feet of sedimentary rock to build up a land surface or bed-rock, or a second bottom

Fig. 1 -Diagram showing variations in the thickness of the Great Whin Sill.

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<th>Thickness (note - not Depth)</th>
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<tr>
<td>6ft.</td>
<td>Swindale Beck, Northumberland.</td>
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<tr>
<td>12ft.</td>
<td>Bed of Lune.</td>
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<tr>
<td>18ft.</td>
<td>Murton Mine,</td>
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<tr>
<td>24ft. --ditto- (from Foster.)</td>
<td></td>
</tr>
<tr>
<td>40ft.</td>
<td>Tees Side Mine.</td>
</tr>
<tr>
<td>54ft.</td>
<td>Raven Beck.</td>
</tr>
<tr>
<td>60ft.</td>
<td>Pennine Escarpment.</td>
</tr>
<tr>
<td>75ft.</td>
<td>High Cup Nick.</td>
</tr>
<tr>
<td>120ft.</td>
<td>Garagill Mines.</td>
</tr>
</tbody>
</table>
platform to receive the lava of the stratigraphically higher Little Whin Sill. Dr. J. J. H. Teall has proved, as will be stated later on, that the petrological characters of both sills are the same.

William Topley and G. A. L. Lebour, in their excellent paper “On the Intrusive Character of the Whin Sill of Northumberland,” considered these sills to be branches of the same intrusive sheet. More than 30 years ago, George Tate stated that the Hett Whin Dyke might possibly have had its origin from the Great Whin Sill; and W. Hopkins, prior to 1868, thought it highly probable that the transverse dykes of the North of England were due to the same cause as that which produced the Whin Sill. Sir Archibald Geikie, William Topley, and G. A. L. Lebour have pointed out that both of the sills thin out westwards, and that the Great Whin Sill changes its horizon—in fact, to the extent of a thousand feet—and lies in beds and bosses at various horizons.

The Great Whin Sill is 241 ½ feet thick in Burtree Pasture Mine, Weardale, as previously stated, and 147 feet thick in the Slitt Mine shaft. Outside the dale, running along the western outcrop in Westmorland and elsewhere, the sill is found 6 feet thick at Rundle Beck; at Murton Mine, 18 feet; at Tees Side Mine, 40 feet; at Dufton Mine, 54 feet; and at Swindale and Knocker Gill, and in other streams in that neighbourhood, W. Hutton gives the thickness at from 42 to 54 feet. Along the Pennine escarpment it is 60 feet, according to the late Richard Howse and J. W. Kirkby; whilst William Topley and G. A. L. Lebour give the thickness as 75 feet at Highcup Nick. At Settling-stones Mine, in Northumberland, the sill is 145 ft., and at Carr Edge in the same county, 222 feet thick. Fig. 1 shows diagrammatically the variations in the thickness of the Great Whin Sill.

The Little Whin Sill has been found by the writer to be 30 feet thick at Messrs. R. Summerson & Company's quarry, Greenfoot, Stanhope (Fig. 2), and about 20 feet thick westward at Horsley Burn waterfall; and still farther west by north, at the


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[Photograph: Fig. 2. Working the Little Whin Sill at Messrs. R. Summerson & Company's quarry, Greenfoot, Stanhope.]

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Turn Wheel Linn, Rookhope Burn, it is only about 8 feet thick. In the next western tributary, Middlehope Burn, the Little Whin Sill is not seen.

It might be of interest to point out that lateral extensions of igneous sheets from basaltic dykes have been proved to exist in the eastern part of the County of Durham. Prof. A. Sedgwick described the lateral or horizontal expansion at Bolam from the Cockfield Whin Dyke,* which later writers have described as being 50 to 60 feet deep and -300 feet across.
On the same line is another horizontal expansion, covering three-quarters of an acre, near Wackerfield Lane, as mentioned by the late Joseph Duff.†

A more interesting lateral extension or whin sill, however, is that associated with the Hett Whin Dyke, described by the late Sir Isaac Lowthian Bell, Bart.‡ This dyke in its direction from Bedburn crosses the River Wear near Pagebank Colliery. A second basaltic dyke occurs about 2 miles to the north, and runs in a parallel direction for some distance. In connexion with mining operations at the above mine, a whin sill was found extending between these two dykes at a depth of 800 feet from the surface. This horizontal sheet or whin sill was proved to be generally of the same composition as the dykes in question, was 20 feet thick, and covered an area of at least 15 acres. Dr. J. J. H. Teall, it may be mentioned, examined all the principal dykes as well as the sills in the North of England, and pointed out that the Hett Dyke, and its accompanying "sill," differed in a marked manner, so far as composition was concerned, from that of the Cleveland Dyke, and that it was more largely composed of crystalline constituents. In all these points, says Dr. Teall, "it approaches in character the rock of the Great Whin Sill, with which I am strongly inclined to regard it as contemporaneous."§

The question as to the intrusive character of whin sills is not


† Notes and Investigations of the Coal-field*, etc., of South Durham, by Joseph Duff, 1885, page 60.

‡ "On Some Supposed Changes Basaltic Veins have Suffered during their Passage through and Contact with Stratified Rocks, and on the manner in which these Rocks have been Affected by the Heated Basalt," by I. Lowthian Bell, Proceedings of the Royal Society of London, 1875, vol. xxiii., page 543.


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one of to-day. John Whitehurst; in 1778,* referred to intrusive toadstones in Derbyshire. Dr. James Hutton proved the existence of intrusive whin sills in Scotland in 1795,† and Dr. John MacCulloch confirmed Dr. Hutton's views in 1819‡; whilst William Topley and G. A. L. Lebour demonstrated the intrusive character of the Whin Sill in Northumberland in 1875, and G. K. Gilbert described, in 1877,§ the intrusive basaltic sheets in the region of Colorado River.

In Weardale, at the Copt Hill Whinstone Quarry, the writer has seen, in the bed of Kiilhope Burn, where the under part of the Great Whin Sill had broken through the shale or pencil bed and had come into contact with the Tyne Bottom Limestone below, the two rocks are fused or welded together as one stone (Fig. 3)

[Diagram: Fig. 3.—Limestone and Whin fused together into one Stone. (a) Pencil Bed; (b) Whin; (c) Tyne Bottom Limestone; (d) Whin and Limestone fused together.]
Mineral Constituents.—The minerals of the whin sills and dykes in the North of England have been dealt with by A. Sedgwick, who visited Teesdale in 1822, by S. Allport, C. T. Clough, and others. In 1884, Dr. J. J. H. Teall (afterwards Director of the Geological Survey of the United Kingdom) gave

* An Inquiry into the Original State and Formation of the Earth, by John Whitehurst, 1778.

† Theory of the Earth, by Dr. James Hutton, 1795.

‡ A Description of the Western Islands of Scotland, etc., by Dr. John MacCulloch, 1819.


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considerable attention to the igneous rocks of the north, and his investigations were published by the Geological Society of London.* This well-known authority stated that the rock of the Whin Sill was remarkably uniform in general aspect; the specific gravity was fairly constant, an average being 2.937; and the essential constituents comprised plagioclase of one or more species, generally more or less altered, a monoclinic pyroxene, having certain special characters, and titaniferous magnetic iron-ore (Fig. 4). The general structure of the sill resembled the basalt dykes of Hett and High Green. S. Allport characterized the rock as a well-crystallized greenish black basalt containing plagioclase, with a few serpentinous pseudomorphs of olivine present.†

[Photograph: Fig. 4.—Microphotograph of section of Little Whin Sill, showing Plagioclase Felspar, Augite, and Titaniferous Iron Oxide. Magnified 20 Diameters.]

Dr. J. J. H. Teall says: "I have also examined the Little Whin Sill of Weardale, which occurs at a somewhat higher horizon than the Great Whin Sill of Teesdale. It is identical in its petrological characters with the latter rock."‡ The mineral olivine was not found. Prof. Grenville. A. J. Cole quotes Dr. Teall's analysis as a typical one of a dolerite without olivine, as follows:—§


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[Table of Composition omitted]
The Little Whin Sill.—In the foregoing pages the two local basaltic intruded sheets have been compared, the horizon given, and their mineral constituents stated; and the writer now proposes to follow the line of outcrop of the interesting Little Whin Sill. In view of tracing the line of exposure of this rock from Stanhope to its disappearance some 3 ½ miles westwards, it will be well to commence at the bed of the River Wear at Broadwood bridge, Frosterley, about 2 ½ miles east of the spot where this igneous sheet is first exposed in the bed of the Wear, immediately west of Stanhope.

Standing upon the blue rock forming the river-bed under Broadwood bridge, one is stratigraphically 211 feet above the Little Whin Sill. This rock platform, 530 feet above sea-level, is about the middle of the Great Limestone, so that there will be about 31 feet of this stratum below the river horizon. The upper surface of the Little Whin Sill would be approximately 211 feet below. The thickness of the strata in Westgarth Forster’s section, in the Burtree section, and in the Brandon Walls section, amounts very nearly to the thickness of the strata given above, but the individual rocks vary considerably. The Brandon Walls section is as follows :

<table>
<thead>
<tr>
<th>Ft.</th>
<th>Ins.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great Limestone (lower part)</td>
<td>31</td>
</tr>
<tr>
<td>Tuff (siliceous)</td>
<td>5</td>
</tr>
<tr>
<td>Plate</td>
<td>4</td>
</tr>
<tr>
<td>Small Limestone</td>
<td>3</td>
</tr>
<tr>
<td>Plate</td>
<td>3</td>
</tr>
<tr>
<td>High Quarry Hazle</td>
<td>5</td>
</tr>
<tr>
<td>Plate</td>
<td>10</td>
</tr>
<tr>
<td>Low Quarry Hazle</td>
<td>8</td>
</tr>
<tr>
<td>Plate and grey beds</td>
<td>11</td>
</tr>
<tr>
<td>Total thickness</td>
<td>210</td>
</tr>
</tbody>
</table>

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The river-gravels immediately west of Broadwood bridge form a grass-covered stretch of low land called the "Batts." In these gravel-deposits there is an abundance of fine-grained whinstone boulders, from a few inches to a foot or more in length, and all water-worn. On a ridge between the Wear Valley Railway and the sewage field at Frosterley, the writer noticed on May 10th, 1905, a number of worn boulders, from a foot to 18 inches in their longer axis, which had been dug out of some potato patches, at a level perhaps of 20 feet above the present level of the bed of the River Wear.

This ridge is evidently river gravel, as there is a bed of boulder-clay at the base of the ridge. After the valley-glacier had left its blue boulder-clay, the upper glacier floods were evidently carrying away fragments of the Little Whin Sill and depositing them 20 feet above the present-day river-bed, as stated. In January, 1908, the writer was having a track cut for some water-pipes from Bridge End, Frosterley, up the lane towards Buckler Dale farmhouses on the southern side of the Wear. A considerable number of whinstone boulders came out of this trench, some large enough to task the strength of the cartman when loading his cart. There were also a number of small pieces, all water-worn. At Buckler Dale, when cutting a trench in 1909, a water-worn whinstone boulder, 3 feet long, was found. The excavated material, from the water-pipe trench mentioned above, contained a number of sandstone boulders, all water-worn, showing that here was evidently an ancient river-bed. The horizon of this ancient river-bed is about 30 feet above the present bed.
of the Wear, which down below to the north washes the edge of Rogerley Park. Fragments of whinstone are thus found all along the valley-gravels at various horizons. As Shittlehope Burn farms and Stanhope are approached, thousands of fragments of whinstone are found in the old fence-walls and farm buildings, all of which belong to the Little Whin Sill and have been turned up in the fields or have been picked up from the river-bed.

If the bed of the Wear be followed up-stream from Broadwood bridge, the outcrop of the Quarry Hazle, Four-fathom Limestone, and Nattrass Gill Hazle is passed over, as at Buddy Holme and at the railway cottages, and then 100 yards or more west of the Stanhope Railway bridge over the Wear, Crookledy

Crag (Fig- 5) is reached, an interesting spot so far as this paper is concerned.

Crookledy Crag is not far from the railway station at Stanhope, and is flanked by the Bond Eales, and the Butts where archery was wont to be practiced in the days of Border warfare. Here, at the crag, on the south side of the Wear is a perpendicular face of blue-grey shale beds, which ovellie [sic] the upper post of the Three-yard Limestone and the Little Whin Sill. These shale or plate beds are given as 33 feet thick in Westgarth Forster's section, 50 feet in the Burtree Pasture Mine section, 34 feet in that of the Slitt Mine, and 37 feet in the Brandon Walls section. This stratum, however, is not all seen at Crookledy. The perpendicular face of shale here is 15 to 20 feet high, and stands up out of the river-bed, where a deep pool touches the base and adds to the picture by reflecting the crag and the overhanging trees. This rock-terrace extends for 100 yards or more, but at the western end of this crag-exposure the river bends to the north, sweeps around the Butts, and then runs along by the side of Stanhope Castle grounds, past Unthank on the south side of the river, and the County Sanatorium at Horn Hall on the north,

where the Little Whin Sill first crops out to form the bed of the Wear (Fig. 6).

From about Unthank Hall and the sanatorium to the rib-arched stone bridge, and to the railway bridge at Messrs. R. Summerson & Company's quarry, at Greenfoot, there are a hundred yards or more of the most interesting geological and physio-graphical features connected with the basaltic sheet, for in this short distance the Wear cuts through the whole of the 30 or more feet of the Little Whin Sill. West of the railway bridge near the whinstone quarry above mentioned, the river runs on

the Six-fathom Hazle, which underlies the bottom posts of the Three-yard Limestone and the basaltic rock under notice.

This whinstone gorge, where the river cuts through it, is most interesting. Standing on the edge of the river, near the southwestern corner of the sanatorium grounds, and looking up stream, the observer sees a long stretch of still water extending along Briggen Winch to the rib-arched stone bridge, and it is bordered by rugged rocks of weathered brownish whinstone; the scene being rendered more picturesque by the overhanging trees, which
are reflected in the long still pool. The vista is broken in the distance by the stone bridge, which, built upon a solid foundation of tinstone on both sides of the river, has withstood the floods of hundreds of years, even when these floods have sometimes all but touched the key-stone of the arch (Fig. 7).

Beyond this bridge, which figures so prominently in the river view, the whinstone continues westwards for some distance, the stream here running more rapidly over the basaltic-rock channel, and being hemmed in on either side by rugged walls of dark weathered whinstone, built up in jointed massive stones. At the end of this channel is situated Messrs. R. Summerson & Company's whinstone quarry, and the valley westwards opens out in a stretch of tableland, widening out from the river, especially where the outcrop of the whin bends around, northwards amongst the farmhouses and pastures, until it reaches Hole House and beyond, where it forms a pretty waterfall on Rookhope Burn.

Might not, this stretch of tableland up to Eastgate village represent a glacial lake held up by the barrier of solid igneous rock, prior to its being broken through at the stone bridge which crosses the river, where the igneous sheet is so conspicuous?

The geologist, however, will probably find a deeper fascination in the study of this rock in Messrs. R. Summerson & Company's quarry. The Little Whin Sill, once a molten mass intruded into its present horizon, no doubt extends in a wide solid sheet eastwards to an unknown distance. We know its outcrop westwards and find that the sill thins out, and is no longer present in the Three-yard Limestone, where exposed in Middlehope Burn, near Westgate, nor in the Slitt Mine shaft, or elsewhere to the west. Considering this western outcrop on each side of the valley one might speculate as to the quantity of basaltic rock which has been carved out of the valley by the joint agencies of glacier, river, and atmospheric denudation. For 3 miles west of the basaltic

[Photograph: Fig. 7.—Stone Bridge over the River Wear, Stanhope: Both Piers are built on the Little Whin Sill.]

gorge at the stone bridge the sill once stretched from the present outcrop on the north to the present outcrop on the south in a solid sheet of igneous rock. The fore-front of the whinstone quarry area is taken up with crushing-mills, railway mineral trucks, piles of paving sets, heaps of mill waste or whin chips, "knoblers'" ** cabins, light tramways, wagons, and heaps of whinstone and limestone road-metal. The quarry-face running up to 30 feet in thickness of perpendicular basaltic rock stretches for some distance east and west, showing a greenish-brown coloration, with bedding planes and vertical

* A "knobler" is one who squares whin sets with a knobling hammer.
joints peculiar to basalt. The rock is very fine in grain, due to the sill being comparatively thin and the consequent more rapid cooling than thicker sheets, like the Great Whin Sill, as found in Weardale. The newly-broken rock has a steel-grey appearance different from the brownish iron-stained natural-jointed exposed surfaces. The analysis shows that the principal minerals

[Photograph: Fig. 9.—a 12-ton Block of Whinstone from Messrs. R. Summerson & Company's Quarry, Greenfoot, Stanhope.]

composing this rock are augite, felspar, and titaniferous ore. The method of working the stone is by big blasts, which dislodge immense quantities of material (see Fig. 8), some of the fragments displaced containing many tons, as, for instance, the 12-ton block shown in Fig. 9.

So far as the whinstone has been worked, the upper post of the Three-yard Limestone has not been seen at the quarry, having been removed by glacial and fluviatile action. The Little Whin Sill is, consequently, overlain by 10 to 15 feet of drift, consisting of boulders of whin, sandstone, water-worn, and ice-scratched limestone, sand, spar fragments, etc. The most interesting boulder found in the drift is a rounded and weathered limestone, about 18 inches long, which, is one mass of fossil encrinites.

In January, 1905, the writer closely examined here an ancient river-bed on the top of the whinstone, which had been laid bare by the removal of the drift. The bed was some 20 feet higher than the present bed of the River Wear, close by, and extended east to north-eastwards for about 240 feet. The top of this ancient basaltic river-bed was smooth and water-worn, or river-polished, much like the present-day river-bed in Killhope Burn, near Cowshill, which is composed of whinstone. In the

[Diagram: Fig.10.—Transverse section through the River Wear at Messrs. R. Summerson & Company's Quarry, Greenfoot, Stanhope.]

crevices of this ancient river-bed was found some very fine clean-washed river-sand, exactly like the clean-washed river-sand of to-day, a sample of which the writer still preserves. The position of this ancient river-bed, and its relation to the bed of the Wear, is shown in Fig. 10.*

Underlying the whin at Messrs. R. Summerson & Company's quarry, the lower "posts" of the Three-yard Limestone are quarried for road-metal. These posts were measured by the writer at a place where they were being worked, and the upper post, under or next to the whin, was found to be 1 foot 10

[Photograph: Fig. 11.—Hole House Crag, Rookhope Valley : the Little Whin Sill is above the Hammer Handle, the Three-yard Limestone below.]

inches thick, the post below 1 foot 5 inches, and the bottom post, called "scraps," 5 inches; the total thickness being 3 feet 8 inches. These posts contain a good deal of iron pyrites in little
"When the Weardale Railway was being made in 1893, the whinstone was cut through along the fields west of Unthank Mill. The line of rails was being made not far from the southern edge of the Wear. When about opposite the ancient river-bed on the north side, as previously mentioned, the railway workmen cut through an "esker" some 80 yards in length and at about the same height above the present river-bed, namely, 20 feet. This "esker" was examined by the writer, and was found to contain clean-washed river-sand, clean and well polished pebbles of various sizes, consisting of sandstones, limestones, etc., all well washed, worn, and polished.

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bright golden cubes. Underneath these limestone posts the writer found some baked shale or pencil-bed.

Leaving Messrs. R Summerson & Company's quarry, the northern outcrop of the basaltic sheet trends along the edge of the tableland, and bends around to the Rookhope valley. At Water Lodge the whin was cut through when the Weardale railway was made in 1893, and at Harelaw, on the northern side of the highway whinstone was quarried many years ago for the turnpike roads. Further westwards, the whinstone is seen in the several pastures on the northern side of the highway, onward, cropping out in Howl John pasture; it then runs past on the northern side of Eastgate House, and thence to the north-eastern bank of Rookhope Burn. Holm House, in the Rookhope valley, stands on the Little Whin Sill, which forms the raised bank stretching all the way from there to Hole House, also erected upon the whin.

[Diagram: Fig. 12. — Shows a Section of Little Whin Sill and Three-yard Limestone at Hole House Crag, Rookhope Valley. (a) Little Whin Sill; (b) Three-yard Limestone (Lower Posts); (c) Three-yard Limestone (Scraps).]

Before coming to Hole House, the bed of basalt is well exposed, presenting a rocky face at the edge of the field, and facing the burn. The top of the Sill is covered with grass, and forms a flat level field. Along the edge of this exposure of 10 to 12 feet high at the whinstone face there are some interesting sections, one of which is shown in Fig. 11. The handle of the hammer shows the dividing-line or junction between the igneous rock above and the limestone posts below. The upper rock was once a molten mass and the lower rock a deep-sea deposit, thus forming an interesting contrast of rock-formation. On August 12th, 1905, when the photograph was taken, the basalt from the handle of the hammer upwards to the grass-covered surface showed a thickness of 8 feet 4 inches, the lower post of the Three-yard Limestone, below the hammer handle, measured 4 feet 3 inches, whilst lower again was a thin post, called "scraps," 5 inches thick (Fig. 12). The whin in section showed a vertical

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cracked and jointed structure, whilst the limestone had a more or less horizontal shattered appearance.

Beyond Hole House there is a similar piece of flat land covering the whinstone, and at the up-stream end the burn bends eastwards, exposing the Little Whin Sill in a sheet some 8 feet thick, where it crosses the Rookhope Burn, forming a pretty waterfall known as Turn Wheel* Linn (Fig. 13).
The edge of the whin crops out along the flat land from Hole House on the side next the burn, and at the waterfall the Little Whin Sill is seen crossing right through the stream to the opposite side.

[Photograph: Fig. 13.— Turn Wheel Linn, Rookhope Burn: Little Whin Sill overlying the Lower Posts or the Three-yard Limestone. The Person in the Photograph is standing on the Limestone, with the Whin behind.]

This waterfall is all the more interesting to the geologist as being formed of a sheet of igneous rock, but the scenery is none the less beautiful to the general tourist, as the north-eastern bank, known as Ashy Bank, forms a fitting background to the snow-looking swirl of the water as it rushes over the darksome basalt at this pretty linn.

* Turn-wheel, from trwyn (British tryn), a snout or nose, as a prominent piece of ground, and weel, wele, wheel (Anglo-Saxon, wael), a whirlpool or eddy, vortex aquarium, as in Ray's North Country Words.

" Whyles owre a linn the burnie plays,
Whyles in a wiel it dimpl".—Burns.

Here the Little Whin Sill is well exposed, and presents fine brown iron-grey water-smoothed front (Fig. 13). The burn runs on the surface of the Little Whin Sill for several yards, then swirls over the edge of the whin on to a bed of limestone, which at the foot of the whin now forms the bed of the burn. The limestone post immediately under the basalt measured 1 ½ feet and the next limestone below 1 foot 1 inch, but this last stratum no doubt is partly under water (Fig. 14). The characteristic appearance of the water-worn whinstone is faithfully represented in Fig. 13.

The post of limestone immediately under the whin is dark blue, and has white fossil-remains on the upper surface. One fossil, about half-an-inch long, showed five joints and six sections of crystalline carbonate of lime. The second post contained numerous amygdaloidal cavities, or small pot-holes, varying in size up to 2 or 3 inches long and 1 inch broad. Some of these contained kernels composed of iron pyrites and clay, and although many were empty, they were probably all filled before the rock was exposed to the weathering influence. Around these holes, several places showed splashes of iron stains, due no doubt to the decomposition of the iron pyrites, a mineral common in limestone associated with igneous rocks such as the Whin Sills.

[Diagram: Fig.14.— Section of Little Whin Sill and Limestone at Turn Wheel Linn, Rookhope Burn, (a) Three-yard Limestone (Upper Post), 4 feet; (b) Little Whin Sill, 8 feet; (c) Three-yard Limestone (Lower Posts), 2 feet 7 inches; (d) Limestone below Water-level.]

On the north-eastern side of the whinstone, forming the bed of the stream, the upper post of the Three-yard Limestone, here about 3 feet thick, runs along the margin or boundary between the bed of the burn and the grass field. After running 150 to 180 feet up-stream, this post dips a little, so that it seems as if to run on to the lower beds of limestone which here appear to crop up and form the bed of the stream. When the writer took his observations on August 12th, 1905, the impression formed as
the probable explanation of this phenomenon was that a fault had crossed and the upper post had slipped down, the upper lost forming the river-bed. If the river runs on the lower posts as it does below the falls, the basaltic sheet has probably thinned out to nothing.

Brandon Walls Lead-mine. From Turn Wheel Linn in Rookhope Burn, where the Little Whin Sill is so well exposed, about three-quarters of a mile up-stream, is situated Brandon Walls lead-mine, now disused, but the water-wheel still figures

[Photograph: Fig. 15.—Brandon Walls Lead-mine, Rookhope Valley: Little Whin Sill sunk through.]

in the bum-side landscape (Fig. 15). This mine was opened to develope [sic] a metalliferous vein which crosses the burn in a north-easterly direction. The washing rake and its machinery stands at a level of about 980 feet above Ordnance datum, or about 100 feet above the top of the whin at the Turn Wheel Linn. John Bailey's 'General view of the Agriculture of the County of Durham' contains a list of Weardale mines; the name of Brandon Walls is found therein, the owner being given as the Dean and Chapter, and the occupiers or tenants as Jopling and Company.*

* 1810, page 37 (Bailey prints the second name "Wells.").

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A working section of this mine shaft and drifts, by John Whaley, sets forth the mine as it stood in 1819, showing all the sinkings then open.

In the section it is seen that the Three-yard Limestone is cut through by the engine shaft, also by one "sump," and one "rise"; and a "drift" has been driven along the top of this limestone, which appears to have the Little Whin Sill in or near the centre. In 1821, this shaft was down through the Five-yard Limestone. A later section shows that the wagon-level from the shaft of this mine had cut, in its course of about 300 feet, right through the Three-yard Limestone and its whin sill, from the bottom to the top. The thickness of this stratum is given as 15 feet, the usual thickness being 9 feet. Mr. John Robinson, the agent, however, in 1841, explains the matter, as he tells us that this stratum appears to be a real whinstone, 15 feet thick, and very productive of lead-ore. Brandon Walls Mine yielded, from 1850 to 1862, 700 tons of lead.

Clearly, as the Little Whin Sill at Turn Wheel Linn has two posts of limestone underneath it and one post above it, whilst the basaltic sheet itself is about 8 feet thick, the 15 feet of the so-called limestone at Brandon Walls is evidently made up in much the same way. Thorney Brow, a mine up Rookhope, and not far from Brandon Walls, is mentioned in 1667 as being within the Fell called "Rooke-hopp." The section of this mine in 1819 shows the Three-yard Limestone with its whin sill as being cut through by the main shaft, and by other workings. It may also be here stated that the Stanhope Burn Mine shaft is sunk through the Three-yard Limestone and its whin sill.

Leaving the Rookhope valley, and going west about 3 miles over the hills, another tributary of the Wear is found at Middlehope valley, which joins the Wear at Westgate. About a mile up-stream from this village is the now disused Slitt Mine. The engine-shaft was sunk down from the Nattrass Gill Hazle through, the Three-yard and other Limestones to the Tyne Bottom Limestone, and through the Great Whin Sill into the Jew Limestone.
In this shaft the Three-yard Limestone is 9 feet thick, and there is no Little Whin Sill. A short distance down the burn from this lead-mine, the above limestone is exposed on the northern bank at a place called Robin Hill's Crag, but here also there is no whin sill (Fig. 16). As the basaltic sheet does not appear in the Slitt Mine shaft or in the exposed burn-section, it must have disappeared between Rookhope Burn and Robin Hill's Crag in Middlehope Burn to the westward.

On the south side of the River Wear, where the whin is so well exposed in the whin gorge at the stone bridge west of Stanhope, the outcrop of the basaltic sheet is traceable from the Unthank fields, where it was cut through in making the Weardale Railway, to Ludwell Burn westward. At the place, where the road to the left passes over the railway on the southern side, opposite Messrs. R. Summerson & Company's quarry, the outcrop is seen, and the sill runs up towards Snows field and to Allergill.

[Diagram: Fig. 16.—Section of Three-yard Limestone at Robin Hill's Crag, Middlehope, near Westgate. (a) Three-yard Limestone (Upper Post), 5 feet (the arrows show the horizon of the Little Whin Sill); (b) Three-yard Limestone (Lower Post), 2 feet 4 inches; (c) three-yard limestone (Lower Post), 2 feet.]

At Horsley Burn the whin forms the bed of the stream, where the road bridge crosses; a few yards farther along its course the whin forms a beautiful waterfall, and is here about 18 feet thick. At the foot of the Horsley Burn waterfall (Fig. 17), the basalt is underlain by the bottom of the Three-yard Limestone, and on examination by the writer these posts were found to contain a good deal of iron pyrites. The southern outcrop continues westwards under Horsley Hall and onwards a little south of Haggate and Billing Shields, and thins out or disappears about Ludwell, 1 ¾ miles west of Messrs. R. Summerson & Company's quarry. This outcrop takes a line nearly parallel to that of the River Wear, due no doubt, to some extent, to the Wear glacier not being much interrupted, whilst the northern outcrop, which bends around to the north as described, has been influenced to some extent by the Rookhope glacier, which would take a similar curve in its action of grinding off the rocks.

The Ludwell district does not give facilities for exploration, but it is possible that the sill may extend to Westernhope Burn before disappearing. The Ordnance Geological Survey map shows the Little Whin Sill running up to the Slitt Vein at Ludwell, after it has crossed the Wear to the southern side, and is shown to cross this vein and to terminate in the bed of Ludwell Burn. As already stated, the whin was sunk into at the Softley and Newlandside mines, the latter being on the Allergill vein, and both on the southern side of the River Wear. The basaltic sheet under notice is not found at any other place westward in Weardale.

[Photograph: Fig. 17.—Horsley Burn Waterfall over the Little Whin Sill.]
water-worn fragments of whin. The more interesting finds are those at the railway side, near the sewage field, which is some 20 feet above

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the present river-bed, and at Bridge End, on the southern side of Frosterley, where whin fragments or boulders have been deposited in great numbers some 30 feet above the bed of the river of to-day. Mention may be made of a thick deposit of river-gravel and fine sand, found a few years ago, behind the Black Bull Inn at Frosterley, in excavating the edge of a terrace for building. This gravel rested on a bed of shale 14 feet above the present river-bed. Continuing the ramble up to Crookledy Crag and to Stanhope, to the whinstone gorge at the stone bridge, the old river-bed on the top of Messrs. R. Summerson & Company's quarry, 20 feet above the bed of the Wear to-day, would be interesting, as also at about the same level the "esker" nearly opposite on the southern bank of the Wear. From above Unthank Mill and Messrs. R. Summerson & Company's quarry the full thickness of the Little Whin Sill has been cut through, and the outcrop splits, as it were, and runs up both sides of the valley for 3 miles or more. A mathematical calculation might give the approximate number of millions of tons of whinstone that have disappeared within the area of a 3-mile angle from the whin gorge on the Wear to the two vanishing points at the ends of the two outcrops.

It may be repeated that the river-bed at Broadwood bridge is about 540 feet above sea-level; at Frosterley bridge, 562 feet; at Messrs. R. Summerson & Company's quarry, the position of the Little Whin Sill may be 650 feet; at Water Lodge, 700 feet; at Howl John pasture, where the whinstone crops out, 800 feet; and at Hole House, which stands on the whin, and at Turn Wheel Linn, about 900 feet. The Three-yard Limestone in Middlehope Burn is about 1,000 feet above sea-level, but the Little Whin Sill has not reached so far westward.

The return journey from Turn Wheel Linn may be taken down the bed of Rookhope Burn to Eastgate village, and in doing so the naturalist will pass over the basset edges or outcrop, in descending order, of the Six-fathom Hazle, Five-yard Limestone, Slaty Hazle, and a thick plate or shale-bed as seen at the foot-bridge of the old corn-mill. Between Holm Linn and this foot-bridge, the rocks mentioned form pretty waterfalls or linns, known by the names of Washpool Linn, Dunter Linn, and Low Linn. The river scenery here is beautiful, what with the linns and rocks and hanging wood. From Eastgate the

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Horsley Burn waterfalls, on the southern side of the Wear may be examined on the return journey.

Three-yard Limestone.—This limestone is so denominated principally upon account of its being, as a rule, 3 yards thick in the North of England lead-mining fields. The name also distinguishes it from the next limestone below, the Five-yard Limestone. Generally speaking it is very constant. Richard Howse and J. W. Kirkby give it as 12 feet in the Alston Moor district. William Wallace, however, in his section of the strata in that district, gives it as 9 feet. The following are taken from the Geological Ordnance Survey sections, which should establish it as a fairly constant stratum: —

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<td>Allenheads Mine : Collier and High shafts</td>
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<td>Blackett Level: Breckon Hill shaft</td>
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Blackett Level : Sipton shaft  
Alston district Haggs Mine, High Raise vein  
Rotherhope Mines, Garrigill  
Burtree Pasture Mine: Weardale Engine Shaft  
Slitt Mine, Weardale  
Green Laws  
Middlehope Burn: exposed section  
Allendale section (T. Sopwith)  

It is difficult to determine the thickness of this limestone where it is shown in connexion with the Little Whin Sill. In several places where this igneous rock is exposed, as at the whinstone quarry near Stanhope, and at Hole House, the section does not show the upper post of limestone covering the Little Whin Sill. At one place, however (Turn Wheel Linn), this top post is, at the northern end, 4 feet thick, and the bottom post at the Hole House section is 4 feet 8 inches thick. These two together make a thickness of 8 feet 8 inches. At Softley and Newlands Mine the agent tells us, in his manuscript notes (1841), that 4 feet of limestone overlies the whin.

Some Associated Minerals.— The minerals associated with the whin sills in Weardale are not of much importance commercially or otherwise; they are nevertheless interesting to the geologist and mineralogist. Generally speaking, the constituents of the whin sill consist of felspar, augite, and titaniferous and magnetic iron-ore. The chemical and microscopical characters of these whin sills have, as already stated, been very exhaustively dealt with by Dr. J. J. H. Teall. He found associated with the whin itself pyroxene, hornblende, mica, quartz, apatite, chlorite, and pyrite. The associated minerals which the writer proposes to mention are principally those which have come under his own observation, or have been communicated to him by persons who worked at the mines mentioned.

(a) Pectolite.—Particulars in respect to the finding of this mineral associated with the Great Whin Sill, at Burtreeford, Weardale, will be found in the Transactions of the Weardale Naturalists’ Field Club.* This mineral, hitherto not known in Weardale, was picked up by the writer and submitted to the authorities at the Museum of Practical Geology, London. It has not been found associated with the Little Whin Sill.

(b) Iron Pyrites.—Though not found in the Little Whin Sill itself, this mineral is very common in the limestones associated therewith. The bottom posts of limestone overlain by the whin at Messrs. R. Summerson & Company’s quarry, Greenfoot, Stanhope, are quarried for road-metal; and the writer has noticed in stones broken to a 2½ inch and 3-inch ring numerous bright golden-yellow cubes of iron pyrites, measuring about one-eighth of an inch on the side; sometimes in one single stone groups of these cubes will be seen, but all separate. The same bottom posts of the Three-yard Limestone under the whin at Horsley Burn waterfall, and at Turn Wheel Linn in Rookhope Burn, contain iron pyrites. The Cockleshell Limestone, which, stratigraphically, lies 62 feet above the Great Whin Sill, is also seen in the bed of Killhope Burn to contain an abundance of cubes, with sides measuring one-eighth of an inch and less, of this mineral.

The above-mentioned limestone is here 18 inches thick, and crops out at a high angle. Where the surface is weathered, the crystals stand out prominently as rounded beads. On breaking the limestone, the sections show a dark, coloured rock, speckled with pyritic cubes.† The Productus shells or "cockles" in this lime-
stone, as in all other limestones subject to the metamorphic influence of the molten mass forming whin sills, are conspicuously white and crystalline, and can be distinguished by their whiteness at a considerable distance.* Limestones in metamorphic areas are found to be distinctly crystalline.

(c) Zinc-blende.—The writer found crystals of blende or black jack in some sparry vein stuff, where a vein crosses the Little Whin Sill below the stone bridge at Stanhope.

(d) Galena:—Miners who worked in the whin sill at Burtree Pasture Mine informed the writer that the vein yielded lead-ore through the igneous rock; also that the Slitt Mine shaft was sunk into the Great Whin Sill, where it proved rich in lead-ore. The Little Whin Sill also yielded lead-ore at Brandon Walls and other local mines in its neighbourhood. Many instances are on record of veins cutting through the Great Whin Sill being productive of lead-ore.

(c) Quartz.—A most interesting mineral specimen from the Little Whin Sill at Stanhope is in the writer's possession. It consists of a piece of whin about 9 inches long, 3 inches wide, and 2 inches thick. The cavity side for one-half of its length is covered with pyramidal quartz-crystals, forming a drusy surface. Over this cluster of forty or fifty crystals arc scattered a number of black opaque specks, like pin-heads, some of which are stuck on to the surface of the pyramid planes, but several are partly sunk into the crystals, whilst others are completely embedded or enveloped in the quartz pyramids. Curiously enough, the other half of the specimen has its surface on the same cavity side covered with beautiful crystalline rhombs of calcite, showing small but well-developed faces along the edges. These drusy rhombs have black specks the same as the quartz, some on the faces of the crystals, some partly sunk into the crystals, and others completely embedded therein. The black specks are haematite. The above-mentioned specimen was taken from a small cavity in the whin.

(f) Calcite. —This mineral is mentioned in the preceding paragraph as being found in beautiful crystals, side by side with

quartz crystals. Calcite is a common mineral, and the writer has seen numerous strings of it running through the basalt at Messrs R. Summerson & Company's quarry. White carbonate of iron occurs in the mines in the Little Whin Sill.

Commercial Uses.—A most interesting use to which whinstone has been put in Weardale recently came to the knowledge of the writer namely, its use as "bushes" or bearings for the axles water-wheels at corn-mills. When the old corn-mill at Boltsburn in Rookhope, Weardale, was demolished in 1890, it was found that the "bushes" were not of hard brass or gun-metal, as generally used for journals and bearings, but of blocks of whinstone, hollowed out for the axle of the wheel (Fig. 18).

[Diagram: Fig. 18.—"Bush," or Bearing, for Axle of Water-wheel, from an old Cornmill, Weardale. This Bush, one of a pair, is made of Whinstone, or Basalt : Length, 8 ½ inches; Width, 5 inches; Thickness, 3 ¾ inches.]

The "bushes" showed evidence of long years of use, and were presented to the writer by Mr. N. Ward in 1905. The millers, when this mill was closed, were Messrs. Joseph Bell & Son.

The two whinstone quarries working in Weardale are the Copt Hill quarry in the Great Whin Sill, worked by Messrs. Monkhouse & Peart, and that belonging to Messrs. R. Summerson & Company, at Stanhope, in the Little Whin Sill. The principal products of the two whin sills are paving-sets for street paving, and 2 ½ inch and 3 inch ring-stones for road-metal. The crushing-mills produce a good deal of chippings, which are used as aggregates in cement-concrete, as top-dressing for highways, and for public and private footpaths. Whin dust is also a product from the crushing mills, and this is used to some extent for mixing with lime and cement. In the neighbourhood of Stanhope and Frosterley, whinstones gathered from the Wear have been largely used as building-stones for farm buildings and fence-walls, and the writer has in his possession a chemist's pestle made of basalt, which was in daily use some 30 years ago. The cobblers' lapstones in the Wear Valley in former days were river-polished blocks of whinstone. The Roman Wall in South Tynedale contains whinstone, and whinstone pillars or monuments exist in the northern lands, as at Redrigs, near Wooler, and at Severing, as mentioned in John Hodgson's Topographical and Historical Description of Northumberland.

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[Plate X.: Map, illustrating the area of the "Little Whin Sill and Lead mines" in the Stanhope/Frosterly locality.)

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1885.—Duff, Joseph, Notes and Investigations of the Coal-fields, etc., of South Durham, page 60.


The Chairman (Mr. T. E. Forster) proposed a vote of thanks to Mr. Egglestone, and said that the members would have an opportunity of discussing the paper at the next meeting.

The vote of thanks was passed unanimously.

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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 9th, 1910.
Mr. T. E. FORSTER, 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 19th and that day.

The following gentlemen were elected, having been previously nominated:

Members—
Mr. William Binnie, Colliery Manager, Wattle Glen Colliery, Bundamba, Queensland, Australia.
Mr. Charles Forster, Engineer, 2, Killowen Street, Low Fell, Gateshead-upon-Tyne.
Mr. Frank Grose, Mechanical Engineer, c/o Messrs. Aramayo, Francke, &Company, Quechisla, Bolivia, South America, via Buenos Aires.
Mr. Frank Cyril Gibson Hill, Engineer, 12, Bigg Market, Newcastle-upon-Tyne.
Mr. Charles H. Holland, Metallurgist and Analytical Chemist, Auckland, New Zealand.
Mr. Richard Algeo Howe, Colliery Manager, Sunnybrow, Willington, County Durham.
Mr. Lionel Clinton Maitland, Colliery Manager, Highfield, Pemberton, Wigan.
Mr. Thomas Rossiter Ridpath, Colliery Manager, Longshaw House, Billinge, Wigan.
Mr. Joseph Crosby Verey, Mining and Civil Engineer, Kilberry, Athy, County Kildare.
Mr. Thomas John Walton, Colliery Manager, P.O. Box 1495, Johannesburg, Transvaal.

Associate Member—
Mr. John Robert Watson, 3, Whitburn Terrace, Marsden, South Shields.

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DISCUSSION OF MR. JOHN CUMMINGS’ PAPER ON "SINKING THE JOHN SHAFT AT HAMSTERLEY COLLIERY, THROUGH SAND AND GRAVEL, BY MEANS OF UNDERHANG1NG TUBBING."

Mr. A. H. Smith (London) wrote that, with regard to the remarks made by Prof. Henry Louis on the form of joint used for the tubbing-segments in the gun-pits sunk through the sludge of the Tyne, he might say that this type was already well known, as lead wires were advocated and used in connexion with tubbing-plates in Germany some years ago. The lead-wire joint (Fig. 1) closely resembled the form of joint (Fig. 2) often used in the United States of America, and had also been employed for the plates installed in the shafts and tunnels of English tube-railways.
At the time when Messrs. Haniel & Lueg introduced finished tooled tubbing-plates, all types of joints, including the lead-wire joint, were taken into consideration, and they came to the conclusion that the form of joint to be adopted for tubbing should not only be capable of shutting out water, but should also be of such a nature as to ensure that the unavoidable inaccuracies in the faces of the tubbing-flanges should be made even.

In engines and machines where; high pressures demanded that machined pieces should join very tightly, it was necessary to have the joining faces carefully scraped, as there were no other means of attaining the purpose in view. It was, however, impossible to scrape the faces of tubbing-plates, for although


these could be machine-tooled in the most accurate possible way it was clear that small inaccuracies would always remain with regard to the parallelism of the horizontal flanges as well as the angularity of the vertical flanges. Machine-tooled faces were moreover, not perfectly smooth, and traces of the steel were always visible. It was consequently impossible to make these tooled faces absolutely tight-fitting, and it was necessary to use a lead joint which touched the whole of the surface of the flanges, so that nowhere did iron meet iron. This form of joint was absolutely necessary for tubbing-plates, and from close observation and extensive experience Messrs. Haniel & Lueg considered that no other type of lead-packing should be adopted. In the lead-wire joint (Fig. 1) the round lead wire must perforce be so thick that the groove was fully occupied by it, and when the plates were being bolted together the lead

must be compressed, otherwise the joint would not be watertight. This compression resulted in part of the lead being pressed into the joint at both sides of the groove, as shown in Fig. 1. The castings were consequently only supported at small areas where the lead wire was squeezed out, whilst the other portions of the faces did not joint. The horizontal grooves must be slotted out so that they did not cross the vertical grooves, which must merely touch at their circumferences, and, in consequence, the lead wires could not possibly be fitted at the points where the greatest distribution of stress took place -that was, at the plates proper. A groove, whether horizontal or vertical, must always be slotted out along the plate (Fig. 1), or bending stresses would occur in the flanges -- a serious disadvantage. Fig. 2 showed an even less practical form of joint, the

plates being put in without lead-packing, so that iron touched iron but not closely. It was, therefore, impossible to attain a uniform distribution of stress. When the tubbing-wall was finished lead rods were inserted into the joints accessible from the shaft, and caulked. This form of joint, it was true, had been extensively employed, but only on account of the fact that the tunnels and shafts of tube-railways were shallow; consequently the tubbing-rings had to stand little pressure. If, however, this form of joint were to be used at greater depths, double failure would ensue, as the lead caulking, owing to high pressure, would be pressed out, and
many tubbing-plates would crack in consequence of the flanges not resting one upon another as accurately as was necessary to attain a uniform distribution of stress.

Such unusually large segments as were used at Elswick could by no means be used at greater depths, as these large plates warped during casting, and it was very difficult to tool plates of such dimensions, for they could not be put into a special machine on account of their unusual size. There would also be a greater risk of damaging and breaking abnormally large castings during handling, carrying, and fitting in. Messrs. Haniel & Lueg had made trials in the direction referred to so far back as 80 years ago, but had come to the conclusion that segments of a uniform size, say, 5 by 5 feet, or 5 by 6 feet, were the practical standard for wholesale manufacture. He (Mr. Smith) congratulated Mr. Cummings, not only upon the able way in which he had overcome the difficulties encountered in his sinking, but upon his very interesting paper on the subject.

DISCUSSION OF MR. CHARLES ARTHUR CROFTON'S PAPER ON "FENCE-GATES FOR WINDING-SHAFT CAGES."

Mr. J. W. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) said that he had some doubt as to the advisability of using fence-gates, because they might in some cases lead to accidents. On the introduction of any new system of that kind, accidents did happen which they did not apprehend at first. In


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the Newcastle district in 1909 there were four cage accidents involving- a loss of seven lives, all of which, he believed, would have been prevented had there been gates on the cages. It was not, of course, possible every year to determine with certainty how many accidents could have been prevented by the use of gates, but it was the case during 1909. On the whole, he should like to see gates tried, as he thought that they might very likely result in the saving of life.

Mr. C. C. Leach (Seghill Colliery) said that he thought that there would be a danger of people getting nipped by the gates, and that danger would exist as long as gates were used.

The President (Mr. T. E. Forster) said that he supposed that in the North of England district they might take it that gates were rather exceptional.

Mr. Atkinson said that practically there were none. In fact, he did not know of a single pit in the Newcastle district where they had gates to close the ends of the cages, and he did not know that gates were common in any district.

Mr. Charles Arthur Crofton (Peases West Collieries) wrote that he agreed with Mr. Atkinson, that it was desirable that fence-gates should be given a trial. It certainly took time to get accustomed to new developments, and a few nips at first would assuredly be better than loss of life; but people would soon learn to keep clear with the same instinct as persons kept their fingers clear of railway-carriage doors. Pits nowadays were getting deeper, and cages bigger, and, in the case of a cage getting "fouled," the tilting, etc., would cause more loss of life, because more men would be conveyed at a time.
DISCUSSION OF MR. WILLIAM MORLEY EGGLESTONE'S PAPER ON "THE GEOLOGY OF THE LITTLE WHIN SILL, WEARDALE, COUNTY DURHAM."

Mr. Stephen Watson (Ireshopeburn, Weardale) wrote that the interesting phenomenon of an extensive igneous sheet wedged into the middle of a thin limestone stratum well merited the attention bestowed upon it by Mr. Egglestone, whose paper


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embraced practically everything that was known about the Little Whin Sill. Although he (Mr. Watson) agreed with Dr. Teall that the Great Whin Sill and the Little Whin Sill might be contemporaneous, he could not endorse the opinion of the late Mr Topley and Prof. Lebour that they were branches of the same intrusive sheet, as local evidence pointed to a different conclusion. A section of the strata from Stanhope through the Slitt Mine to the Burtree Pasture Mine would show the two igneous sheets, not only 550 feet apart stratigraphically, but diminishing in thickness as they approached each other. This latter fact would seem to indicate two widely separated vents or sources.

Mr. John Barker (Bishop Middleham) wrote that the intrusive nature of the Little Whin Sill was evidenced by the fusion, marmorization, etc., of the limestone on which the whin rested. The same evidence was shown on the under surface of the limestone resting upon the whin, the Little Whin Sill having evidently been thrust into the limestone bed.

Mr. T. L. Elwen (Brandon Colliery) said that Mr. Egglestone had made reference to a paper by the late Sir Isaac Lowthian Bell, Bart., in which mention was made of the Hett Whin Dyke, which traversed the workings of Pagebank Colliery, and of its neighbouring dyke, running parallel with the former through the workings of Browney Colliery. At the latter place, the intruded whin sill described in the paper referred to, occurred.

It was generally thought that the whin dyke which passed through Browney Colliery, and might conveniently be called the Browney Whin Dyke, was a split from the Hett Whin Dyke, and that a junction was effected with the latter farther east, probably in the neighbourhood of Shadforth. At that point the Hett Whin Dyke was shown on plans as having a bend to the south-west, and a line projected on the known route of the Browney Whin Dyke met the main dyke at that point. A widening divergence was observed as these dykes were followed westward. How far the Browney dyke extended in a westerly direction the writer was unable to say, although some other member of the Institute might be able to give this information, and place on record further particulars of the dyke.

The intruded whin sill referred to by the late Sir Isaac Lowthian Bell, very probably owed its origin to this whin dyke, as one was in the immediate vicinity of the other. The intruded whin sill lay to the south of the whin dyke. No whin sill was found in the shafts on the north side of the dyke and in the same neighbourhood, although the position of the shafts was in the vicinity of the dyke. It was correct to say that there were several beds of stone called "whin," and described as such in the published shaft-sinkings; but these, although they were of a very hard, gritty nature, were not to be compared with true basalt. In his opinion there was more than a suggestion that the beds of post called "whin" had been affected by infiltration of heat in either a liquid or a gaseous form under great

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pressure. Where these beds had been observed, they were usually found to be of an undulating form in the bedding, and situated well within large beds of post. "Post, with whin" is a term often found in the sinking accounts. The following statement was made in Sir Isaac Lowthian Bell's paper:—

"Above and below the basaltic bed, as found in the pits, there are two well-known seams of coal. In the neighbouring colliery spoken of [Littleburn] these are separated by 50.25 feet of fireclays, shale, and sandstones, while in the present case the intervening rocks measure 103.66 feet, showing an increase of 53.41 feet. Of this only 19.75 feet is due to the whin, the remaining 33.66 feet arising from the thickening of the sandstone and other deposits." *

Further experience had proved that these figures were not quite correct. The thickness of strata between the two well-known seams (the Harvey and Busty) was 100 feet at the pits in the vicinity of Browney Colliery. At that colliery, the thickness of strata tabulated in the published sections between the two seams mentioned was 121 feet, an increase of 21 feet. The thickness of whin was given as 19.75 feet. The deduction to be drawn from a consideration of these figures was a practical confirmation of the theory of its being an intruded whin sill.

It may be of interest to point out the erratic character of this dyke as proved by drifts in the Brandon Colliery district. At one point in the workings of that colliery, a division of the dyke, forming a sort of loop-line of whin dyke with a maximum divergence of 80 yards, was proved. Consequently there was a much

* "On Some Supposed Changes Basaltic Veins have Suffered during their Passage through and Contact with Stratified Rocks, and on the manner in which these Rocks have been Affected by the Heated Basalt," by I. Lowthian Bell, Proceeding of the Royal Society of London,1875,vol.xxiii., page 545.

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larger area of spoilt coal, as each dyke had its accompanying area of cinder-coal. Another case of a division of that particular dyke was proved, the writer understands, at Croxdale Colliery. A break in the vertical continuity of the dyke had been proved by drifts. In one case, it was found that the dyke was encountered in the top part of the drift only, the whin dyke terminating in an oval shape in the middle of the drift, and the strata in the lower part of the drift beneath the whin being made up of contorted shale. The thickness of whin in the dyke decreased slightly to the westward, and increased to the eastward as it approached the junction with the Hett Whin Dyke. This observation applied to the different seams at or near the same geographical position. Several faults ran parallel with, and in close proximity to, the whin dyke. An alteration of the level of the seams on opposite sides of the dyke had been observed, but this was due to ordinary faults in close proximity to the dyke, and not to the dyke itself.

In the vicinity and on both sides of the dyke the direction of the cleavage of the coal in all the seams had been altered. The normal direction of the cleat was north 20 degrees west; but near the whin dyke this became north 65 degrees west, or from headways-way to full cross-cut. The line of cleavage gradually came round to normal at a varying distance from the whin dyke. The direction of the whin dyke was north 80 degrees west. The cleavage had been drawn round to the dyke in an easterly direction.

On thinking over the peculiar nature of an intruded whin sill, the writer had considered whether, and to what extent, subsidences due to the adjoining faulting of the
strata (if such occurred at the time of the forming of the whin dyke) could have favoured the presence of the whin sill. It was possible for a large area of strata, to be held up, as it were, in such circumstances, and to admit of an intrusion of lava between beds of strata. In the case in question, the intruded bed of whin lay directly under a thick bed of post, and also stratigraphically in the position previously occupied by a seam of coal called the Lower Harvey, which seemed to have been burnt to some extent. A large fault with downthrow to the south existed in the vicinity, and on the south side of the whin dyke near the intruded whin sill.

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Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) said that Mr. Egglestone stated that the Little Whin Sill was unknown in any other locality in the North of England. There was an intrusive Whin Sill, 10 to 11 feet thick, now being quarried at a place called Salmon Field, near Rowley Burn, in Hexhamshire. It was not shown on the Geological Survey map; but, according to the succession given on the map, it was above the Fell Top Limestone, though below two thin limestones: and it was quite possible that this might be the same bed as the Little Whin Sill. Mr. Egglestone, in giving a summary of the Carboniferous rocks of the North of England, had also stated that the Upper Red Sandstones were not present anywhere. In a paper by Drs. B. N. Peach and J. Horne, on "The Canonbie Coal-field, its Geological Structure and Relations to the Carboniferous Rocks of the North of England and Central Scotland," it was stated that red sandstones which had hitherto been considered Triassic were Carboniferous. He (Mr. Atkinson) thought that a bore-hole had been put down on the English side, through these red rocks, proving the extension of the Canonbie coal-field. Then, in the northern part of the Cumberland coal-field there were red sandstones that were shown on the Geological Survey map as Triassic, but he suspected that they were Carboniferous, and equivalent to those red rocks that were to be seen over the Canonbie coal-field. In the section of strata given by Mr. Egglestone, use was made of the word "tuff," the term "siliceous" being added in brackets. He (Mr. Atkinson) thought that this must be a misprint, the bed being really known as "tuft," a very fine-grained sandstone, almost like ganister---in fact, if was worked as ganister at Fourstones below the Great Limestone. The word "tuff" really meant volcanic ash, and there was no suggestion that this was volcanic ash.

He (Mr. Atkinson) should also like to have the opinion of the writer or any of the members as to the meaning of the word "craw-coal." Was it simply outcrop coal, or burnt coal, as some people seemed to think? The word occurred two or three times in Mr. Egglestone's paper, and, on making enquiries, he had found it difficult to understand what was meant by the term.


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The President (Mr. T. E. Forster) thought that craw-coal originally taken to mean outcrop coal, and then the word to be applied to inferior coal, because it was like outcrop coal.

W. M. Egglestone (Stanhope) wrote thanking those members who had found his paper interesting, and submitted the following observations on the various points raised in the discussion. With respect to the statement that the upper post of the Three-yard Limestone had not been found at the top of Messrs. Summerson & Company's whinstone
quarry at Stanhope, the writer had been informed that at the eastern end of the quarry the manager had found the limestone post, which was there to 5 feet thick.

Referring to the use of whinstone for cobblers' lapstones, he had been informed quite recently by a shoemaker at Stanhope that he had a lapstone* of whinstone in daily use.

The Salmon Field intrusive whin sill, near Rowley Burn, in Hexhamshire, was mentioned by Mr. Atkinson as being above the Fell Top Limestone. In Weardale that limestone was, roughly, about 200 feet above the Little Whin Sill, which in Weardale had not been found to change its horizon. At Stanhope the Little Whin Sill was 30 feet thick; in Rookhope Burn, 3 miles north-west, it was 8 feet; and in Middlehope Burn, 3 miles farther west, it did not appear in the Three-yard Limestone or in the Slitt Mine shaft. Prof. Lebour† had mentioned a thin sheet which occurred in the North Tyne, close to Haughton Castle, as being very similar to the Little Whin Sill of Weardale. The thin Weardale sill would not be likely to reach the Salmon Field district unless the original source was favourably located. That source was not known.

The writer had not seen the memoir by Drs. B. N. Peach and J. Horne on "The Canonbie Coal-field, its Geological Structure, etc.," which mentioned the red sandstones, hitherto known as Triassic, as being Carboniferous.

*"Lap-stone, is not, as might naturally be supposed, the stone which the shoemaker places in his lap to hammer leather upon it, but the cobble-stone (from Dutch 'lappen', to cobble or patch, lapper, a cobbler, lapwerk, cobblery)."—Folk-Etymology, by the Rev. A. Smythe Palmer, 1882, page 208.


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Tuff, as mentioned by Mr. Atkinson, was a misprint for tuft. There was no tuff or volcanic ash in Weardale.

Craw-coal or crow-coal was a name given to small seams of impure coal found amongst the Mountain Limestones of Weardale and adjoining dales. Formerly this coal was employed locally for three purposes. It was used, after being crushed small, for mixing with clay to form balls called "cats," and these were used in connexion with peat as fuel for domestic fires. At bed-time the dwellers amongst the hills covered the kitchen fire completely over with these clay-balls and then made a few holes through the top covering with the poker. In the morning there was a good hot fire. Secondly, as the limestones cropped out along the hillside, and also this impure coal, the farmers bent on improvement won limestone and coal, and with wood and peat made lime-kilns on the ground, which were called "soo-kilns." The coal, wood, and limestone were covered with sods or turf, and after so many days the farmer had a good stock of lime to lay on to his pasture-land. Sometimes, when pit-coal was dear, the craw-coal was used for domestic fires.

The Weardale seams of craw-coal were from a few inches to 18 inches thick, but rarely 2 feet thick. There were one or two of these seams associated with the Fell Top Limestone. Coal and ironstone occurred in descending order above the firestone stratum. Two seams, 12 and 18 inches thick respectively, occurred in the coal-sills situated just above the Great Limestone. Another seam was seen below the Scar Limestone. The coal was hard and slaty, and gave off a sulphurous smell. John Bailey said: "Not crow coal, as some people term it. It is derived from the craw or crop of a fowl: and in many places is called crop coal; and any seam coming to the surface, is said to crop out."**
J. T. Brockett explained crow coal as a seam of coal so called, of inferior quality.† In R. Oliver Heslop's Northumberland Words,‡ an extract was taken from Hodgson's History of Northumberland,§ as follows: "The crow-coal is a thin seam of coal worked in the South Tyne, obtained from grooves made in the * The Agriculture of the County of Durham, by John Bailey, 1810, page 11.


‡ 1892, page 191.

§ 1840, vol. iii., part ii., page 33.

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craw or crop of the strata." An early reference may be given from John William's book, from which later writers may have copied:

"The vulgar error of the craw coal, as it is called in Scotland, frequently proves a dangerous error, and, therefore, I will explain the matter in order to give a caveat against the pernicious consequences of that notion. What is meant by the craw coal, is the crop coal, or upmost seam of coal in the field, which is always supposed to be a thin one. The notion of the craw coal originated from the false supposition, that in all places where coal is found, a thin seam is upmost, and that when once a thin seam is found, you are sure to find a thick seam at a moderate depth below the thin one, or craw coal. the notion of the craw coal still prevails in many parts of Scotland." *

Evidently thin seams of coal cropping out in the various valleys were called "out-crop" coal, to distinguish them from what might be termed pit-coal, and the initial component "out" has been dropped, hence crop-coal. There would, however, be nothing out of place in calling this coal "crag"-coal, a thin seam of coal cropping out amongst the rocks or crags.

The writer was inclined to favour craig (Wales), crick (England), crau (Savoy), a rock or crag, as was found in many names of places. In the Tyrol, Isaac Taylor pointed out, we have the prefix kar, and in the Savoy it took the form of crau; this form also appeared in the name of a barren boulder-covered region between Arles and Marseilles, which was called La Crau.†

A tributary of the Wear in Wolsingham parish was called Wascrow or Westcrau. The first component might be from waes (water), and crau (a crag or rock). Crawley or Crawlaw Side, near Stanhope, was a rocky edge of moorland, evidently the crau or rocky law. There was a Craw Law in Northumberland. All the seams in the Mountain Limestone in Weardale were thin, and were all called crau-coal.‡

The note contributed by Mr. T. L. Elwen had added considerably to the knowledge of the conditions and behaviour of the basaltic dykes and sills in the East Durham coal-field. George Tate mentioned in 1868, that "in a pit-sinking at Long Dike, in search of the Shilbottle coal, two layers of basalt were passed through: one, 15 feet thick, is between metamorphosed * The Natural History of the Mineral Kingdom, by John William, 1789, vol. i., page 65; second edition, 1810 vol.i, page 62.

arenaceous beds; and the other, 63 feet lower down, and 2 ½ feet thick, penetrates, metamorphoses, and partly replaces a seam of coal."**

Mr. Watson had stated that he could not endorse the opinion of the late Mr. Topley and Prof. Lebour that the two whin sills were branches of the same sheet, as local evidence pointed to the Little Whin Sill thinning out towards the Slitt Mine westwards and the Great Whin Sill thinning out from the Burtree Pasture Mine towards the Slitt Mine 3 miles eastwards. The Great Whin Sill had been sunk through at both of these mines, which were about 6 miles apart, and at Burtree Pasture Mine the basalt was considerably thicker than at the Slitt Mine. The limited view of a stretch of 6 miles, and the only apparent evidence being the thickness of the whin sill, would not, he (Mr. Egglestone) thought, have any bearing upon the general view of the thinning out of the whin sill westwards, as laid down by Sir Archibald Geikie in The Ancient Volcanoes of Great Britain. The diagram (Fig. 1)† clearly showed all along the western escarpment the thinning of the whin sill (as at Swindale Beck, 6 feet), and then there were 18, 40, 54, and 60 feet at the Pennine escarpment, and 75 feet at High Cup Nick. It was well known that the Great Whin Sill formed in many places along its Northumberland outcrop great bosses of abnormal thickness, and a boss of this basalt was shown at Burtreeford. If the boss in Killhope Burn, where it was being quarried, were examined, on the immediate west side of the quarry, it would be found that the whin was seen dipping westward underneath the bed of the burn. Eastward, it rose out of the burn, and within about 100 yards near the church to a height of 45 feet or more above the bed of the burn. The basalt then fell on the eastern side through the effect of the Burtreeford fault, and dipped at a high angle into and under the bed of the burn. From this point eastward down to the fault near Burtreeford bridge the various limestones and sandstones showed the bedding at a high angle. The Burtree Pasture Mine shaft was on the eastern side of the great fault, and whether or not that disturbance affected the thickness of the whin sill in the shaft, there was no apparent reason to suppose that the abnormal thickness

"We constantly find sheets of lava thus inserted between beds of aqueous origin. The areas over which these intrusive sheets of rock sometimes extend may be very great, but the more fusible, basic lavas (basalt, etc.) usually form much more widely-spreading sheets than the less fusible, acid lavas. In some cases these great intrusive sheets are found extending to a distance of twenty or thirty miles from the centre at which they were ejected, and they often follow the bedding of the strata with which they are intercalated in so regular a manner, that it is difficult for an observer to believe at first sight that they can have been formed in the way which we have described. A closer examination will generally reveal the fact that while these intrusive lava-sheets retain

their parallelism with the strata among which they have been intruded, over considerable areas, yet they sometimes break across, or send off shoots into them, as shown in Fig. 56 [i.e our Fig. 2]. In all cases, too, the rocks lying above and below such sheets will be found to be more or less baked and altered, and this affords a very convincing evidence of the intrusion of the igneous mass between the strata so altered."

Referring- to the use of whinstone for water-wheel axle-bearings, Mr. J. J. Angus, engineer, who went from the Wear valley to the United States of America many years ago, informed him (Mr. Egglestone) that it was customary to line the inside of the whinstone bearing with a strip of thick pigskin taken from a flitch of bacon with some of the fat bacon still adhering to the inside, which came in contact with the journal of the axle. This made an excellent lubricant, and by the time that the fat bacon of the pigskin was all worn away with the revolution of the axle, the surface of the whinstone bearing was found to have taken on a glaze-like polish, which, with a proper lubricant, was practically everlasting.

* Volcanoes, by John W. Judd, 1881, page 136, and Fig.6

The following paper on "The Ignition of Coal-dust by Single Electric Flashes," by Prof. W. M. Thornton and Mr. E. Bowden, was read by Prof. Thornton :—

THE IGNITION OF COAL-DUST BY SINGLE ELECTRIC FLASHES.


Introduction. The experimental work described in this paper is in two parts, (1) a short examination of the properties of coal-dust under electrification, and (2) an investigation in detail of the conditions under which a cloud of coal-dust can be ignited by single electric
flashes. The point of view throughout is that of the user, of electrical plant, and no attempt is made to follow the nature of the chemical and physical changes which occur.

The ignition of coal-dust by a steady continued source of heat, such as a flame, a red-hot wire, or a stream of sparks, has been very fully investigated by Prof. P. Phillips Bedson. The chief points which have been established are the temperature required to cause ignition, the density of the cloud, and the relative susceptibilities of different kinds of coal-dust, having regard to the percentage of volatile matter. Prof. Bedson's method of producing a cloud has been found to be most convenient.

The coal-dust upon which the present experiments were made was a mixture of three typical dusts from different seams, kindly sent by Mr. Philip Kirkup, from the Birtley Collieries. By mixing the three dusts, the uncertainty of depending upon any one dust was averaged. The dust was not sieved before use, and contained 10 per cent. of ash, chiefly calcareous.

Dry Coal-dust on Insulator----It has long been known that coal in bulk, or as dust, is not a conductor of electricity. Its specific resistance (ohms per centimetre cube) is, in fact, so high that it is, when dry, a good insulator.* It was found to undergo no change when placed for several months between terminals.


Wet Coal-dust a Conductor.—If, however, a paste, made of coal-dust and water, is placed between terminals 1 inch apart on a marble base, and electrified either by direct or by alternating-pressure at 480 volts, a remarkable change takes place. Sparks pass through the substance of the paste, and eventually a large flash strikes across, short-circuiting the terminals. The cause of this has not yet been determined. It may be the ignition of gas given off by the action of the sparks in the moist dust, or by the carbonization of the dust, so that it is rapidly reduced from an insulator to a conductor. It is not solely due to the presence of water, for wet sand under identical conditions never flashes over. Nor is it due to the conductivity of the flame, for a candle-flame held between terminals 0.25 inch apart with 480 volts across them will not cause a flash over. It requires more than 1,000 volts to do this. The result is more probably due to the establishment of a line of carbonized particles of the dust short-circuiting the terminals.

It is of interest to compare the behaviour of wet and dry dusts with that of other mixtures. The following trials were made to examine the effect of changing the percentage of volatile matter. The dusts were placed between terminals ¾ inch apart, at 480 volts direct current.

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Mixture of coal-dust and pentane</td>
<td>No effect</td>
</tr>
<tr>
<td>(b) Mixture of coal-dust and methylated spirits</td>
<td>Slight sparking.</td>
</tr>
<tr>
<td>(c) Dry powdered shale</td>
<td>No effect</td>
</tr>
<tr>
<td>(d) Wet powdered shale</td>
<td>Steamed and sparked slightly.</td>
</tr>
<tr>
<td>(e) Powdered coke : loosely sprinkled</td>
<td>No effect</td>
</tr>
<tr>
<td>(f) Powdered coke : pressed together</td>
<td>Sparked, flamed, and flashed over.</td>
</tr>
</tbody>
</table>
(j) Wet coke-dust
Steamed, but did not spark or flash.

(h) Powdered arc-lamp carbon
Sparked and flashed over.

(i) Powdered carbon brushes
Sparked and flashed over.

(k) Damp, wet, or very wet sand
Steamed and dried, but did not flash.

Short Circuit by Metallic Vapour.--- Although a flame caused by the slow combustion of hydrocarbons will not short-circuit terminals under moderate pressure, it can be shown that the vapour of a fuse when blowing will do so. For this purpose a box was made containing four terminals on a teak base, arranged as in Fig. 1. Across the upper pair a pressure of 480 volts was maintained, and between the lower a, fuse of copper or tin was connected. When this was blown by short-circuiting 100 volts through it from a small generator, on either direct or alternating current, the incandescent vapour reaching the upper terminals short-circuited them, and caused a violent flash over.

[Diagrams: Fig 1.—Experimental Box with Four Terminals; Fig. 2.—Distribution-box : Wrong method of arranging terminals; Fig. 3.—Distribution-box: Right method of arranging terminals]

A point of some practical importance arises from this. When electric cables are brought along a roof, they are sometimes taken into a distributing-box from the top, so that in a simple case they would be as in Fig. 2. In the event of one of the inner fuses blowing hard, the dividing partition not being sound, the vapour can short-circuit the main distributing-bars, and cause a flash over with all the power on the mains behind it. If, however, the cables are brought in from below, as in Fig. 3, the fuse clears itself without risk to the circuit. It may be mentioned that the stone forming the side or roof of a gallery is always so good an insulator that there is no flash or spark produced by striking it with the ends of live cables, even when these are only half an inch apart. The flashes which have been sometimes attributed to the contact of a broken cable with the roof can only be due to the interruption of the current between the broken ends of the wires.

Ignitions of Clouds of Coal-dust. — To produce a coal-dust explosion experimentally, the cloud of dust must not be too thin or too dense. In the former case, a local ignition is extinguished by the cooling action of the air, in the latter by the products of combustion. The space also in which ignition occurs must not be too confined.

[Diagram: Fig. 4.—Apparatus for Producing Coal-dust Explosion : Longitudinal Section.]

The apparatus used (Figs. 4 and 5) consisted of a stout wooden box, with a hinged lid, in which was a glass window. The dust as blown in by foot-bellows through a 1/4 inch glass tube from a storage-bottle. Through the sides of the box brass rods were fitted, one fixed, the other free to slide in a sleeve, and with a stout spring so arranged that by a trigger a quick break could be made between the poles a and b, if desired. When the free rod was fully drawn back, the distance between the poles was 2 ½ inches. While testing the action of fuses, two spring contact-makers were slipped over the ends a and b, and the fuse inserted between them. After each ignition the air in the box was swept out. The break was always at...
the same rate, and after practice the draught could be adjusted to give nearly the same cloud in each case. Any variation in this was covered by the large number of tests made.

[Diagram: Fig. 5.—Apparatus for Producing Coal-dust Explosion: Cross Section.]

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Electric flashes can be produced by the mechanical breaking of the circuit or by the fusing of a wire. In coal-mining practice the latter is not very likely to occur in a dangerous place, and attention was therefore concentrated upon flashes produced by the quick breaking of circuits under different conditions of voltage and current.

Direct current was first tried, and, in order to examine the case least favourable to ignition, the circuit was kept non-inductive. The object was to find the smallest current which would fire dust, and, if possible, that which always caused ignition.

In many cases there was burning of the dust around the flash, which travelled locally in the box, but which was not a complete ignition accompanied by a considerable rise of pressure. The results have therefore been divided into full and partial ignitions. No case can be considered safe, however, when there is even a partial flare. For the purpose of tabulation, two partial ignitions have been taken as equal to one full one.

[Graph: Fig. 6.—Percentage of Ignitions vs. Amperage, from Table 1.]

TABLE I. (Fig. 6). Quick Break; 100 volts; Direct current; Non-inductive [Simplified]

<table>
<thead>
<tr>
<th>Amperes</th>
<th>% of Ignitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>0.0</td>
</tr>
<tr>
<td>75</td>
<td>2.5</td>
</tr>
<tr>
<td>84</td>
<td>6.6</td>
</tr>
<tr>
<td>90</td>
<td>10.0</td>
</tr>
<tr>
<td>110</td>
<td>20.0</td>
</tr>
<tr>
<td>120</td>
<td>24.0</td>
</tr>
</tbody>
</table>

(Least current causing ignition 71.3 amps.)

[286]

TABLE II. (Fig. 7). Quick Break; 240 volts; Direct current; NON-INDUCTIVE. [Simplified].

<table>
<thead>
<tr>
<th>Amperes</th>
<th>% of Ignitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.8</td>
<td>0.0</td>
</tr>
<tr>
<td>12.0</td>
<td>4.8</td>
</tr>
<tr>
<td>15.5</td>
<td>11.3</td>
</tr>
<tr>
<td>18.0</td>
<td>24.0</td>
</tr>
<tr>
<td>27.0</td>
<td>48.0</td>
</tr>
</tbody>
</table>

(Least current causing ignition, 11 amperes).

[Graph: Fig. 7.—To Illustrate Results given in Table II. Plot of % Ignitions versus Amperes gives a straight line graph.]

TABLE III (Fig. 8) Quick Break: 480 volts Direct Current, NON-INDUCTIVE. [Simplified]
Amperes. | % of Ignitions.
---|---
5.78 | 0.0
6.67 | 8.1
7.14 | 18.0
7.65 | 19.8
10.30 | 60.0
13.00 | 100.0
25.00 | 100.0 (violent)

(Least current causing ignition, 5.8 amperes.)

From the figures in the foregoing tables it will be seen that the percentage of ignitions is proportional to the increase in current. Calling the ratio of ‘change of percentage increase’ to corresponding ‘change of current’ (M), and drawing M with respect to voltage as in Fig. 9 the curve obtained follows nearly a square law; that is, the increase of percentage per ampere is proportional to the square of the voltage. Writing then \( M = k(v^2) \), \( c \) the current, and \( p \) the percentage of ignitions, \( p = k(v^2)c - a \), where \( a \) is the intercept on the vertical axis of the straight lines of Figs. 6, 7, or 8. The percentage is therefore not proportional to the power of the flash, but to the product of this and the voltage.; For a given voltage it has, as shown, a linear relation to the current; so that the risk of ignition is proportional to the volume of the flash.

Inductive Circuits. — In practice, direct-current motor-circuits are to be classed as inductive, although the field-coils are connected across the armature when running, and do not affect the flash at break of the main circuit. By comparison of the experimental flash with that on breaking a 20-horsepower 480-volt motor-circuit, an inductance was chosen to imitate the case.

Two 2.5-kilowatt transformers were, connected with their primary coils in series, and all the direct current broken passed through them. The inductance was 1.08 henry at low saturations. The results were as follows:

<table>
<thead>
<tr>
<th>Volts.</th>
<th>Quick break; Direct current; Inductive circuits.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Simplified</td>
</tr>
<tr>
<td></td>
<td>TABLE IV.</td>
</tr>
<tr>
<td>Volts.</td>
<td>Amperes.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>100</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>32</td>
</tr>
<tr>
<td>240</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td>9.0</td>
</tr>
<tr>
<td>480</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>5.5</td>
</tr>
</tbody>
</table>
Least currents causing ignition were 16, 5.7, and 2.3 amperes respectively,

Comparing the inductive with the non-inductive cases, it will be seen that the influence of inductance has been to lower the limit of safety by one-half at least, and in the 100-volt case to nearly one-fifth of its value in non-inductive circuits. The same inductance was inserted in the line in each case, but the saturation depending to some extent upon the current, its influence is less for higher currents.

Slow Break.—In the case of a cable parting by a gradually applied load, such as a subsidence, the break may not be rapid. This was imitated by drawing the poles apart slowly by hand. As might be expected, any current broken in this way is found to be more liable to produce ignition than when interrupted quickly.

**TABLE V.** Slow break ; Direct current ; Non-inductive.[Simplified]

<table>
<thead>
<tr>
<th>Volts.</th>
<th>Amperes</th>
<th>% of Ignitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>33</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>7.7</td>
</tr>
<tr>
<td></td>
<td>38</td>
<td>64.5</td>
</tr>
<tr>
<td>240</td>
<td>20</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>21.0</td>
</tr>
</tbody>
</table>

With 480 volts the currents were so small that the results can better be expressed qualitatively. With 0.3 ampere, there was one slight ignition; with 0.65 ampere, occasional full ignitions: with 0.9 ampere, ignitions almost every time; and at 1.15 amperes, every flash caused ignition.

Alternating Currents.— In view of the extensive application of alternating current to underground work, it was necessary to determine the percentage of ignitions for alternating current also. By the nature of the case there should be less risk from breakage of cables, for in addition to the probability or improbability of ignition, as expressed by the foregoing tables, there is the frequent chance that the arc may break in passing through zero current, and may not be able to re-establish itself. The current is therefore very rapidly cut off. On the other hand, if a current breaks at the crest of the wave the flash is larger than for equivalent direct current; but this occurs so rarely that, during the present experiments, it has only been seen once or twice.

In dealing with alternating currents, the same method was used as with direct currents when the circuits were non-inductive, the same resistances, giving a power factor of 0.92, being used. This is sufficiently non-inductive to compare with carbon incandescent lamps, which have a power-factor of 0.95 and upwards.

**TABLE VI.**—Quick Break ; Alternating Current; Non-inductive; Frequency, n.[Simplified]

<table>
<thead>
<tr>
<th>Volts.</th>
<th>Amperes</th>
<th>% of Ignitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>170</td>
<td>2.0</td>
</tr>
<tr>
<td>n = 40</td>
<td>300</td>
<td>5.8</td>
</tr>
</tbody>
</table>
Least current, about 150 amperes at 77 volts.

It was not possible to obtain non-inductive currents higher than 112 amperes at 100 volts, and the lowest direct voltage used was 100, for which the least current on non-inductive circuits was 70.3 amperes. It is clear from the above figures that the least value in the alternating case is not far short of twice that for direct currents.

Alternating currents in colliery work have a power-factor usually less than unity. An average value of 0.8 would represent favourable conditions in a load composed of induction-motors with a little lighting. The following trials were made with the power-factor kept as nearly as possible to the standard 0.8.

TABLE VII.—Quick Break; Alternating Current; with Some Inductance; Frequency, 40.
[Table and graph omitted: An extensive set of results with graph (Fig. 10), showing that at 1000 volts the % of Ignitions, at power factor 0.50, increase, from 0 to 60, quite quickly with current increases from 3.3 to 5.5 amps.]

The least currents given below were not so surely found as in direct current cases, on account of the difficulty of controlling the conditions. They are, at least, close approximations.

Proceeding as before, and plotting the increase of "percentage of ignitions per ampere M" against "voltage", Fig. 11 is obtained.

Above 400 volts this follows a square law, as in Fig. 9, but below this the increase of M is exceedingly slow. The product \( Mv^2 \) must always be positive, but for it to have appreciable values the current to produce ignition must be very large. The increase of safety gained by alternating currents breaking frequently in passing through zero is well shown by comparison of Figs. 9 and 11. In the former, the curve starts from zero voltage, and in the latter the marked rise begins from about 350 volts. There is a parabolic rise in each case, the horizontal displacement in the latter being caused by the above effect.

For ready comparison, the least currents have been collected in Table VIII., and these give the limits at which certain danger of ignition begins. They are drawn in Fig. 12.

TABLE VIII.—Least Current which Ignites Coal-dust, when Interrupted by a Quick-break Switch.
[Table omitted]

[Graph: Fig. 12.—Least Current Required to Ignite a Cloud of Coal-dust: A, Alternating Current: Power-factor, 0.8; B, Direct Current, Non-inductive; C, Direct Current, with Some Inductance.]
Graph: Fig. 13.—Comparison of Safety of Alternating and Direct Currents. R=Ratio of least Alternating to least Direct Current to produce Ignitions of Coal-dust.]

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The curves show without doubt that the order of danger of Ignition over the whole range of voltage examined is direct inductive, direct non-inductive, and alternating currents, as might have been expected. The remarkable feature is the great increase in safety at about 100 volts. Taking direct non-inductive current as the standard, because of the certainty of its conditions, the relative safety can be expressed as in Table IX. and Fig. 13.

**TABLE IX.—Relative Safety of Electric Currents at Different Voltages.**

<table>
<thead>
<tr>
<th>Volts</th>
<th>Direct Non-inductive Currents</th>
<th>Direct Inductive Currents</th>
<th>Alternating Currents</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1.0</td>
<td>0.228</td>
<td>2.00</td>
</tr>
<tr>
<td>200</td>
<td>1.0</td>
<td>0.407</td>
<td>3.56</td>
</tr>
<tr>
<td>300</td>
<td>1.0</td>
<td>0.438</td>
<td>3.54</td>
</tr>
<tr>
<td>400</td>
<td>1.0</td>
<td>0.338</td>
<td>2.78</td>
</tr>
<tr>
<td>500</td>
<td>1.0</td>
<td>0.354</td>
<td>2.09</td>
</tr>
</tbody>
</table>

The safety-ratio of alternating to direct currents increases and then decreases. The risks of ignition are more equal at lower voltages because of the larger volumes, and at higher voltages because of the longer duration of the flashes.

The fact that at any given voltage the increase in the percentage of ignitions is proportional to the increase of current, suggests that in any case the probability of ignition is proportional to the volume of the arc; that is, since the arc is drawn out in the same way in each case, to the surface in contact with the dust.

Under the favourable conditions of the experiments, the actual volume required to start an explosion is surprisingly small. The process is probably a liberation of gas at the surface of the flame, followed by its local ignition. The volume of flame is then rapidly increased, and an explosion occurs. The influence of voltage is to introduce a time element, the longer duration of the flash at high voltages more than compensating for the smaller current necessary for ignition.

The currents required to ignite dust with certainty at every flash can be found from Figs. 3, 4, 5, and 7. They are given in Table X.

At higher pressures the ratio is unity; that is, every flash produces ignition, whatever the current may be.

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**TABLE X.—Quick Break of Current.**

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Least Current</th>
<th>Certain Current</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 direct current</td>
<td>70.3</td>
<td>270.0</td>
<td>3.80</td>
</tr>
<tr>
<td>240 direct current</td>
<td>41.0</td>
<td>44.2</td>
<td>1.08</td>
</tr>
<tr>
<td>480 direct current</td>
<td>5.8</td>
<td>13.0</td>
<td>2.20</td>
</tr>
<tr>
<td>1000 alternating current</td>
<td>4.1</td>
<td>6.4</td>
<td>1.56</td>
</tr>
</tbody>
</table>

Three-phase Currents.—The flash on breaking a three-phase circuit differs only from that of single-phase in the division of energy between the three terminals, and the formation
of a smaller arc at each. There is, however, the risk that the break of one of the three may occur at a crest value, and this seems to take place more frequently than in single-phase working. Trials were made by bringing all three cables into the ignition-box and arranging them so that the break should be simultaneous on each. The greatest power which could be obtained for the experiment was 5 kilowatts on a fully-loaded 200-volt induction-motor.

There was found to be no chance of ignition with the currents used. From a comparison of the behaviour of single- and three-phase circuits at the same voltage and load, it may be said that a load of 5 kilowatts can be interrupted in a dusty atmosphere with comparative safety at 200 volts, and rather less than this on 500 volts, with either system.

Fuses.—Fuses are not generally placed where a cloud of dust can reach them; but a case is known of a distribution-box being broken several times by a fuse blowing in a space to which coal-dust could penetrate through a small hole. On plugging the hole, the explosions ceased.

The trials recorded in Table XI. were made in order to compare the action of a blowing fuse on direct and alternating currents with the previous results.

The list is not complete, but sufficiently so to bring out the following essential points:—(1) The more violently a fuse blows—that is, the greater the ratio of the current in the circuit to the fusing current of the wire, the greater is the risk of ignition; (2) the ratio of percentage of ignitions of direct to alternating currents for the same low voltage and current is 4 to 1; (3) the nature of the fuse-wire does not appear to have much influence; (4) the least current for ignition is comparable with that for direct non-inductive circuits, much less at low voltages, and nearly equal at 500 volts. The determining factor in each case is the volume and duration of the arc.

TABLE XI. —Ignition of Coal-dust by Fuses. T, Tin-alloy; C, Copper wire. All circuits non-inductive.

Conclusions.—Coal-dust, although an insulator when dry, becomes a conductor if wet enough for carbonization to take place.

The necessity for keeping commutators clean, especially the small gap between live copper and the frame, is obvious. There appears to be no danger of flashing over on 480 volts between live parts 1 ¼ inches apart, unless the deposit of dust is entirely conducting, as from carbon brushes.

Distributing-boxes should be dust- and flame-tight, and should be in compartments, so arranged that the main terminals cannot be short-circuited by a flash. Cartridge-fuses should be always used where possible, and once used should not be replaced by bare wire or by running wire through an empty tube.

Momentary arcs produced by break of cables or conductors can ignite dust, but the current required to do so is very much greater when the voltage is low, and at moderate voltages is greater for alternating than for direct current. This suggests that the arrangement most satisfactory from the point of view of safety, both for flashes and for shocks, is high-
tension transmission to a sub-station or transformer house, probably with cables well enough armoured to prevent any external flash, and quite low-tension local transmission for power and lighting. Series lighting with incandescent lamps is not to be recommended.

It will no doubt be objected that these results are not under practical conditions. They are certainly under conditions more uniform than can ever be obtained in practice. For any reliable comparison to be made, this is not only advisable but necessary.

It is only by examining a large number of cases that anything like a law can be found. In the present experiments about 2,200 trials have been made, of which 1,800 are recorded here. The percentages of ignition given are those of greatest probability of explosion with typical dusts of average fineness. With selected dusts carefully sieved, the proportion might even be higher.

The risk that any user is willing to take must be based on his own view of the chance that conditions so favourable to ignition may not occur on his plant. To a great extent this is a question of suitable design and of revision of obsolete designs. It is equally one of efficient supervision by skilled men, and of regular attention to the machinery and transmission system.

In conclusion, although it has been shown that a cloud of coal-dust can be ignited by small single flashes, and the degree of probability has been found for most cases likely to occur in practice, it does not follow that the use of electricity in collieries is dangerous. Electricity is no more dangerous than the supply for domestic use of highly-poisonous and explosive coal-gas. An efficient leakage-indicator is equally necessary for both. No indicator will prevent risk from sudden breakage of either pipes or cables; but in the electrical case there is the advantage that the main supply can, if desired, be cut off by a small leakage current.

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The paper does not profess to cover the whole ground. It would, for example, be important to know what influence the presence of gas would have on dust ignitions. Nor can the results be regarded as absolute, for although they have been made with standard dusts for this (the North of England) district, lower percentages of ignition would probably be obtained with anthracite, and higher with brown coal. All that has been attempted here is to place the electrical engineering side of the question on a sound experimental basis.

The President (Mr. T. E. Forster) said that Prof. Thornton had intended to illustrate the paper with experimental demonstrations, but, unfortunately, the electric current available would not allow of this. Prof. Thornton had, however, very kindly invited the members to Armstrong College upon some future date to witness a demonstration of the ignition of coal-dust by single electric flashes, and the members would be advised of the date arranged in due course.

Mr. W. C. Mountain (Gateshead-upon-Tyne) said that Prof. Thornton had touched upon a very important matter. Personally, he thought that the risk of explosions of coal-dust from electricity was very greatly exaggerated, and that there was a great deal of fear existing in the minds of people for which there was no justification whatever. He had no doubt that a great many of the members had read the experiments made on gas some time ago, which did not, however, touch on coal-dust; but at the same time, they were interesting as showing that the risk was not very great either from coal-dust or from gas. The point in Prof. Thornton's paper requiring the greatest attention appeared to him to be the question of the cloud. They were told that a cloud of coal-dust was set up, and, of course, Prof. Thornton had done the best that he possibly could in making a cloud of coal-dust in a small apparatus;
but that hardly represented the conditions in a coal-mine. He considered that if experiments could be conducted in Mr. W. E. Garforth's apparatus at Altofts, they would be very helpful indeed. All Prof. Thornton's experiments left a certain amount of doubt in one's mind; if, however, they could have practical experiments similar to Mr. Garforth's, but conducted with electricity in the same way

[298] as those described in the paper, the information gained would be of value. He did not mention this in any way as deprecating the value of the paper, but he thought that it would be a good method of obtaining practical results. The same tests could be made with coal-gas or marsh-gas, if it could be produced, and that again would clear up a point upon which there was much doubt. Referring to Prof. Thornton's experiments, he would like to know of what the contacts were made, and whether carbon had been tried.

Prof. Thornton (Armstrong College, Newcastle-upon-Tyne) said that they were of brass, and that he had not used carbon.

Mr. Mountain remarked that nearly 25 years ago he had an accident with two brass contacts on a switch at the Birmingham Cattle Show buildings. In those days block-switches were used, and although the pressure of the current was only 65 volts, the result was that an arc was set up, and it continued to burn until the Fire Brigade was brought out. The whole of Prof. Thornton's experiments seemed to turn rather on the question of voltage. In breaking the circuit, did Prof. Thornton establish a permanent arc, or was it merely a flash?

Prof. Thornton replied that it was just a momentary flash; it could not maintain itself across the distance; the total length of the arc would be about 2 ½ inches. They were working with small currents.

Mr. Mountain remarked that he would have thought, with two electrodes like those, that when they came to heavy currents, it would almost maintain a permanent arc. He could quite imagine that in breaking with 100 volts with carbon electrodes an arc 4 or 5 inches long could be maintained, and therefore it appeared to him as if the explosions which had occurred with the higher pressures might be due to a permanent arc set up instead of a flash. He thought that with a higher voltage an arc could be maintained for a longer period, and it would be very much more likely to fire the coal-dust than it would with a lower voltage. Of course, the conclusions were the most important part of the whole paper, and they appeared to him to be perfectly justified; but he should like to have the discussion brought to bear upon the actual danger in a coal-pit, because,

[299] in all his long experience in connexion with the introduction of electricity into coal-mines, he had never known an explosion occur in the way described, either from exposed terminals or from any sudden breaking of an arc. He was quite aware that such might occur, and it was very wise and right that they should guard against such a possibility; but he could not help thinking that, in ordinary practice applied to coal-mines, the risk of explosion from coal-dust and electricity was rather exaggerated.

There was another point—the risk of coal-dust accumulating between the live copper bars and the motor-frame. Coal-dust could not be a very good conductor, because only a week previously he had seen a machine, which had been running at a colliery, in which the
connecting-bars were clogged up with coal-dust, and he had advised the man in charge to get compressed air and blow it out. That incident brought to his mind the fact that coal-dust was not very easily fired.

Another conclusion with which he was in sympathy was the question of attention. Nearly all the troubles which occurred with electricity in collieries arose, not so much from its use, as from want of attention. He believed that if men who were good mechanics—they need not be electricians—were employed, men who knew their work and kept their apparatus clean, and paid attention to the simple instructions given by the contractors, or by the managers or engineers in charge, all the worries and anxieties as to the risk of using electricity would entirely disappear.

Prof. P. Phillips Bedson (Armstrong College, Newcastle-upon-Tyne) congratulated the authors on the experiments that they had made. The writers appeared to him to have put the matter in a very thorough and scientific manner, and seemed to have determined the exact conditions under which coal-dust and air could be fired by electricity. He was rather surprised about 12 months ago to find that there was a considerable amount of scepticism on the part of people associated with these matters at the idea that an electric flash could fire a cloud of coal-dust and air. His surprise had been all the greater seeing that he had exhibited before the members repetitions of experiments made by Holtzwart and von Meyer some 20 years ago, which started from

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the point of view that coal-dust and air mixed together could be ignited by electric sparks. The question had been raised by Prof. Thornton as to the possibility of a cloud of coal-dust being fired by an electric flash, and what surprised him was the scepticism with which that suggestion had been received. He could only say that the members should be very grateful for that scepticism, for the result had been the present investigation as epitomized in Prof. Thornton's paper, which had established very thoroughly and firmly the exact conditions under which an electric flash could ignite such a mixture of combustible matter as coal-dust and air. His surprise had been all the greater seeing that he had exhibited before the members repetitions of experiments made by Holtzwart and von Meyer some 20 years ago, which started from

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) said that he was not sufficiently an electrician to discuss the paper from an electrical point of view. The ignition of coal-dust, hitherto, had been looked upon as due to a shot, or to the ignition of fire-damp. In both such cases they had flame and disturbance at the same time——that was, a disturbance to raise a cloud of dust. He doubted whether they would have in a single electric flash sufficient disturbance to raise a cloud of dust, and he thought that it would only be in the case of a heavy fall, causing a cloud of dust and a fracture of the cable at the same time, that they would be likely to get the conditions necessary for an ignition
of coal-dust by an electric flash. Perhaps tubs getting off the way might have the same effect. Of course, there was still the possibility of fire-damp being ignited, and in turn igniting the coal-dust. He did not suppose that anybody would dispute the statement that an electric flash would ignite fire-damp. With regard to the statement that the cloud of coal-dust was produced in Prof. Thornton's experiments under conditions perhaps more favourable than those met with in practice, he was not quite sure that Mr. Mountain was correct in that respect. On old haulage roads, along which cables were sometimes taken, they had the very finest of coal-dust resting on the upper part of the road and timbers; and with a swift current of air which sustained and bore up the coal-dust after it was in the air, he thought that they would get a cloud of coal-dust even more ready to ignite than those produced by Prof. Thornton.

Mr. T. Campbell Futers (Whitley Bay, Northumberland) said that he would like to know whether, in carrying out further experiments, Prof. Thornton proposed to mix gas with the coal-dust, so as to determine what effect the gas would have in the chamber in carrying the arc across the terminals. He remembered a peculiar accident which occurred at a colliery where the switch was in a gas-tight box. Immediately the man pulled out the switch, an arc was formed, causing an explosion which blew out the front of the box, and so burnt the man that he died shortly afterwards. The man's hands were burnt to the bone, proving that it was an electric-arc burn, and not merely the flame resulting from an ignition of gas. The conclusion to which he (Mr. Futers) had come was that the presence of the gas was the cause of the electric arc being lengthened to such an extent that it spread into the atmosphere beyond the box. He thought that the question of gas intermixing with coal-dust was probably of more consequence from a mining point of view than whether an electric flash would ignite the coal-dust alone.

Prof. Bedson said that, with regard to the question of coal-dust and gas, he could not give the exact data, but some experiments were made some years ago on the effect of gas rendering lamp-black and air explosive. It was in connexion with the explosions which occurred in lamp-black factories in Germany, and very small percentages of gas were found to be sufficient to make a mixture of lamp-black and air—which was non-explosive by itself—explode. It had been stated that 2 per cent. of marsh-gas, whilst non-inflammable without coal-dust, became inflammable with coal-dust.

Mr. Futers explained that his point was that, supposing there were no coal-dust at all, and a certain gap between the two electrodes gave a certain flash, if that space were filled with gas, would there be a greater tendency for the arc to be carried forward through a longer gap—that was to say, for the gas to become a conductor for the arc?

Mr. Mountain asked whether Prof. Thornton found it necessary to make any careful adjustment of the air-pressure in order to get the best results, or whether he obtained them with any kind of pressure. He remembered that in Dr. Bedson's experiments, unless he got his correct air-pressure, the experiments failed.
Prof. Thornton said that his method was not quite the same as Dr. Bedson's. A foot-bellows was used, and uniform results were obtained so long as there was a thorough diffusion of the dust in the box.

Mr. H. W. Clothier (Wallsend, Northumberland) said that he had seen Prof. Thornton's experiments, and it was a matter of great surprise to him that there had not been more accidents directly attributable to the ignition of coal-dust in mines. It must be remembered with regard to the treatment for ignition of coal-dust that whilst Prof. Thornton had had favourable conditions, yet the intensity of the sparks which he obtained in his experiments was merely that of a test-room spark as compared with what they would get in actual practice when a fault occurred in any of their electric plant in mines. He thought that the uncertainty of their present knowledge of the subject warranted a proper test under mining conditions, and he emphasized Mr. Mountain's suggestion that a test, corresponding to those which Prof. Thornton had made in his box, should be made under electric-fault conditions with a big force behind, and in proper tubes which would more nearly represent the actual working conditions in a pit. The arcs which they got on badly-designed apparatus were sometimes terrific, and of course the way to obtain safety in that respect was to have greater care taken in the complete enclosure of cables, motors, and accessories. Prof. Thornton might supplement his present results by tests made on very low-voltage alternating currents. There was no reason why 25-volt lamps should not be used in mines, and Prof. Thornton would do the coal-trade a service if he would investigate the possibility of the ignition of gas as well as coal-dust by the breakage of low-voltage lamps. Certainly, they would get a much greater factor of safety from shocks by using low-voltage lighting fittings; and it would appear from the figures in the paper that with low voltages there might be a reduction in the explosion risks, as it had been shown that there were less at the lower voltages tested so far.

Prof. Thornton thought that the conditions in his experiments were just about as favourable as they could be; but he would welcome any chance of trying them on a larger scale under the conditions prevailing, for example, at Altofts. He understood that it was necessary there to have blown-out shots to ignite the coal-dust, and that nothing short of two shots would do it.

Mr. Atkinson stated that two cannons were fired, one after the other, the first to disturb the dust, and the second to represent a blown-out shot to ignite the dust.

Prof. Thornton asked whether, after the dust was disturbed, a revolver shot would fire it. Prof. Bedson believed that it had been shown by the late William Cochrane that a revolver shot would ignite coal-dust.

Prof. Thornton said that, before any experiments were carried out on a large scale, it would have to be ascertained whether a small chemical flash would ignite coal-dust, because it was no use carrying out experiments with a small electric flash if it took more than a small chemical flash. Experiments at Altofts would be costly, and one might carry out a number of experiments and only get negative results. It would have to be ascertained where the limit began for large-scale experiments. It was no use doing over again what already had been recorded in the paper. Perhaps something about twice as large
as the least currents would have to be tried to begin with. With regard to Mr. Atkinson's remarks about the cloud, the point that he (Prof. Thornton) had always had in mind was something like tubs going off the line and bringing a prop down, or some local disturbance of that kind. As mentioned by Mr. Futers, dealing with a short circuit, a badly-designed junction-box right against the roof would, even without the first mechanical disturbance, cause flame to travel along the top of the timbers. No one could conceive of any person striking a match and putting it to the floutry dust there; would not it be equally fatal to have an electric flash taking place in the same position? With regard to Mr. Clothier's point about the exceedingly low voltage, that seemed to be the thing of the future. He, personally, would welcome 5,000 and 6,000 volts right down in-bye. It seemed to him that, having regard to the excellent switch-gear and cables for high-tension currents now to be obtained, the risk from extra high tension was just the same as at 500 volts, but the local distribution from that they could make as low as they pleased. For motor work they could not have it lower than 250, but for lighting it could be as low as they wished, and the risk then would be absolutely nil.

Mr. Atkinson remarked that the Altofts station was being carried on by the coal-owners, and he had no doubt that if proper representations were made to the authorities they would include these electrical tests in their programme.

Mr. Reginald Guthrie, referring to the Altofts station, said that the present position was that a report on the experiments already carried out was being prepared for publication by the Mining Association of Great Britain, and before very long it would, he expected, be available to the public generally. The experiments had so far only been made with one kind of explosive, and the Association had under consideration the question of continuing them with the use of higher explosives. He had no doubt that the coal-owners would take into consideration the question of making further experiments, as suggested by Mr. Mountain, if a suggestion to that effect were put before them.

The President (Mr. T. E. Forster) said that they had all listened with great interest to the paper and to the discussion which had followed, and they were much indebted to the authors for having brought the matter before them. The question as to the dangers attending the use of electricity in mines had been very much discussed in the press, and he thought that if any experiments could be made to show whether there were any real dangers, and, if so, what those dangers were, they would be thankfully received by those interested. The effect of the paper had been to show that there were fewer dangers than they had anticipated. He moved a very hearty vote of thanks to the authors of the paper.

The vote of thanks was carried unanimously.

The following paper on "The Electrification of Murton Colliery, County Durham," was read by Mr. E. Seymour Wood:
THE ELECTRIFICATION OF MURTON COLLIERY, COUNTY DURHAM.
By E. SEYMOUR WOOD.

Introduction.—Murton Colliery (Fig. 12), the property of the South Hetton Coal Company, Limited, is situated on the east side of the Durham coal-field, the shafts having been sunk between the years 1838 and 1842. The seams worked are the Main Coal, Low Main, and Hutton, the output being about 4,000 tons per day.

There are three pits, the West, Middle and Polka, and East and New (Fig. 1, Plate IV.). The West Pit, or upcast, is entirely a ventilating shaft, and the Middle and East Pits are the coal-drawing shafts.

Ventilation was carried out by means of an underground furnace, assisted by the heat from twenty underground boilers, the quantity of air circulating being 500,000 cubic feet per minute.

The Old Steam-plant.—The underground pumping- and primary haulage-plant was driven by steam generated from twenty boilers, situated underground, as follows:—

(a) Polka Pit, Main Coal Seam.—Two externally-fired cylindrical boilers, 40 feet long by 5 feet in diameter, with a steam-pressure of 40 pounds per square inch; and two tubular boilers of Cornish type, 28 feet long by 6 feet in diameter, with a steam-pressure of 60 pounds per square inch.

(b) Middle Pit, Low Main Seam.—Six Babcock-and-Wilcox water-tube boilers, 22 feet long by 4 feet in diameter, with a steam-pressure of 110 pounds per square inch; two tubular boilers of Lancashire type, 30 feet long by 7 ½ feet in diameter, with a steam-pressure of 40 pounds per square inch; and four externally-fired cylindrical boilers, 40 feet long by 5 feet in diameter, with a steam-pressure of 40 pounds per square inch.

(c) East Pit, Hutton Seam.—One tubular boiler of Cornish type, 28 feet long by 6 feet in diameter, with a steam-pressure of 60 pounds per square inch; and three externally-fired cylindrical boilers, 40 feet long by 5 feet in diameter, with a steam-pressure of 50 pounds per square inch.

These boilers were connected together, and supplied steam to the whole of the pumping- and haulage-plant underground.

Haulage-plant.—There were five main haulages underground, particulars of which are given in Table I.

[Photograph] Fig. 12.—Murton Colliery, County Durham.

[Photograph] Fig. 13.—View of Sub-station.

Table I.—Particulars of Haulage-plants.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Number of Cylinders</th>
<th>Diameter of Cylinders (Inches)</th>
<th>Stroke (Inches)</th>
<th>Diameter of Drum (Feet)</th>
<th>Steam Pressure (Pounds per square inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawthorn</td>
<td>2</td>
<td>30</td>
<td>60</td>
<td></td>
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</table>
Pumping-plant—This plant consisted of three Hathorn-Davey differential pumping-engines, with cylinders 32 inches in diameter and 60 inches stroke, and 8-inch double-acting rams, forcing from the Main Coal Seam to the surface, a vertical height of 1,224 feet; and one Evans pump, with cylinders 14 by 8 inches and 24-inch stroke, forcing from the Hutton Seam (bottom level) to the Main Coal Seam standage, a vertical height of 260 feet. The whole of this plant was fairly efficient, but, owing to its age, the low pressure of many of the steam-boilers, and the long ranges of steam-pipes, it was costly to work and maintain.

Electrification.—After the establishment of the Durham Collieries Power Company, with their generating station at Philadelphia, a distance of 8 miles from Murton Colliery, it was decided to dispense with the whole of the boilers underground, substitute electric power, convert the haulages to electric drive, put down ram pumps driven by motors, and do away with the underground furnace. The current is three-phase alternating with a periodicity of 40 per second, and a voltage of 5,500, and is supplied through duplicate cables to a sub-station on the surface (Fig. 13). This sub-station is equipped with three switchboards, namely: — The No. 1 or high-tension switchboard (Fig. 14) receives the current from the cables, and distributes it through the separate panels to (1) the fan-circuit, (2) the four transformers for underground work, and (3) the transformer to the surface screening machinery. The No. 2 or medium-tension (2,000) volt Switchboard.

The No. 2 or medium-tension (2,000 volts) switchboard (Fig. 15) receives the current from the low-tension side of the four transformers for underground work, and distributes it through separate panels to the three shaft-cables, connected to a distribution-board underground in the Main Coal Seam.

The No. 3 or low-tension (500-volt) switchboard receives the current from the low-tension side of the fifth transformer, and distributes it to the motors for driving the screening machinery at the surface.

The 5,500- and 2,000-volt switchboards (Figs. 14 and 15) are built of granite-concrete and are of the cellular type, with enclosed bus-bars, each panel being equipped with an oil-break switch, overload relay, time-limit fuze, and isolating switches to separate the switch-gear of any panel from the bus-bars.

From the surface sub-station the whole of the system may be divided into three circuits: (1) the high-tension circuit (5,500 volts) for ventilating fans; (2) the medium-tension

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>HP</th>
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<tr>
<td>Low Main</td>
<td>2</td>
<td>20</td>
<td>60</td>
<td>60</td>
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<tr>
<td>No.1 Main Coal</td>
<td>2</td>
<td>26</td>
<td>60</td>
<td>35</td>
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<tr>
<td>No.2 Main Coal</td>
<td>2</td>
<td>18</td>
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<td>Hallfield</td>
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circuit (2,000 volts) for underground power for haulages and pumps; and (3) the low-tension circuit (500 volts) for screening machinery at the surface.

[Photograph] Fig. 16.—An External View of Capell Fan-house.

(1) High-tension Circuit for Ventilating Fans.—The current is transmitted through two 19/15 double-armoured dialite cables to the switch-panels in the fan-house. The switch-panels are of special make for high-tension work, the bus-bars and switch-connections are enclosed in granite-concrete cells, and each panel is arranged to work one or both motors. The fan-installation (Figs. 16, 17, and 18) consists of two duplicate single-inlet Capell fans, each capable of passing 300,000 cubic feet of air, with a 4-inch water-gauge, at a speed of 200 revolutions per minute, and are arranged with a rope drive (Fig. 17)

consisting of twelve cotton ropes, each 1 ½ inches in diameter. The fans are driven by two 12-pole induction motors (Fig. 18) of the slip-ring type, with a synchronous speed of 400 revolutions per minute, each machine being capable of developing 400 brake-horsepower and sustaining an overload of 25 per cent. for 1 hour, with a temperature rise of 80° Fahr. and a maximum overload of two-and-a-half times the full load. The efficiency and power factor is as follows: —

Efficiency at half-load, 88.2 per cent.; three-quarter load, 92 per cent.; full load, 92.8 per cent.; one-and-a-quarter load, 92.4 per cent. Power-factor at half-load, 80 per cent.; three-quarter load, 87 per cent.; full load, 89.5 per cent.; one-and-a-quarter load, 90.2 per cent. Air-gap, 0.07 inch radially.

[Photograph] Fig. 17.—Internal View of Capell Fan-house, showing Fan-drive.

The weight of each motor, without pulley and slide-rails, is 11 tons 15 hundredweight 2 quarters 24 pounds. The slip-rings are fitted with a short-circuiting device of the clutch type, and the winding of both rotor and stator is of the enclosed slot type and formed coils. To each motor is attached a liquid starter, the electrodes of which are worked by a balanced-pulley arrangement.

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[Photograph] Fig. 18.—Internal View of Capell Fan-house.

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(2) Medium-tension Circuit.—The current is distributed to the underground distribution switchboard in the Main Coal Seam (Fig. 19). The power of this circuit is transmitted through three 37/14 double-armoured dialite cables, which are carried in the shaft by wooden cleats resting on wrought-iron clamps attached to steel-wire ropes suspended in the shafts of the Middle and East Pits. The cables feed on to the bus-bars of the switchboard in this distribution house, which has the same equipment as the switchboard at the surface sub-station. The current is then transmitted through separate panels to the motors at each pumping and haulage station.
Electric Underground Haulage Stations.—Six three-phase induction haulage-motors have been installed, representing a total rating of 1,550 brake-horsepower, particulars of which are given in Table II. :

Table II.—Particulars of Electric Underground Haulage-stations.

(a) The Hawthorn Haulage (Figs. 2, 3, and 4, Plate V.) in the Hutton Seam is one of the largest underground haulages known. The distance to the farthest landing is 13,464 feet, the average gradient being 1 in 33.5, and the maximum 1 in 9 against the load. The load consists of 60 tubs, the total weight of the set being 45 tons, and the maximum speed is at the rate of 16.5 miles per hour. In addition to the coals, sets of empty tubs are run for the purpose of conveying the men and boys in- and out-by at a speed of 6 miles per hour, an auxiliary motor being used operating the same drums.

The motor (Fig. 20) is attached to the old haulage-drums by double-reduction gear, the gear in the first motion being machine-cut cast-steel wheels. The motor is of the protected ventilated type, with a capacity of 400 brake-horsepower, working at a speed of 285 revolutions per minute.

[Photograph] Fig. 19.—Underground Distribution Switchboard.

The auxiliary motor is connected to the shaft of the 400-horsepower motor with a clutch, the gear operating the clutch also working a change-over switch, which cuts off the current from the stator of the 400-horsepower motor and switches it on to the auxiliary motor when required. This arrangement entirely prevents the possibility of the current being switched on to one motor whilst the other is in gear. The auxiliary motor has a capacity of 200 brake-horsepower, and works at a speed of 575 revolutions per minute.

The controller is of the liquid type, having a high-tension reversing switch, and three movable electrodes operated with a wheel-gear by the attendant. The cooling is done by water from the shaft-tubbing passing through a coil above the electrodes. The switch-panel is fitted with an overload relay and a wattmeter. Careful tests have been made with this haulage, and load-curves (Figs. 5 and 6, Plate V.) designed from the observations taken show a maximum load of 610 horsepower.

[Photograph] Fig. 20.—Hawthorn Haulage-motor.

(b) The Low Main Haulage deals with all coals on the east side of the Low Main Seam. The most important landing is 9,000 feet from the shaft, the average gradient being 1 in 130, and the maximum 1 in 30 against the load. The load consists of 60 tubs, the weight of the set being 45 tons, and the maximum speed is at the rate of 13 miles per hour.

The haulage is a converted one, the motor being attached to the old haulage-drums by double-reduction gear (Fig. 21). The motor is of the induction ventilated type, with slip-rings. The rating is 300 brake-horsepower, with a speed at full load of 390-revolutions per minute. The controller is of the same type and size as that on the Hawthorn haulage.

(c) The Hall field Haulage in the Middle Pit works the south
side, or Shotton Low Main Seam, and runs into a landing 3,900 feet from the shaft, the
average gradient being 1 in 234, and the maximum 1 in 185 with the load. The load is 35
tubs, the weight of the set being 26 ½ tons, and the maximum speed is at the rate of 10
miles per hour.

The motor is of the same type as the former haulage, having a capacity of 150 brake-
horsepower. The speed at full load is 380 revolutions per minute, and is applied to the drums
of the old haulage by double-reduction gear.

[Photograph] Fig. 21.—Low Main Haulage Motor.

The controller is of the metallic type, with which is combined a high-tension reversing
switch. The secondary switch is connected to the rotor circuit, which is two-phase wound,
and consists of six fixed and two movable contacts, each fitted with four fingers, the tips of
which are fitted with sparking-pieces. The whole of the contacts operate in oil.

The resistance frames comprize main, multiplying, and wire resistances, which are
enclosed in well-ventilated cases, and placed as near to the controller as possible. The
method of control is as follows —The first movement of the wheel closes the

primary switch, and allows the current to enter the stator; in this position the fingers are all
clear of the contacts, with all the resistances in series. The second movement is on to the
first contact with the first fingers, and this cuts out the wire resistance. The third movement
cuts out the multiplying resistance, and leaves the main resistance in series. The fourth
movement brings the second fingers on to the first contact, and puts the first step of the main
resistance in parallel with the multiplying resistance, whilst the fifth and sixth steps of the
main resistance are in series with the multiplying resistance. The movements over the six
contacts result in cutting out or putting in sections of resistance, working the section in
parallel or series according to the speed required, and this arrangement gives a range of 25
speeds to the motor.

(d) No. 1 Main Coal Haulage (Figs. 7, 8, and 9, Plate VI.). —This haulage works the
south-east side of the Main Coal Seam the most important landing being 9,900 feet from the
shaft. The average gradient is 1 in 67, and the maximum 1 in 25 against the load. The load
consists of 65 tubs, the weight of the set being

50 ¼ tons, and the maximum speed is at the rate of 13 miles per hour. The drums are 7
feet in diameter. The motor is of the same type as the Low Main haulage-motor, with a
rating of 300 brake-horsepower, and a speed at full load of 380 revolutions per minute. Figs.
22 and 23 show the arrangement of the drums and gear, and Figs. 10 and 11 (Plate VI.)
load-curves designed from this haulage. The controller is of the liquid type.

[Photograph] Fig. 23.—No. 1 Main Coal Haulage-motor: Arrangement of Haulage-Drums
and gear.
(e) No. 2 Main Coal Haulage.—This haulage has been converted, and works the north side of the Main Coal Seam, the chief landing being 5,280 feet from the shaft. The average gradient is 1 in 70, and the maximum 1 in 19 against the load. The load consists of 40 tubs, the weight of the set being 30 tons.

The motor (Fig. 24) is connected directly on to the end of the main shaft, and is of the same type as those described in the former haulages, the rating being 200 brake-horsepower, and the speed at full load 165 revolutions per minute. The controller is of the metallic type.

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The maximum horsepower developed during the run is 275, and the speed 11 ½ miles per hour.

Pumping Stations.—The feeders of water to be pumped from the mine are 100 gallons per minute from the Hutton Seam and 200 gallons per minute from the Main Coal Seam. The water from the Hutton Seam is pumped up to the large standage in the Main Coal Seam, where the water from that seam is collected, the whole then being forced 1,224 feet to the surface.

[Photograph] Fig. 24.—No. 2 Main Coal Haulage-motor.

The Hutton Seam pump, which forces 260 feet to the Main Coal Seam standage, is a three-throw ram-pump, with a capacity of 200 gallons per minute. The rams are 8 inches in diameter, with a 9-inch stroke, the speed of the crank-shaft being 43 revolutions per minute. The driving arrangement consists of double-reduction spur-gear; the first reduction being machine-cut cast-iron wheels. The pump is driven by a 30-brake-horse-power induction-motor of the enclosed type, with slip-rings, enclosed in a gas-tight case, and runs at a speed of 480 revolutions per minute.

The main pumps, which force from the Main Coal Seam

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standage to the surface, a height of 1,224 feet, consist of two three-throw ram-pumps, the rams being 7 inches in diameter, with a 12-inch stroke. The capacity of each pump is 200 gallons per minute, the speed of the crank-shaft being 45 revolutions per minute. The driving is done from each end of the crank-shaft with machine-cut cast-iron spur-wheels from an intermediate shaft, this being driven from the motor by eight cotton driving ropes, 1 ¼ inches in diameter. The pumps are driven by two induction-motors of the slip-ring protected type, each having a capacity of 120 brake-horsepower at a speed of 385 revolutions per minute. The starting arrangements consist of two starting rheostats, with resistance and contacts immersed in oil. Thorough tests have been made with these pumps, and careful measurements of current and water show an overall efficiency of 73 per cent.

[Photograph] Fig. 25.—Golightly Drift Pump.

The Golightly Drift pump (Fig. 25), for supplying water for boiler purposes at the surface is situated in what is known as "Golightly's" Drift, 790 feet below the surface. The standage is fed by water from behind the shaft-tubbing. The pump is of the three-throw ram type, the rams being 5 ¾ inches
in diameter with a 9-inch stroke, and the capacity of the pump 150 gallons at 47 revolutions per minute. The pump is belt driven, worked by an induction-motor of the slip-ring type, which has a capacity of 60 brake-horsepower at a speed of 460 revolutions per minute.

(3) Low-tension Circuit.—This circuit is for the surface screening machinery at the Polka and Middle and East Pits. The current is transmitted through two 37/12 main cables to two small distribution switchboards, from which it is transmitted through separate cables to each motor-panel.

[Photograph] Fig. 26.—Motor for Driving Surface Screening-plant.

The Polka Pit circuit consists of five motors, namely, one 50-brake-horsepower induction-motor, working at a speed of 500 revolutions per minute, for driving three shaking-screens, three cleaning-belts, three tipplers, two creepers, and one elevator; one 20-brake-horsepower induction-motor, working at a speed of 580 revolutions per minute, for driving the nut-screening apparatus (Fig. 26); one 15-brake-horsepower induction-motor, working at a speed of 580 revolutions per minute, for driving the apparatus elevator; one 10-brake-horsepower induction-motor, working at a speed of 770 revolutions per minute, for driving two nut-cleaning belts (to this motor is attached a Baker reduction-gear, which reduces the speed from the motor to 12 revolutions per minute); and one 20-brake-horsepower induction-motor, working at a speed of 580 revolutions per minute, for driving the machinery in the workshops.

The East Pit circuit consists of three motors, namely, one 20-brake-horsepower induction-motor, working at a speed of 580 revolutions per minute, for driving the East Pit shaking-screen, cleaning-belt, tippler, and creeper; one 20-brake-horse-power induction-motor, working at a speed of 580 revolutions per minute, for driving the Shotton Low Main Seam screen, cleaning-belt, tippler, creepers, and nut-screening apparatus; and one 20-brake-horsepower induction-motor, working at a speed of 580 revolutions per minute, for driving the East Pit nut-screening apparatus, elevator, and conveying-belt.

The whole of these motors are of the slip-ring type, totally enclosed! and dust-proof. Each motor is equipped with a switch-panel, fitted with an oil-break switch, a wattmeter, and a starting switch with cast-iron grid resistances.

The whole of the plant described has been in full work since August, 1908, and is giving good results.

The writer is indebted to Mr. W. O. Wood, Mining Agent and Director of the South Hetton Coal Company, Limited, for permission to record the details of this large plant, and also to Mr. E. Raffle, Chief Mechanical Engineer, South Hetton, and Mr. J. Plummer, Resident Engineer at Murton Colliery, for their assistance in preparing this paper, the successful working of this large plant having been greatly due to the energy and to the careful attention to detail of these two latter gentlemen. Messrs. D. Selby Bigge & Company, of Newcastle-upon-Tyne, were the electrical engineers.
Mr. W. C. Mountain (Gateshead-upon-Tyne) said that Mr. Wood's paper was one of those very practical ones which went to show how an apparently old-fashioned, out-of-date colliery could be brought up to something like modern conditions. It would be even more satisfactory if the author could give the figures of what the consumption of the colliery was in the old days, and the saving that had been effected by the introduction of electricity, as the whole matter turned largely on the commercial aspect of the case rather than on the scientific side. He did not know whether he was asking for more data than Mr. Wood was prepared to give, but such figures would certainly be interesting, and add greatly to the value of the paper.

With regard to the conversion of the haulages, the paper showed in a very practical way how existing steam could be converted into electrically-driven haulages. Mr. Wood had described the larger as liquid and the smaller as metallic controllers. Personally, he thought that where liquid controllers could be used, and where there was water to cool the liquid, they got a cheaper controller, and altogether an apparatus which required less attention than a metallic controller, where there was a large number of fingers always requiring dressing up and refitting. The auxiliary motor arrangement seemed to him to be very neat. In some mines where endless-rope haulage was in use, a combination of such a device to speed up the haulage would be valuable. Many mine-owners said that if an endless rope were installed, the men could not be run in; but where one had an apparatus of that kind, endless-rope haulage could be utilized and made to serve the purpose. He noticed that three-throw pumps had been adopted, which seemed to him to be the only satisfactory kind to use, considering the small quantity of water and the high head. Rope-driving had also been adopted, which he personally thought was very necessary, as it took all vibration off the motors, increased very considerably their life, and reduced the cost of upkeep.

Mr. H. W. Clothier (Wallsend, Northumberland), speaking of the metallic controllers described in the paper, said that they made a very satisfactory job, but, unfortunately, they were too expensive to manufacture in competition with liquid resistances, and so he considered that there was not much prospect of more of them being made. He thought, however, that some photographs of them would be of interest, not historically.

Fig. 27 showed the controller with all tanks and covers removed. There was only one hand-wheel for the complete operations, including switching in and out and the control of the speed and direction of the motor. The dial seen at the back of the hand-wheel indicated the "on," "off," and "intermediate" steps, the indicator moving clockwise for one direction, or anti-clockwise for the reverse, to correspond with the direction of the hand-wheel. The drum of the multiplying controller was seen on the left.

[Photograph] Fig. 27.—Controller with Tanks and Covers removed.

of the hand-wheel indicated the "on," "off," and "intermediate" steps, the indicator moving clockwise for one direction, or anti-clockwise for the reverse, to correspond with the direction of the hand-wheel. The drum of the multiplying controller was seen on the left.

[Diagram] Fig. 28.—Diagram of Controller-connections. The Diagram shows the Controller in its second notch position; in its first position the resistance, A, would also be in circuit.

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[Photographs] Fig. 29.-- Mechanism of Controller and Inter-locking gear.
Fig. 30.-- Details of High-Tension Contacts and Operating Gear.

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and the high-tension change-over quick-break stator switch on the right. Convenient arrangements were made for lowering the oil-tanks, thus providing an easy means of inspecting the various contacts.

It should be noted that although there were only ten cable-connections per phase to the resistance (Fig. 28), thanks to the multiplying arrangement twenty-four different speeds were obtained in either direction. A wire resistance, A, was subsequently added to give an additional speed for slowly taking up the slack

[Photograph] Fig. 31.—Section of Grid Resistance enclosed in a Ventilated Cover.

rope; the cable-connections to this resistance did not complicate the controller, but merely connected the main and multiplying resistances together.

Fig. 29 showed the mechanism of the controller and the gear which interlocked it with the high-tension switch. It should be noted that the motors had two-phase rotors and three-phase stators.

Fig. 30 showed the details of the high-tension switch-contacts and operating-gear. It also showed the iron cover over the terminals of the controller and the bushes for the low-tension leads to the rotor and resistance.

Fig. 31 showed one section of the grid resistances enclosed in a ventilated cover.

Mr. Wood, replying, said that there had been a large saving in coal-consumption at Murton Colliery since the introduction of electricity. With regard to the commercial outlay, he thought that if a return of 15 to 20 per cent. could be got on the money spent, it was not a bad investment. He would be very pleased to take out the actual cost per ton-mile on the electrical haulage system.

The President (Mr. T. E. Forster) said that the figures promised by the author would be of great interest. He moved a vote of thanks to Mr. Wood for his paper.

The vote of thanks was cordially adopted.

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ELECTRICITY AT THE SHAMROCK I. AND II. COLLIERY, HERNE, WESTPHALIA, GERMANY.
By HENRY MOORE HUDSPETH.

Introduction. - The advantages of electric power in mining work are too well known to need any comment by the writer. Its adoption in every direction, seems to meet with success, except, perhaps, in the case of winding, in which field, however, it is an ever-
increasing competitor with, and even promises to displace, the steam winder, if not generally, certainly in particular cases.

The writer does not intend to deal with the whole of the electric plant at the Shamrock I. and II. Colliery in detail, but only to draw attention to part of it, and give some details and costs which he hopes may prove of interest.

The exhaust-steam plant is worthy of notice, because the economical use of exhaust-steam at collieries is a subject which has come forcibly to the front of late years; and an excellent plea was put forward for its better utilization by Mr. Gerald H. J. Hooghwinkel in his paper upon "Exhaust-steam Turbines at Lancashire Collieries."*

The collection and supply of exhaust-steam to a low-pressure turbine, coupled direct to an electric generator, probably forms the best arrangement for this purpose. Since the first turbine using exhaust-steam was patented in the year 1894, it has been largely used in connexion with reciprocating-engines and high-pressure turbines on board ship, thereby increasing the efficiency of the whole plant by as-much as 20 per cent. Its use for colliery purposes has also made considerable progress recently; and, where it is necessary to generate electricity at a colliery, the exhaust-steam from winding and other engines forms an inexpensive source of supply-for developing power from a low-pressure turbine.


Although the capital cost of a plant on these principles is necessarily somewhat high, yet an electric unit can be generated at so low a cost that an excellent return will be given year by year on the invested capital. The first cost may be reduced by adopting a mixed-pressure turbine, and thereby avoiding the absolute necessity of regenerative accumulators. It must, however, be borne in mind that the working-costs are thus increased, and the benefit got by the accumulators from any excess of exhaust-steam is lost, so that, unless the power required to be developed is much in excess of that which can be got out of the exhaust-steam available, the advantage derived from cutting down the capital cost will not be so great as it at first may seem. A mixed-pressure turbine, owing to the addition of the high-pressure end, is necessarily longer, and requires more space, and the governing of such a turbine is also a very complicated matter. On the other hand, if live steam has to be used, the mixed-pressure turbine will use that steam more economically than a low-pressure turbine. In the case of a colliery, exhaust-steam may be available only during coal-drawing hours, and as it may be required to run the turbine constantly, live steam will be required. Under these circumstances, a mixed-pressure turbine would best answer the requirements.

Whilst depending to a great extent upon other things, such as the pressure in the accumulators, the design, etc., the most important requirement in a turbine is a very high vacuum for a good steam-consumption, upon which the efficiency depends, which, at the best, in the case of a low-pressure turbine, is low. An increase in the vacuum materially reduces the steam consumption; hence attention ought to be paid to the adoption of a high-class condensing plant.

A further use to which exhaust-steam driving low-pressure turbines has been put of late is that of generating compressed air. The writer had the pleasure of seeing a plant built on these lines at Witkowitz. Two low-pressure Bateau turbines, taking exhaust-steam from a winder and a ventilator, were each direct-coupled to two compressors representing the first and second and third and fourth stages respectively of a Bateau compressor: the latter drawing 141,266 cubic feet (4,000 cubic metres) of air per hour and pressing up to 5 ½ atmospheres (80 pounds per square inch). It must, however, be added that a comparatively
large quantity of live steam was added through an automatic reducing-valve; but even this is consequent upon the exhaust-steam plant not receiving so much exhaust-steam as was at first anticipated.

In view of the dangers attending the use of electricity underground, the notes on haulage, where bare-copper conductors carry current at 220 volts to, in some cases, within a few yards of the coal-face, are of interest.

In England, electric locomotives underground have not been adopted to any great extent, probably due in some measure to the stringent regulations of the Act dealing with the use of electricity in mines, and also to the preference for rope-haulages. The latter, however, are often replaced by electric locomotives abroad. At the same time, there is probably a considerable future for them even in English mines. Their advantages are at once evident, there being neither ropes nor rollers on the engine-planes, and consequently the upkeep on the haulage-roads is only that involved by the renewal of rails and sleepers.

With these few introductory remarks, the writer now proposes to give some details of the plant at the Shamrock I. and II. Colliery, and will deal chiefly with the subjects already alluded to, examples of which are available.

Generating Plant.—The generating plant consists of three turbo-generators, with a total normal output of 4,300 kilowatts; two are driven by live- and the third by exhaust-steam. The following are the main particulars of the machines:

One 1,000-kilowatt live-steam Curtiss turbine, with Allgemeine-Elektricitats-Gesellschaft generator, running at 3,000 revolutions per minute.

One 1,800-kilowatt live-steam Parsons turbine, with Brown-Boveri generator, running at 1,500 revolutions per minute.

One 1,500-kilowatt exhaust-steam Parsons turbine, with Brown-Boveri generator, running at 1,500 revolutions per minute.

One of the live-steam turbo-generators usually stands as a reserve.

Condensing Plant (Fig.6).—This plant consists of three separate identically equal installations. The turbines exhaust into a main receiver, which is connected to the three condensers, of the surface-cooling type, through valves. Usually, two only of the condensing plants work at one time, the third being kept in reserve. Each is capable of dealing with 44,097 pounds (20,000 kilogrammes) of steam per hour, with a vacuum of 90 per cent. The circulating pump is directly connected to an electric motor of 89 horsepower, the latter driving, by means of belting, the air and condensed-water pumps. To avoid interruption of working by the stopping of either of the condensing plants, the pipes from the condensers to the circulating pumps, the air-pipes, and the condensed-water suction-pipes are in each case connected with one another, so that any of the condensing plants can be used for any one of the three turbines. The two cooling-towers are capable of dealing with 661,140 gallons (8,000 cubic metres) of water per hour, and each of the circulating pumps has a capacity of 220,380 gallons (1,000 cubic metres) per hour.
Exhaust-steam Plant (Figs. 1 and 2, Plate VII.).—Before describing this plant, the writer will give some details of the colliery plant itself, which is directly connected with the above.

The total output from the two winding shafts is about 3,248 tons per day of 10 hours. From No. 1. shaft 1,083 tons per day were drawn from a depth of 1,217 feet (371 metres) by a high-pressure non-condensing steam-engine, with cylinders 39 3/8 inches in diameter and a stroke of 78 ¾ inches. From No. II. shaft about 2,165 tons per day are drawn from a depth of 1,870 feet (570 metres) with a similar engine, the respective diameter and stroke being 43 ¼ and 74 ¾ inches. Two small auxiliary winders wind between intermediate levels. These winders, with two ventilating machines and five compressing engines, are connected up with the regenerative accumulators for supplying the low-pressure turbine.

The effective horsepower of No I. winder is 986; of No.I. auxiliary winder, 197; of No. II. winder, 1,183; of No. II. auxiliary winder, 123; of each compressor, 118; of the main ventilator, 357; and of the reserve ventilator, 118; representing a total of 3,554 horsepower. The winders exhaust immediately into a receiver (an old cylindrical boiler), which serves as a feed-water heater and also to steady up the intermittent flow of steam due to the winders, and to deliver the same in a more constant flow to the regenerative accumulators. From this receiver is carried the main exhaust-steam range, which is joined by the exhausts from the ventilators and compressors before reaching the accumulators.

All the exhaust-pipes are covered. A general view of the steam-collection is shown in Fig. 3 (Plate VII.). Before entering the accumulators, the whole of the exhaust-steam is passed through an oil-extractor, which reduces the oil contents of the steam to 0.001 per cent., the oil being afterwards recovered. The oil-freed steam next passes into the accumulators.

There are two regenerative accumulators (Fig. 1, Plate VII., and Fig. 7), each having a diameter of 157 inches (4 metres) and a height of 236 inches (6 metres). Each consists of a wrought-iron shell the interior of which is so arranged that the exhaust-steam entering nearly at the top of the vessel descends down one side to the bottom, and then ascends through the downcoming water. The water is kept in circulation by means of two small centrifugal pumps. It enters at the top of the accumulators, and, as it falls to the bottom, is baffled, so as to allow it to come into contact with the ascending steam as much as possible; a self-regulating apparatus keeps the level of the water at the bottom of the accumulators at a depth of about 18 inches.

The accumulators are provided with valves, which allow of the release of the steam in case the supply exceeds the demand. This steam is conducted and passed through a
receiver, where it gives up some of its heat to the condensings from the turbines, which are passed through the receiver and on to the boilers. The intermittent supply of steam to the accumulators is converted into a steady supply to the turbine by the evaporation of the circulating water when the quantity of steam is deficient, and by the absorption of heat by the circulating water when the quantity of steam is in excess.

From the accumulators the steam passes through water-separators before entering the turbine. The latter develops 1,500 kilowatts, which is probably the largest load developed by such a plant. The steam is supplied at a pressure varying from 1 to 1.2 atmospheres absolute, equal to from 14.7 to 17.6 pounds per square inch. The turbine is coupled to a Brown-Boveri generator (Fig. 8), giving three-phase alternating current at 5,000 volts and a frequency of 50, with a power-factor equal to 0.8, and is provided with a 19-kilowatt 110-volt exciter, which is fitted on the main shaft. The steam-consumption with a 90-per cent. vacuum and a load of 1,100 kilowatts equals 37.4 pounds per unit.

Under ordinary working-conditions, all the engines above-mentioned are supplying steam, with the exception of the reserve ventilator. The turbo-generator is always running when the pit is working. During the night-shift it runs on a very light load, there being only three to four compressors and the ventilator supplying exhaust-steam. The ordinary working-day load on the turbine can be seen from Fig. 4 (Plate VII.). The drop in the load at mid-day is due to the changing of hewing shifts and the consequent cessation of coal-drawing. The load on the live-steam turbine is at these times somewhat increased, although not to any appreciable extent, as the needs of the colliery are practically nil. Should it be necessary to load the exhaust-steam turbo-generator more than what can be carried by the exhaust-steam, live-steam is admitted through a reducing-valve to mix with the exhaust-steam before entering the turbine. An automatic live-steam inlet-valve is in process of being fitted to the plant for the purpose of keeping the turbine loaded up to 1,500 kilowatts.

When the turbine is developing 1,500 kilowatts, the horsepower represented by the engines supplying exhaust-steam amounts to 3,436. It is somewhat remarkable that so large a power can be generated from what is otherwise a waste product. The total capital cost amounted to £17,500, the cost of the building and cooling-towers being apportioned. This represents a plant cost of approximately £12 per kilowatt. To produce the electricity by the agency of live-steam, the cost for steam would be about £5,000. The units generated in 1908 amounted to 6,248,000, and live-steam is charged to the rest of the plant at the rate of 0.2d. (1.7 pfennige) per unit.

Distribution.—The generators run in parallel, and are built for a voltage of 5,000, three-phase current, 50 cycles, and deliver on to the main switchboard.

The power-station at this colliery forms one of five, which are in connexion with each other, the others being situated at other collieries of the company, namely, the Hibernia, Shamrock III. and IV., Blumenthal III. and IV., and Schlagel and Eisen III. and IV. The respective distances between the stations are as follows : — Hibernia to Shamrock III. and IV., about 5 miles (8 kilometres); Shamrock III. and IV. to Shamrock I. and II., about 3 miles (5 kilometres); Shamrock I. and II. to Blumenthal III. and IV., about 7 ¾ miles (12 kilometres); and Blumenthal III. and IV. to Schlagel and Eisen III. and IV about 7 ¾ miles (12 kilometres); showing a total distance of about 23 miles (37 kilometres).
Two cables are laid alongside each other for the whole of the distance, representing about 40 miles (74 kilometres) of cable. The cables are of the lead-covered armoured type, and are laid in a brick trench 31 ½ inches (80 centimetres) below the surface of the ground. A special telephone-cable is also laid alongside the main tables for connecting up the power-stations.

The generators at all the collieries can be connected in parallel to the main system, thus making it possible for current to be supplied from one to the other in case of a breakdown. Continuous supply is in this case practically essential, as the power is required not only for colliery purposes, but for lighting and power for a large district. The voltage of transmission is 5,000, step-down transformers being fixed at required points for light-distribution, etc. From the cables other collieries of the company, and also collieries belonging to other companies, are worked through distribution-stations. Either of the cables is large enough to carry the ordinary load, one of them usually acting as a reserve.

The total units generated in 1908 amounted to something like 34,000,000, of which about 24,000,000 were used for colliery purposes.

For distribution at the colliery, alternating current is universally adopted, the transmission and driving, except in the case of the underground haulage, being all done by this current. Aboveground, distribution is done at 1,000 volts, high-tension transformers being used for stepping down the voltage from 5,000 volts. The three-phase slip-ring motors for driving the washery, screens, workshops, etc., are all built for 1,000 volts. For lighting purposes, the 1,000 volts are further reduced to 110.

Transmission to the underground distribution-station at the 1,870-foot (570-metre) level is through two 5,000-volt high-tension three-phase cables of a section of 3 x 0.185 square inches, one of which serves as a reserve. The main pumps are driven at 5,000 volts, but for smaller voltages static transformers are used to reduce to 1,000 volts for power and to 110 volts for lighting distribution.

All the cables are of the three-core lead-covered armoured type, and are connected up to the switchboard and the machines through fuses on each phase by means of oil-switches. No trouble is found with the latter, provided that the oil is kept clean. The shaft-cables are supported at distances of 19.8 feet (6 metres), and the armouring is strong enough to carry the whole length of the cable in the shaft. All motors underground, if situated in intake air, are of the open-ventilated type, whereas if situated in return air they are of the totally-enclosed type.

Haulage.—The method adopted is locomotive haulage on the overhead-trolley wire system. The voltage system adopted is 220 volts direct current, the rails serving as the return. For the conversion of the alternating current to direct current, there are two motor-generators in a room situated near to the downcast shaft and ventilated by intake air. Although the intake air has not a clear passage through the room, owing to the presence of only one door, an air-tube extending to the innermost portion of the room serves for the outlet of the air, which outlet is further assisted by the injection of compressed air at intervals.

The motor-generators are connected up to the low-tension side of the 5,000/1,000-volt static transformers by means of a high-tension lead-covered armoured cable for 1,000 volts, with oil-switches, and fuses on each phase, at both ends. Each motor-generator is capable, under ordinary working conditions, of sustaining eight locomotives in working order. Six locomotives are at present in constant use, two others being in reserve. Consequently, one of the motor-generators is, as a rule, standing in reserve. Each has an output, at 730
revolutions per minute, of 65 kilowatts at 230 volts; and the outgoing trolley-wires are charged at this voltage. The generators are compound wound, each being connected up to the direct-current switchboard, from which the feeding-cables for the line go. Fig. 5 (Plate VII.) shows the method of switch arrangements.

The trolley-wires, which must be fixed at a minimum height of 6 feet (1.8 metres) above the rails, are firmly attached to the roof, and insulated therefrom by means of double-shed porcelain insulators, which have a protective iron covering. The insulators are fixed at distances apart varying from about 16 $\frac{1}{2}$ to 20 feet (5 to 6 metres). Should a short-circuit occur, the whole line is instantly made dead by the opening of a blow-out switch on the main switchboard in the motor-generator house. The diameter of the trolley-wire in the main road is 0.394 inch (10 millimetres), corresponding to a section of 0.124 square inch (80 square millimetres), the respective diameter and section for the branch-road trolleys being 0.315 inch (8 millimetres) and 0.077 square inch (50 square millimetres) respectively. The necessary lighting is done at the landings, etc., by simply putting 220-volt lamps between the trolley-wire and the rail.

[Photograph] Fig. 9.—Electric Locomotives.

Each locomotive (Fig. 9) is provided with two compound-wound motors, each having a normal of 118 and a maximum of 177 horsepower, so that each locomotive has a normal of 23.6 and a maximum of 35.4 horsepower. They are wound for a voltage of 220, and run at 500 revolutions per minute, driving on to the wheels through 5.33 to 1 gearing. The motors are hung on to the frame by springs, and are entirely enclosed for keeping out the dust. To be able to inspect the commutator and the brushes of the machine, or to take out the bearings or the armature, the end of the casing enclosing the motor is detachable.

Normally, the motors can run 1 hour, and with the maximum output 20 minutes, without the temperature reaching a dangerous point. Under ordinary working conditions, the average run of a locomotive lasts about 12 minutes, with a pause of 4 minutes.

The tractive force is normally 970 pounds (440 kilogrammes), and has a maximum of 1,940 pounds (880 kilogrammes).

The weight of the locomotive is 11,023 pounds (5,000 kilogrammes); therefore, with a coefficient of friction of 0.15, the adhesive force is 1,653 pounds (750 kilogrammes). By the use of sand, the coefficient of friction can be increased to 0.25, thus raising the adhesive force up to 2,756 pounds (1,250 kilogrammes).

The frame of the locomotive rests through strong springs on to the steel axles, the bearings of which can be easily oiled from the outside. By means of a drawbar with spring, no jerk is given to the set of tubs on starting. The driver's seat is as low as possible, and is so arranged that the hand-wheel of the brake can be operated by the right hand, whilst the left hand of the driver serves for the operation of the controller. The controller is arranged for series and parallel connexions for running the motors either in parallel or in series; it is also provided with a reversing-switch. The locomotive is provided with a roof to protect the driver from the overhead trolley-wire. This forms the highest point of the locomotive, and is at 53 inches (1.34 metres) above the rail-level. The overall length of the locomotive is 128 inches (3.25 metres), the greatest breadth being 40 inches (1.01 metres), beyond which no part projects. Fig. 9 shows one of the electric locomotives in use.
By normal revolutions of the motors (500 per minute), the speed attained by the locomotives is at the rate of 8 miles (12.87 kilometres) per hour. The wheel-base is 52 inches (1.32 metres) and the diameter of the wheels 26 ¾ inches (680 millimetres).

The plant deals with about 1,920 tubs of coal in a working time of about 7 ½ hours. This is equivalent to an approximate output of 2,110 tons per day, the average weight of coal per tub being about 0.55 ton.

The total length of haulage-road at present under electrification is about 4 miles, which is being gradually extended; and the longest single run is about 1 ½ miles.

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The rail-gauge is 24 inches (607 millimetres); the weight of the rails 30 pounds per yard (14 kilogrammes per running metre); the height, 3 inches (75.2 millimetres); and the length, 20 feet (6 metres). These rails are to be replaced by rails of 36 pounds per yard. Steel sleepers are used, placed 31 ½ to 39 1/3 inches (800 to 1,000 millimetres) apart, the rails being attached to the sleepers by means of clips and bolts. Curves of a less radius than 32 ¾ feet (10 metres) are avoided. The average gradient of the roads is in favour of the load, and amounts to 1 in 450, and does not vary to any great extent.

The whole of the electric haulage at the above colliery is at the 1,870-foot (570-metre) level. Numerous telephone-stations are situated at this level, and there is a signal-wire by means of which the driver can, in case of accident, signal to the motor-generator house from any point on the road.

The working of inclined seams allows the roads for haulage, etc., to be driven to the best advantage for those purposes. This, however, cannot be done, when the haulage-roads have to follow the floor of the seam, on account of the unevenness caused by faults, undulations, etc.

The small even gradient is good for locomotives, and may in some measure account for their success. There are, however, cases under this company in which the full load is drawn up a gradient of as much as 1 in 80.

Working-costs and Output.—The costs of the haulage-plant given in Table I. are taken out for the month of March, 1909, and represent 20 working days of 10 hours each.

Table I.—Costs of Electric Locomotive Haulage at the 1,870-foot (570-metre) Level, Shamrock I. and II. Colliery.

<table>
<thead>
<tr>
<th>Description</th>
<th>Marks</th>
<th>£  s.  d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Interest on capital at 4 percent</td>
<td>500.00</td>
<td>25 0 0</td>
</tr>
<tr>
<td>(2) For renewal of plant, life taken at 15 years; rate, 4</td>
<td>624.13</td>
<td>31 4 1 ½</td>
</tr>
<tr>
<td>% = 4 993 per cent. on capital</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Oil and grease</td>
<td>37.80</td>
<td>1 17 9 ½</td>
</tr>
<tr>
<td>(4) Waste, etc</td>
<td>0.73</td>
<td>0 0 9</td>
</tr>
<tr>
<td>(5) Repairs</td>
<td>849.66</td>
<td>42 9 8</td>
</tr>
<tr>
<td>(6) Power: 15,725 units at 0.36d</td>
<td>471.75</td>
<td>23 11 9</td>
</tr>
<tr>
<td>(7) Wages</td>
<td>3453.80</td>
<td>172 13 9 ½</td>
</tr>
<tr>
<td>(8) Subscriptions to workmen's funds, etc.</td>
<td>323.49</td>
<td>16 3 6</td>
</tr>
<tr>
<td>Total cost of haulage</td>
<td>M6261:36</td>
<td>£313 1 4 ½</td>
</tr>
</tbody>
</table>

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Table II.—Total Output of Locomotives.

<table>
<thead>
<tr>
<th></th>
<th>Ton-kilometre</th>
<th>Ton-miles</th>
<th>Cost per English Ton-mile, pence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal, stone, etc.</td>
<td>88,579.84</td>
<td>55,008</td>
<td>1.38d.</td>
</tr>
<tr>
<td>Coal</td>
<td>72,464.64</td>
<td>45,000</td>
<td>1.69d.</td>
</tr>
</tbody>
</table>

German Tons    Cost per Ton  If English Tons, pence

| Total coal-output | 54,010.65     | 1.39d. | 1.42d. |
| Total tons carried| 68,308.25     | 1.10d. | 1.12d. |

It must here be mentioned that the "total tons carried," tabulated above, includes all bricks, wood, stowing, etc., carried by the tubs from the shaft to the places required in-by. The ton-mile output of each locomotive was in March, 1909, 151.2 (243.5 ton-kilometres) per shift, the hewing shift bank to bank being 8 hours, and the working shift of locomotives about 7 ½ hours. The average cost of the same, including interest on capital at 4 per cent. and depreciation on plant reckoned at (approximately) 5 per cent., amounted to 1.365d. per ton-mile, which in this case corresponds to 1.39 per ton of coal. Allowing for the carriage of wood, stones, etc., the cost per ton of useful load dealt with by the electric haulage is reduced to 1.1d. per ton. These costs are low, and if the amount under (8) in Table I., which in English practice is not usually included, be deducted, the cost is further reduced. Again the charge per kilowatt to the colliery plant is somewhat high. The amount under (5) is large; this being due to the renewal of armatures in the locomotive motors. There is only a very small air-gap, and the bearings must be true and kept in good repair, or the armature in revolving comes into contact with the magnets, with serious results.

If the costs (6) and (8) be modified in requirement with the above, charging 0.30d. per kilowatt, then the cost per English ton of coal is only 1.235d., and per English ton-mile, 1.46d. These costs have since been further reduced.

It may be interesting to note that the appointment of a competent person, whose sole duty was to regulate and superintend the traffic of the locomotives, was to a great extent, or in a great measure, the means of raising the ton-mile output of each locomotive from 111.20 in January, 1909, to the above 151.2, which amply justified the increased expenditure in wages. Another interesting point is that the workmen are taken to and from their working-places by this means, the current being

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switched on immediately before starting and switched off immediately after stopping the set.

Watering Arrangements. Considering the danger attending the adoption of electricity underground, it may be interesting to review the extensive watering arrangements adopted at this colliery. The writer does not wish to imply that watering is done so that this system can be adopted; on the contrary, the watering is certainly detrimental to the electric installation. At the same time, it serves to prevent the accumulation of dry coal-dust on the haulage-roads, thereby reducing the dangers connected therewith; and the existence of dry coal-dust is rendered practically impossible by the frequent and copious use of water. An idea of the extent to which this is carried out may be gathered from the following few particulars.

The output from the mine is about 3,248 tons per day, and there exists almost exclusively for the purpose of keeping down the coal-dust 109,341 yards (99,980 metres) of water-piping, 39,670 gallons (180 cubic metres) of water being the average daily
consumption; and it is the exclusive duty of thirty-four men to water every part of the mine at least once per day. Every tub of coal is watered before leaving the face, and at least once on its way to the shaft.

Pumping.—The pumping arrangements are at present undergoing alterations, the old steam-driven force-pumps being replaced by electrically-driven high-speed centrifugal pumps and an electrically-driven forcing set.

The advantages of the centrifugal pumps for mining work are well known, and it is unnecessary for the writer to enumerate them; at the same time, they have their disadvantages, which may be summed up in low efficiency, heavy repairs, and a comparatively short life.

The two latter, however, depend to a great extent upon the nature of the water to be dealt with. If the pit-water is clean, the pumps as a rule do not require many repairs, and have a fairly long life. It is seldom the case, however, that pit-water is clean. The pit-water at Shamrock I. and II. Colliery contains gritty material, and it is necessary every 8 or 10 weeks to clean off the crust which collects on the pump-impellors. This forms practically the only trouble connected therewith.

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The main pumping is at present done by two high-speed electrically-driven centrifugal pumps, one of the Sulzer and one of the Schwartzkopf type. In the method of mounting both types are arranged identically, each consisting of two pumps in series, coupled to a motor between, which drives through elastic couplings. The three-phase slip-ring open-ventilated type motors are built in each case to take the full transmission-voltage, namely, 5,000 at 50 cycles per second; both pumps have the same capacity, and raise 660 gallons (3 cubic metres) of water per minute through a head of 1,870 feet (570 metres).

The motor for the Sulzer pumps is of 690 horsepower, and runs at 1,485 revolutions per minute, the respective figures for the Schwartzkopf pump being 690 horsepower and 1,480 revolutions per minute. Both pumps are situated near the shaft, directly above the water-standage, and run alternately, one standing as a reserve.

On the 2,190-foot (670-metre) level, which is only now being developed, are two temporary electrically-driven centrifugal pumps for lifting the water from this level to the water-standage at the level above. Two 5,000-volt cables convey the current from the distribution-board at the fifth level to these pumps. At present the cables only carry 1,000 volts, the higher-tension cable being for future developments. Each pump is directly connected through an elastic coupling to a three-phase asynchronous motor, and is erected on girders immediately above the water-standage.

The pumps are identical, one usually standing in reserve; each has a capacity of 210 gallons, and lifts through a head of 328 feet (100 metres). The motors are of 44 horsepower, taking current at 1,000 volts, at 1,440 revolutions per minute.

Lighting, Signalling, and Shot-firing.—These do not present any outstanding features of interest, and are therefore brought under one head.

For lighting, three-phase current at 110 volts is mostly used, the 110 volts being reduced by static transformers from 1,000 volts. Underground on the electric haulage-roads, as already mentioned under the head of haulage, the direct-current

[Plate VII, Figs.1 to 5, Diagrams illustrating “Electricity at Shamrock Collieries, Germany”]
220-volt lamps are simply put between the trolley-wire and the rail. Osram metallic-filament lamps are largely used both above and below ground. It is worthy of note that for telephonic purposes and signalling the voltage is about 35, a voltage inadmissible in an English mine of a similar kind.

All shot-firing is done by electricity. Small hand-batteries are used underground, the keys of which must always be in the possession of the special man appointed to fire the shots.

In conclusion, thanks are due to Director G. A. Meyer for the privileges granted for the collection and publication of these particulars.

A vote of thanks to Mr. Hudspeth was moved by the President (Mr. T. E. Forster), and was carried unanimously.
agree with him when he said that King Edward had endeared himself to all his subjects, and that all those connected with the great mining interests which they represented in the district felt that they had lost, in his late Majesty, one who ever extended his heartfelt sympathy and help in times of trouble and disaster.

The Council had sent the following loyal and dutiful Address to His Majesty King George V. on the occasion of the demise of his late Majesty King Edward VII., and of compliments and congratulations on his accession to the throne:

To the King's Most Excellent Majesty.

Most Gracious Sovereign,

The North of England Institute of Mining and Mechanical Engineers, Incorporated by Royal Charter in 1876, humbly beg to express to Your Majesty their profound grief and sorrow at the lamented death of His Most Gracious Majesty King Edward VII., which has caused a deep feeling of pain and sadness in His Wide Dominions, also throughout the World.

Whilst giving expression to their deepest sympathy and condolence with Your Majesty and all the Members of the Royal Family, they also humbly beg to convey to Your Majesty their sincere and zealous wishes for the happiness and prosperity of Your Majesty's Reign and to assure Your Majesty of their deep devotion and loyalty to the Throne.

Witness our Hands and Seal the fourteenth day of May, 1910.

T. E. FORSTER, President.
JOHN H. MERIVALE, Honorary Secretary.
LAWRENCE AUSTIN, Secretary.

[Seal]

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WHITEHAVEN COLLIERY DISASTER.

The President (Mr. T. E. Forster), alluding to the recent deplorable disaster at Whitehaven Colliery, proposed a vote of sympathy and condolence with the relatives of the unfortunate workmen who had been killed, with the owners of the colliery, and with the officials who had endeavoured to secure the safety of the workmen as far as possible.

The motion was unanimously adopted.

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

The Secretary read the balloting list for the election of officers for the year 1910-1911.

The following gentlemen were elected, having been previously nominated:

Members—

Mr. Ben Cook, Mechanical Engineer, Woodbine, Beacon Hill, Camborne.
Mr. William James Greener, Mining Engineer, The Reliance Coal Company, Sijua P.O., Bengal, India.
Mr. Percy Joseph Emerson Kennedy, Electrical Engineer, 4, St. Nicholas' Buildings, Newcastle-upon-Tyne.
DISCUSSION OF MR. E. SEYMOUR WOOD’S PAPER ON "THE ELECTRIFICATION OF MURTON COLLIERY, COUNTY DURHAM."

Mr. E. Seymour Wood (Murton Colliery) said that he was not yet able to give the members all the figures promised at the last meeting, but he might say that the quantity of coal saved amounted to about 35,000 tons a year.

Prof. P. Phillips Bedson (Armstrong College, Newcastle-upon-Tyne) submitted for inspection a piece of cable, which was an instance of something that should be avoided in mines, illustrating as it did a want of elementary knowledge of chemical matters in connexion with the properties of the materials used. The insulation appeared to have been a paper one, to protect which there was lead, further protected by tarred hemp. Unfortunately, the tarred hemp, in the presence of moisture, readily attacked the lead, and so the lead sheathing, which might have been a protection, was made futile by this further coating of tarred hemp; in fact, the condition of affairs in the cable in question was not unlike those present in the manufacture of white-lead, the object of which was to corrode the lead.

Mr. W. C. Blackett (Sacriston) thought that the experience of most people was that if there was one thing to be avoided in a cable, especially one in a pit-shaft, it was lead in any form whatever. It was many years since he had arrived at the conclusion that lead-covered cables should not be used.

The Rev. G. M. Capell (Passenham) wrote that the fans at Murton Colliery were on the Capell duplicate system, with a balanced passage between. They were each 15 feet in diameter, with single inlets 5 ½ feet wide. Each fan at 200 revolutions per minute gave 300,000 cubic feet of air at a water-gauge of 4 inches. When working as duplicates at the same number of revolutions (200), the water-gauge rose to 6.4 inches, and the air volume at the same time increased very largely above normal calculations. The reason of the rise in the water-gauge was that when one fan only was running, it did not show its full water-gauge, having turned a part of its water-gauge into volume.

With the two fans working, the water-gauge rose to the standard water-gauge of the single-inlet fans 15 feet in diameter, the air-volume being divided equally between them. The balanced passage guarded the fans against any slight irregularity in speed, which would cause one fan to pass more air than the other: it put the fan-cases in equilibrium, and counteracted that effect.

DISCUSSION OF MR. HENRY MOORE HUDSPETH'S PAPER ON "ELECTRICITY AT THE SHAMROCK I. AND II. COLLIERY, HERNE, WESTPHALIA, GERMANY:"

Mr. T. L. Elwen (Brandon Colliery) asked for further information respecting the watering arrangements. From the figures given in the paper, there appeared to be 62 miles of pipes. Did that length of pipes correspond with the mileage of roadways kept watered every day by thirty-four workmen, and did the workmen for that purpose use a hosepipe with necessary connections at intervals to the main service-pipes? Was water sprayed upon the top of the full tubs before they left the face or while journeying to the shaft, and was any provision made for damping the dust in the empty tubs in the mine or at the surface? He would also like to know the depth of the mine, and whether the watering had any effect on the roof and sides of the roadway.

Mr. H. M. Hudspeth (Willington) replied that the 62 miles of roadway represented approximately the distance that was covered by the thirty-four men, and the watering was to a great extent done by a hosepipe attached to the main service-pipe at intervals. Sprays were used, but not in the main haulage-roads; when driving headings in the seams, and sometimes when shot-firing was being done, they were, however, employed. Some of the sprays were put on prior to and taken off after shot-firing. There was no arrangement whatever for keeping damp the inside of the empty tubs. The depth of the mine on the fifth level, which was where the electric haulage-plant was situated, was 1,870 feet (570 metres). The water did not seem to exercise any detrimental effect whatever on the sides or on the floor.


DISCUSSION OF PROF. W. M. THORNTON AND MR. E. BOWDEN'S PAPER ON "THE IGNITION OF COAL-DUST BY SINGLE ELECTRIC FLASHES."

The meeting having adjourned to the Electrical Engineering Lecture Theatre of Armstrong College, Newcastle-upon-Tyne, the discussion was preceded by a number of demonstrations of the ignition of coal-dust, etc., by single electric flashes.

The first experiment demonstrated the fact that, although dry coal-dust was a good insulator of electricity, thoroughly wet coal-dust became a good conductor—so good a conductor eventually that an electric current passed through it freely. That this was not due
solely to the water present was shown by the fact that sand, although not so good an insulator as coal-dust, did not become a conductor when thoroughly well wetted to the same degree. There was, of course, a current passing, due to the moisture present; but, in the case of coal-dust, this current gave rise to secondary effects, either carbonization or ignition of volatile vapours, which caused a flash-over to take place under certain conditions of voltage and distance, as described in the paper. The experiment was conducted with both direct and alternating currents, the flash-over being found to occur somewhat more readily with the latter.

In the next experiment, crushed arc-lamp carbon, in the form of fine powder, was laid between the terminals, and a sparking current seemed to pass, which eventually flashed over, blowing the fuse. Thus wet coal-dust ultimately behaved in the same way as a carbon powder not as an insulator.

The third experiment demonstrated that metallic vapour from a fuse blown violently was so good a conductor that it short-circuited two terminals above it between which 480 volts was maintained. This did not occur with flame from a taper, showing that the flashing over was produced by the metallic constituents of the fuse arc. That hydrocarbon vapour can, however,


produce a short circuit was shown by its starting an arc between vertical copper rods, between which there was 1,500 volts.

The ignition of a cloud of coal-dust by single electric flashes was next demonstrated. As described in the paper, a box was provided with terminals which could be separated while a current was passing between them. The cloud of dust being formed in the box previous to the separation of the poles, an ignition took place under certain conditions of voltage and current, which filled the box and travelled along an inspection-tube attached to it. Experiments were conducted with both 480- and 100-volt direct and alternating currents, and the difference between them was illustrated.

The effect of blowing a fuse in a mixture of coal-dust and air, causing explosive ignition, was also demonstrated.

The experiments concluded with one in which flour was substituted for coal-dust, the violence of the explosion being much greater than in the case of a coal-dust explosion.

During the demonstration Mr. H. W. Clothier was asked to explain the experiments which he had made with flame-proof boxes for enclosing electrical apparatus. He said that he had had a strong cast-iron box fitted with a hinged lid, there being a flanged joint between the box and the lid; the flange was about 1 ¾ inches wide, and had a machined surface. The experiments were made with the most explosive mixture of ordinary town gas and air, which was ignited by means of an electric spark inside the box. It was shown that, although a very violent explosion was obtained, the gases were cooled in passing through the flanged joints, so that no flame was emitted from the box.

Mr. W. C. Blackett (Sacriston) proposed a vote of thanks to Dr. Thornton and his assistants for the great trouble that they had taken in giving the demonstration. Those present had seen in a very short space of time what had no doubt taken very many days to prepare. He was sure that they had very little idea of the amount of trouble which Dr. Thornton had had in arranging the experiments.
Mr. J. H. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne), in seconding the vote of thanks, said that to a very large extent both coal-dust and electricity were new things in coal-mining; or at least, the danger attending coal-dust was not recognized in his younger days, and electricity had been in use in coal-mines for even a less time than that. He did not think that they could have had a better demonstration of what might happen with these two combined than they had had in the present series of experiments.

Mr. W. C. Blackett said that, in the course of the experiments, it had been stated that the spark was passed much more easily when heat was present; he would like to know how that was demonstrated, and whether there was any possibility that it was pressure and not heat. They all knew that sparks did pass more readily when the pressure of the atmosphere was greater than when it was otherwise; was there any possibility that the pressure would develop and create a sort of chamber of its own in the atmosphere, and that the passing of the spark was due to pressure and not to heat?

Dr. Thornton said that Dr. Bedson had proved that they could fire coal-dust at 284°F (140° Cent.), and in the experiment just carried out he thought that they had over 284°F. He did not advance any theory as to the ignition or the flashing over of the moist coal-dust, excepting that it was different from any other kind of insulator. Coal-dust was an insulator, and flashed over; wet sand was not so good an insulator, and yet did not flash over; and whether that was due to carbonization or to volatile matter, or to the influence of the heat on the occluded gases, they could not tell. He did not know whether it was worth while determining the point, so long as they had the fact and recognized it. The simplest explanation was that it was carbonization.

Mr. H. W. Clothier (Wallsend) asked whether there was not some explanation to be found in the fact that carbon when hot was a much better conductor of electricity than when cold.

Dr. Thornton remarked that that was a new idea. In the case of a carbon lamp, for example, the resistance fell about one-half from cold to hot. As the coal-dust got warmed up, there might be a point at which the resistance became so low that a current immediately jumped across.

In conclusion, he thanked the members very much on behalf of himself and his assistants for the kind way in which they had received the demonstration.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING,
Held at Blyth, July 7th, 1910.

BLYTH HARBOUR.

The Harbour.—Blyth harbour, situate about the centre of the Northumberland coal-field, is the natural port of shipment for a large number of collieries. Although coals have
been shipped at the mouth of the river for upwards of 600 years, it is only during the last 25 years that Blyth has risen to prominence as a coaling port. From 1813 to 1867, the harbour consisted of a short length of the river-channel, nearly dry at low water, having a few small coaling-staithes on the south side, and a ballast-quay on the north side. The sea-channel of the River Blyth runs south-south-eastwards, following approximately a line of fault in the rocks which form an extensive reef (dry at low water) upon its eastern side.

In 1856, a pier, consisting of timber-framing, enclosing a hearting of rubble-stone, was built upon this reef; and on the west side of the channel a training jetty of timber was constructed. At this time, the channel, although dredged to a depth of 4 feet at low water, was shoaled by every storm to about low-water level. In 1867, two coaling-staithes were opened on the north side by the Cowpen and North Seaton Coal Company, and a depth was dredged alongside sufficient for vessels of 1,200 tons.

This condition of the harbour obtained until 1882, when the Blyth Harbour Commission was formed, and the Commissioners, in conjunction with the North-Eastern Railway Company, constructed two coaling-staithes on the south side. In 1885, a new west pier was constructed to protect the channel from shoaling upon that side, and the east pier was extended in solid concrete. In 1887, a new entrance-channel, having a depth of 10 feet at low water, was dredged about 210 feet to the west of the old channel, thus clearing a reef of rocks which extended on the line of the old channel for 1,500 feet outside of the pierhead the great cost of removing which would have made it impracticable to provide a deep-water channel upon the old line. In 1888, two additional coaling-staithes were constructed on the south side of the harbour. In 1896, the harbour was enlarged and deepened, and four additional coaling-staithes were constructed on the north side. In 1898, the entrance-channel was widened, and deepened to 16 feet at low water. In 1899, a new south harbour of 25 acres in area was completed, having a depth varying from 30 to 38½ feet at high water, with wharves, cranes, and railway-connections.

A new lighthouse, of reinforced concrete on a monolithic base, has recently been constructed at the end of the east pier, forming the roundhead of the pier. The focal plane of the light is 63 feet above high water. The light is a white group flashing light of 60,000 candle-power, four flashes in quick succession being given every 10 seconds. A lower subsidiary red light is shown over sectors covering the rocks to the east of the pier and those at St. Mary's Island.

The following is a summary of the improvement of the harbour during the last 28 years:—In 1882, the harbour area was about 25 acres, and, except at the Cambois staithes, was practically dry at low water; it could not accommodate more than about forty small sailing-vessels, while the channel to the sea was frequently shoaled to about low-water level.

At the present time, the area of the harbour is about 83 acres, the depth varies from 22½ to 38½ feet at high water, it is capable of accommodating over 100 large steamships, and vessels up to 7,500 tons capacity have used the harbour. The sea-channel has a depth of 16 feet at low water, and is being deepened to 20 feet.

Coal-shipping.—The north-side staithes, belonging to the North-Eastern Railway Company, are laid out upon the high-level gravitation principle, the staithes being parallel to the river. The full track rises at 1 in 90 towards the far end, and the empty track falls at 1 in 60. The height varies from 44 to 48 feet, and there are four sets of spouts placed from 350 to 360 feet apart, each set consisting of two teeming-spouts placed 90 feet apart.
The loaded sets are propelled by locomotives to the far end of each track, and thence fall by gravitation to the respective spout in use, and, after teeming, pass forward into the empty bay. With 10-ton trucks, 700 tons per hour can be shipped at one spout. The spouts are fitted with electrically-driven anti-breakage appliances for use in running up coal under the hatches.

The four staithes adjoining to the east are the property of the Cowpen Coal Company, Limited. They are high-level gravitation staithes, at right-angles to the river, with four spouts, the height to rail being 36 feet at the western and 40 at the eastern berth. The latter is fitted with anti-breakage boxes, worked by gravitation. The south-side staithes are also the property of the North-Eastern Railway Company, and are laid out in a manner similar to those on the north side of the harbour, with the addition of one electrically-driven bunkering hoist of the steel-belt type, suitable for delivering coals to vessels which are too high for the ordinary spouts. This appliance is capable of delivering coal into a vessel at a point 43 feet above the high-water mark of ordinary spring tides, the rate of delivery being 400 tons per hour.

The following table shows the shipments of coal for the past 20 years:

<table>
<thead>
<tr>
<th>Year ending Dec. 31st</th>
<th>Tons.</th>
<th>Year ending Dec. 31st</th>
<th>Tons.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1890</td>
<td>1,756,055</td>
<td>1900</td>
<td>3,279,505</td>
</tr>
<tr>
<td>1891</td>
<td>2,092,889</td>
<td>1901</td>
<td>3,219,537</td>
</tr>
<tr>
<td>1892</td>
<td>2,180,837</td>
<td>1902</td>
<td>3,343,376</td>
</tr>
<tr>
<td>1893</td>
<td>2,366,943</td>
<td>1903</td>
<td>3,400,617</td>
</tr>
<tr>
<td>1894</td>
<td>2,672,418</td>
<td>1904</td>
<td>3,536,853</td>
</tr>
<tr>
<td>1895</td>
<td>2,485,159</td>
<td>1905</td>
<td>3,755,139</td>
</tr>
<tr>
<td>1896</td>
<td>2,561,745</td>
<td>1906</td>
<td>3,882,172</td>
</tr>
<tr>
<td>1897</td>
<td>2,760,519</td>
<td>1907</td>
<td>3,946,084</td>
</tr>
<tr>
<td>1898</td>
<td>3,124,391</td>
<td>1903</td>
<td>4,037,787</td>
</tr>
<tr>
<td>1899</td>
<td>3,314,826</td>
<td>1909</td>
<td>4,047,862</td>
</tr>
</tbody>
</table>

Timber Imports.—The south harbour, by a considerable extension of the quays, is being equipped to deal with the import of mining timber. The work is not yet completed, but the timber work and decking is finished. Electric cranes and capstans, railway sidings, stocking grounds, and other facilities, will be provided.

Herring Industry.—A large herring-fishing industry has been recently established at Blyth, resulting in the use of the

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harbour by a considerable number of both steam and sailing-vessels, as many as 150 having been berthed in one day. During last season upwards of 40,000 crans of herring were landed. Extensive yards have been laid out for the curing of the fish, which is afterwards packed in barrels and exported, and recently erected "smoke-houses" for kippering purposes are now in operation. Provision has been made for coaling these fishing-vessels by means of hulks, as, owing to the number of boats and the small quantity of coal taken by each boat, the other facilities of the harbour proved inadequate.

Shipyards.—There is an extensive shipyard, and five large graving-docks at the port.
Improvements in Progress.—(a) Harbour Deepening.—As already mentioned, the present depth of the river-channel at low water is 16 feet, and this is being increased to 20 feet. Where there is a rock bottom, it is being broken up by means of Lobnitz rock-breakers. This breaker consists of a barge carrying sheer-legs, from which is suspended a heavy steel ram, 15 tons in weight, 40 to 50 feet in length, and 18 inches in diameter, with a renewable conical point, tempered so as to combine a hard core with a softer exterior, thus enabling a sharp point to be preserved as it wears away. The ram is lifted by a wire rope wound on a loose drum, driven by a friction-clutch, and with a fall of 8 feet and an average of 8 blows penetrates the rock to a depth of 3 feet, the points of penetration being placed about 3 feet apart. This is found to break up the rock sufficiently to enable it to be removed by dredging, and the most powerful rock-dredger yet constructed, the "Viscount Ridley," has recently been obtained specially for this work. It is capable of dredging to a depth of 45 feet below water-level, and its parts are of such great strength that the machine will not break down even if the buckets get a fast hold of the solid rock. The dredger delivers into steel hopper-barges. The other dredgers, the "Blyth" and "Cambois," are of the hopper type, one being fitted with sand-pumping appliances.

(b) Underpinning of Quay-wall at the South-side Staithes.—Perhaps the most interesting work in progress at present is the underpinning of the old quay-wall (700 feet in length), retaining ground on which the south-side coal-staithes stand. This work was found to be necessary on account of the undermined condition of the old foundations, and also in order to enable the depth at the berths to be increased to 24 feet at low water. It has necessitated some very difficult cofferdam work, and the underpinning or rock-excavation of a section is now in progress, rock-drills and electric centrifugal pumps being in use.

(c) South Harbour.—New timber quays are nearing completion, and extensions to the fish quays have also been recently made. A large market, intended for the white-fish trade which it is expected will be established, is also in course of construction.

(d) Coal-shipping.—On the north side of the river it is proposed to erect additional staithes, above the present staithes belonging to the North-Eastern Railway Company. This work will probably be commenced shortly, and will provide a means of shipping an additional quantity of 1,000,000 tons per annum. Provision is, at the same time, being made for further extensions if required.

After inspecting the harbour, the members adjourned to the Mechanics' Institute, where they were entertained to light refreshments by the President (Mr. T. E. Forster), who proposed a vote of thanks, which was heartily accorded, to the Blyth Harbour Commissioners for their great kindness in providing vessels and for conducting the party round the harbour.

Councillor S. K. Young (Blyth), replying on behalf of the Blyth Harbour Commissioners, said that it had been a great pleasure to them to receive the members of the Institute. Perhaps they had not a great deal to show, but they had, he was sure, one thing, and that was enterprise. What was a few years ago a muddy stream was now a great harbour capable of receiving vessels up to 10,000 tons, and he believed that Blyth had a great future before it.
Mr. John Simpson (Heworth Colliery) proposed a vote of thanks, which was carried unanimously, to the President (Mr. T. E. Forster) for his kind hospitality.

[1]

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 following contractions are used in the titles of the publications abstracted: —

Bol. Ing. Minas, Peru. Boletin del Cuerpo de Ingenieros de Minas del Peru, Lima.
U.S.A.

[2]

The author refers, in the first place, to Dr. Richard Lachmann's paper on the bauxites of the Bihar Mountains in Eastern Hungary, which occur as irregular reddish-brown masses in association with Upper Jurassic limestones, and unconformably overlain by Upper Cretaceous sandstones and conglomerates. These bauxites exhibit a conchoidal or parallelipipedal fracture and a finely granular, "sphaerolithic-porphyritic" structure. They are regarded by Dr. Lachmann as being of metasomatic origin; and the conditions under which they occur show that they result from the widening of cavities within the limestones by ore-bearing solutions which ate away the rock and replaced it with bauxite by "molecular substitution." Both from the geological and from the mineralogical standpoint, the Italian bauxites present surprising similarities with those of Eastern Hungary. The author adduces as an example the deposits at Pescosolido, in the Liri valley, in the Terra di Lavoro district of the Abruzzi, which he has had the opportunity of investigating personally.

Bauxite is of comparatively recent discovery in Italy, the first published announcement regarding its occurrence in that country dating from 1901. It has been found at various localities in the Central Appennines, more especially in the above-mentioned district of Terra di Lavoro, and is invariably inter-bedded with certain cryptocrystalline or compact limestones of Cretaceous age (Upper Cenomanian or Lower Turonian). The mineral is of a reddish-brown colour, irregularly mottled with paler spots, and of a finely granular oolitic structure, with numerous bigger oolites or sphaerulites of a darker brown dispersed throughout the mass. The specific gravity ranges from 3.22 to 3.95: the percentages of alumina, from 54.60 to 58.85; of oxides of iron, from 18.62 to 30.63; and of silica, from 3.65 to 7.91. The Pescosolido deposit occurs on an outlying spur of Monte La Brecciosa, at an altitude ranging between 2,600 and 3,000 feet above sea-level, in the shape of a stratum interbedded with the white Cretaceous limestones, striking, like them, from north-west to south-east and dipping 50 degrees south-westwards. The mineral is of very uniform character throughout, and the deposit is quite conformable to the beds above it, exhibiting a gradual passage into the limestones at the hanging-wall. But, at the footwall, the conditions are very different: the bauxite lies upon an irregular hillocky surface of limestone, and, enveloping innumerable fragments of the same rock, appears to invade the cavities present within the underlying limestone, ultimately forming a sort of calcareo-bauxitic breccia or conglomerate.

The author holds that the Pescosolido bauxite is of contemporaneous origin with the marine limestones that overlie it. Deposition took place practically at the surface, and is not assignable to the percolation through the limestones from below of acidic solutions. Either the aluminous and ferruginous particles were precipitated on a shallow sea-bottom that was much disturbed by wave-action; or, as the author now thinks more likely, over a sea-bottom formed of calcareous material flowed acidic solutions bearing particles of alumina and iron, and the erosion of this material was accompanied by an exchange of chemical bases, with consequent precipitation of alumina and oxides of iron.

There seems to be no doubt regarding the great similarity in character, approximating to identity, between the Italian bauxite-deposits and those of

[3]

countries just as there is between the bedded deposits of pisolitic limonite. Moreover, there are numerous instances of the passage of bauxite into such limonite, and this again
presupposes a very close genetic relationship between these deposits. Certain French occurrences are cited as examples; and so too, barely 900 yards away from the Pescosolido bauxite-deposit, there occurs on the Colle Rotondo, under similar stratigraphical conditions, a small lenticle of brown iron-ore. A little farther away, on the Colle Como, is a bigger lenticle: both these were mined at one time. Then several outcrops in the same neighbourhood are enumerated, which, consist partly of brown iron-ore and partly of bauxite.

L. L. B.


The overlying barren measures in this region (Trias and Jurassic) are practically continuous, but they vary greatly in thickness. For more than half a century attempts have been made, at intervals, to strike the prolongation of the known coal-belt beneath them. An attentive study of the stratigraphy enabled the author to prove, several years ago, that the two crystalline buried ridges of the Mont Rouvergue and the Mont Cabane formed shallows in the Triassic sea or great lake, around which the thickness of (Triassic) sediments is proportionately diminished. But a boring put down in 1899 at Campredon, near Mialet, south-west of the Mont Cabane, revealed the existence of an unsuspected deep syncline, within which the lacustrine sediments of the Trias attain a thickness of 1,246 feet, and rest immediately upon the granite, Coal-measures being entirely wanting. North-east of the Mont Rouvergue, parallel with the Ceze valley, another syncline appears to have been formed a little later, in Charmouthian (Liassic) time, trending east and west and filled up with siliceous limestones to a depth of 1,300 feet or more. Yet it is in those very limestones that the author counselled a boring in 1902 at St. Bres, hoping to meet in depth with the oblique Castillon fault, which might cut out the whole (or a good part) of the Trias. He predicted that the Coal-measures would be struck at a depth of 1,475 feet or thereabouts: the actual results were as follows:—Toarcian marls, 180 feet; Charmouthian limestones, 1,358 feet; pyritous grit and fault-debris, 36 feet; Coal-measure grits and shales, with sixteen-coal-seams, 777 feet; total depth reached, 2,351 feet. A boring, put down as long ago as 1866, at Les Mages, 9 miles or so north-east of Alais, had proved a thickness of 525 feet of Coal-measures, including seven coal-seams, after passing through 1,532 feet of Jurassic and Trias. Until recently, this was held to indicate a local diminution in thickness of the Lias and Trias, but the author has accumulated evidence to show that here again is a case of oblique faulting, whereby much of the Lias and Trias is cut out. He summarizes as follows:—(1) the barren measures increase in thickness concurrently with increasing distance from the two crystalline buried ridges of the Mont Rouvergue and the Mont Cabane; (2) various synclines or graben were formed, or at all events deepened, during Triassic and Jurassic times, and have been largely filled up with sediments of those ages; (3) the extension of the coal-field should therefore be sought in future only at the points where oblique faulting may be expected to have cut out a considerable thickness of these sediments.

L. L. B.


South of the little town of Drebkau, in the hills ranging from Geisendorf to Straussdorf, brown coal has been worked for several decades: but the original opencast workings are now superseded by underground workings, the maximum depth to which a shaft has been sunk being stated as 165 feet or thereabouts. The area covered by the Merkur mining concession, which is more particularly dealt with by the author, amounts to
2,572 acres: the detailed section illustrates the folding of the strata into more or less irregular anticlines and synclines. After a general description of the geology of the region, which forms part of the great North German Drift plain, the hill-ranges representing probably either terminal moraines or eskers, the author deals in the third chapter with the brown-coal formation itself. The folded and generally disturbed condition of the strata is doubtless due to Glacial agencies. Where the borings have struck the limb of a steep anticline, the coal is found close to the surface in such amazing thicknesses as 150 and 180 feet: in other borings several seams (in some cases probably the same seam repeated by overfolding?) would appear to have been proved. In an appendix details are given of selected borings wherein the succession of the strata is comparatively regular, and the main coal-seam has its normal thickness of 29½ feet. It is really divided into an upper and a lower seam by a parting of brown clay, averaging a foot in thickness. The upper yields a good fuel which is marketable without being made into briquettes; while the lower is of inferior quality, and bands of lignite make themselves increasingly manifest towards the floor of the seam.

Analysis yields the following percentage result:—carbon, 27.19; hydrogen, 2.09; sulphur, 0.37; oxygen and nitrogen, 11.78; hygroscopic water, 55.51; and ash, 3.06. The heating power has been determined as equivalent to 2,138 thermal units, or 1 lb. of the brown coal converts 3.36 lbs. of water at 32° Fahr. into steam at 212° Fahr. The main seam is overlain by black clays and underlain by a brown loam, below which come sandy beds with streaks of coal, often passing quite gradually into seam No. 2, after a maximum interval of 13 feet. This seam attains thicknesses of 6½ and even 10 feet. A third seam is mentioned, but not described; and below it come the “farewell” or basement strata of the brown-coal formation, grey plastic clays ranging from 3¼ to 16½ feet in thickness: Below these again come quicksands full of water. Emphasis is again laid upon the extremely disturbed condition of the strata, the irregularity (as might perhaps have been expected) increasing towards the surface. Generally speaking, the cover of Glacial Drift is thickest over the Tertiary synclines, and thinnest over the anticlines. The problem of the originating cause of the disturbances is discussed at some length, and, noting by the way that the district was covered by ice during the first and third epochs of glaciation, but not during the second, the author surmises that the topmost coal-seam was crushed and smashed up by the first ice-cap. The last ice-sheet kneading and crushing the upper beds, thrust up the plastic lower strata into overfolded anticlines, etc. On its retreat, it left behind it the signs of a long interval of repose in the shape of hillocks of sand and gravel, and accumulations of boulders.

There would appear to be a traceable connexion between the brown-coal formation of Drebkan and the extensive coal-basins of Posen and the Mark (Brandenburg) on the one hand, and with the sub-Sudetic coal-basin on the other, all of which are of Miocene age.

L. L. B.


After investigations extending over a period of six years, two officers of the French Army (Capt. Maury and Lieut. Hust) have succeeded in proving several coal-seams, varying in thickness from 2 to 8 inches, in the highly fossiliferous Westphalian beds that occur in the far south of the department of Oran. A specimen taken from the outcrop at Jorf el Feham (the “Coal Rock” so christened by Capt. Maury), near Hassi Ratma, is very black and crumbly, and yields on analysis 36.15 per cent. of fixed carbon; 19.31 of volatile matter; 25.94 of hygroscopic water: and 18.6 per cent. of ash. This coal is closely comparable with the coal from Le Gressin, near Nantes (Loire Inferieure). It may be expected, however, that the coal got from deeper down will prove to be of better quality. With the beds containing
Westphalian plant-remains are associated bands yielding Spirorbis, Carbonarius, Belinurus arcuatus, Anthracomya, and small ostracoda, vividly recalling similar bands in the English Coal-measures.

Mr. Flamand claims, however, to have discovered the first known coal-outcrop in Southern Oran, associated with a Westphalian flora, at Hasi-Hadri (Khenadsa), and to have reported his discovery to the Governor-General of Algeria in June, 1907, a few weeks before Capt. Maury's report was received. He refers to sundry publications of his dealing with the subject of coal in Southern Algeria.


This coal-belt extends for more than 30 miles from north-west to southeast, between Les Essarts in the department of Vendee and St. Laurs in the department of Deux-Sevres. while in breadth it barely reaches 1,100 yards. It may be pictured as a long and narrow lake occupying a depression in the talcose and quartzitic, varicoloured schists of the so-called "Transition Series." In the eastern part of the belt the Coal-measures crop out repeatedly; but west of the Merre river at least two-thirds of the coal-area are hidden by an outlier of Lias. The barren Coal-measures consist of an alternation of grey and pink, usually felspathic and frequently quartzose grits, black highly foliated shales, and red and green conglomerates not seldom containing big pebbles of quartz and lydianstone. In this succession the grits predominate; both in them and in the shales plant-remains occur. The productive Coal-measures dip, as a rule, from 50 to 80 degrees northwards; but some beds show an unmistakable southerly dip, and others again dip in both directions. Eleven distinct groups of coal-bearing strata are enumerated and briefly described, beginning with that of St. Laurent—Ste. Marie, which includes eight coal-seams varying in thickness between 2 ½ and 40 feet, and separated one from the other by from 6 ½ to 33 feet of shales or grits. Some 650 feet of conglomerates, grits, and shales intervene between this and the Ste. Clotilde group, which includes nine coal-seams ranging in thickness from 2 ½ to 6 ½ feet, divided one from the other by from 16 ½ to 40 feet of barren strata. About 220 yards west of the second group is that of Ste. Claire-Couteau, with six coal-seams, from 2 ½ to 8 ¾ feet thick respectively; then follows an interval of more than 870 yards of grits and shales until the Centre-Bois Menias group is reached, including five coal-seams of much the same thickness as in the preceding group, and 875 yards to the north is the Verrerie group with three coal-seams, the uppermost of which has a conglomerate-roof. West of the last-named group, that of La Croisiniere has two coal-seams, 3 ½ feet thick, dipping 65 degrees northwards; and about 2 miles to the south occurs the Moriniere group, also with two coal-seams (one of which has a thickness of well nigh 4 feet of excellent coal), but dipping at 80 degrees. Proceeding westwards, at a distance of 650 yards or so from La Croisiniere, we find the Espagne group, which includes several seams, but one alone that is workable (5 feet thick). The Noliere group, includes two seams, 2 ½ feet thick respectively, dipping 60 degrees northwards; and the Puyrinsant group (2 ½ miles distant from Espagne) includes but one seam worthy of mention, about 3 ½ feet thick. Finally, the Chantonnay group boasts four seams, dipping from 50 to 60 degrees northwards, one of which, 4 feet thick, is undoubtedly workable. There are so many differences between the various groups just described, in regard both to the character of the coals and to that or the barren measures, that it seems natural to infer that each group represents the deposits laid at the bottom of a small lake, the entire coal-field constituting a chain of such lakes. The palaeobotanical evidence implies that the first four groups belong to
the Lower Coal-measures, and the others most probably to the middle portion of the Upper Coal-measures. While the author stands firm by his theory of deposition in a chain of small lakes, he holds that further exploration in the coal-belt might conceivably yield favourable results from an industrial point of view, as nothing so far disproves the possible existence of other coal-deposits besides those already known in this area. In the Verrerie group, it should be mentioned, bituminous shales with reniform nodules of clay-ironstone occur between the two lowermost coal-seams, and are particularly suitable for the oil-distilling industry, as tests made with them have shown.

L. L. B.

The Huayday Coal-measures, Peru.—By Ernest D. B. Lukis. Bel. Ing. Minas, Peru, 1908, No. 64. pages 1-62.

After examination of the coal-belts which range through several provinces of Peru, the author desires to draw more especially attention to the importance of the neighbourhood of the Huayday homestead, near Lucma, in the province of Otuzco, as the coal-deposits there are most advantageously placed with regard to the probable consumers of the output. The mineral is a good anthracite, yielding only 4 to 5 per cent. of ash; and it may be observed in passing that the anthracitiferous seams of Peru appear destined to bulk largely in the future industrial development of that Republic. The amount of workable anthracite there is beyond comparison vaster than that known to exist in the United States. This variety of coal, purely from want of habit or custom, is but little used in Peru at present, even in the numerous districts where firewood is scarce and dear. The railway-terminus of Ascope is 56 miles distant from the spot where it is proposed to put down the necessary sorting-plant (picking-belts, tipples, etc., at the base of the ridge where the Huayday coal occurs, 4,000 feet above the level of the Pacific. The construction of a branch-railway presents no serious engineering difficulties. Another railway-line terminates, near Casa Quemada (“Burnt House”), only 40 miles distant from the projected installation. The climate is good, and the water-supply abundant, as also suitable labour.

Some 30 years ago a mine was being worked on the right bank of the Calmon ravine, whereas operations are nowadays being pursued on the left bank. A landslip has completely blocked up the old adit, but the coal-formation can be traced along the wall of the ravine south-eastwards, and so

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fresh workings (of minor importance it must be said) were opened up on the seam. The want of a local market, which would have been an infallible stimulus to active mining operations, may largely account for the insignificance of these workings. About 1,000 tons of coal, more or less, have been extracted.

Some 3 ¾ miles away to the east, the ridge of Sayapullo, with its important silver and copper-mines, rising to an altitude of 5,000 feet above the Huayday homestead, dominates the horizon. The previously mentioned railway-terminus of Ascope is 47 miles distant from the harbour of Salaverry on the Pacific seaboard, but it is much nearer Malabrig harbour, which could be made available for the loading of coal. The coal-bearing formation, undoubtedly of infra-Cretaceous age and possibly Jurassic, consists largely of quartzites (no less than 18,000 feet thick), and the slates (containing badly preserved plant-remains) with which the coal-seams are more directly associated. These are two in number, so far as known, averaging, with slaty and quartzitic partings, a total thickness of 30 feet. In a later portion of the memoir, it is stated that the upper seam has a thickness of 5 feet of pure coal, and the lower seam a thickness of 3 ¼ feet of the same. But several seams are mentioned in other localities, some of which occur in close proximity to the igneous crystalline rocks, as, for instance, at Chala Alta : although, even hereabouts, the coal is
frequently separated from the diorites by a thin band of slate. The author describes in detail the exploration work which he started at Huayday, on his arrival there at the beginning of December, 1907. The dislocated condition of the strata, and the abundance of water-feeders are difficulties which the miner must be prepared to face here. Three analyses of typical specimens of Huayday anthracite are tabulated, showing an average percentage of 85.28 of fixed carbon; 5.84 of volatile matter; 3.95 of hygroscopic water; and 4.92 of ash. It seems probable that the workable coal-area will be found to approximate to a length of 3 ¾ miles and a breadth of 2 ½ miles.

The fifth chapter of the memoir embodies the results of a study of the physical properties and chemical composition of the anthracite. It is described as a very lustrous black, somewhat laminated mineral, very hard, and yet brittle along the natural joint-planes. It burns with difficulty at first, but has not the defect (common to many anthracites) of decrepitating and crumbling away when it does burn. Samples were taken with great care, and the laboratory tests proved, first of all, that the mineral contains a notable proportion of combustible gas. No less than twelve analyses are tabulated, in four of which only is the specific gravity noted (ranging from 1.56 to 1.62). The heating power (deduced from two analyses) averages 7,925. calories. The percentage of ash varies from a minimum of 3.5 to a maximum of 13.21, and that of fixed carbon from 62.29 to 88.02. A detailed description is given of the tests carried out with the anthracite, which confirmed the author's opinion of its excellent quality. It is suitable for domestic purposes, but more especially for steam-raising and gas-producers.

In the seventh chapter consideration is given to the preliminary work which will be necessary before mining operations on an extensive scale can be started at Huayday. Details are also supplied regarding the probable amount of capital required (for which the reader should also consult the ninth chapter), and the various installations requisite (including engine-slopes, tramways, tipplers, etc.). Stress is once more laid on the advantageous situation of Huayday, as regards means of communication with the sea-coast, when compared with other coal-fields in Peru. L. L. B.

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The symmetrical alignment of workable coal-fields along both limbs of this great syncline had long since suggested the probable association in depth of the Waldenburg and Schatzlar seams, but it was not until recent years that borings had been carried down to really considerable depths. One such boring, put down to 5,150 feet at enormous expense, is cited as an example of the present activity of German industrial enterprise; although, of course, the profitable working of coal at such depths cannot be as yet looked upon as a practical proposition. In this area, all the beds, reckoning from the Xaveristollen or Upper Saarbrucken Series upwards, are regarded as "covering strata" merely. The consideration of the problem to which the author addresses himself, namely, the probable depth at which the workable seams may be expected to lie in the very centre of the syncline, is complicated by two not unimportant factors: tectonic structure, and the presence of numerous eruptive rocks with their derivative tuffs. A detailed synopsis of the rock-succession is tabulated, beginning with the uppermost Carboniferous (which occurs chiefly on the Bohemian side of the frontier); this consists largely of equivalents of the Ottweiler Series. Next comes the middle division of the Upper Carboniferous, consisting of two groups: in descending order (1) the Lower Schadowitz = Upper Saarbrucken = Xaveristollen Series, with but two or three coal-seams; and (2) the Schatzlar = Lower Saarbrucken Series, with nineteen or twenty seams and a very rich flora. The lowermost division of the Upper Carboniferous here is
equivalent in part to the Culm (so called) of British geologists: it includes two groups (separated by an unconformity), the lower being the Waldenburg Series, with about twenty generally workable seams, the full number occurring only in the Waldenburg district itself. A marked unconformity separates the foregoing groups of strata from the dark slates and "grauwacke" of the Lower Carboniferous. A short description is also given of the overlying Rothliegende (Permian), and of the manner in which its relation to the Carboniferous varies from place to place between conformity and unconformity.

There can be no dispute whatever as to the presence of the productive Coal-measures everywhere in the deeper-lying portion of the Lower Silesian and Bohemian basin, and it is with this portion that the author more especially deals, the immediate neighbourhood of the Waldenburg, Gottesberg, and Neurode coal-fields (now in full industrial activity) being excluded from his purview. With regard to the borings already carried out or projected in the district of Preussisch-Friedland, it is shown that coal could only be reached there at depths ranging from 5,575 to 6,315 feet. The results that may be predicted from the Braunau and Grussau districts are hardly more encouraging. Whence it is concluded that in the actual centre, apparently but little dislocated, of the great Silesian-Bohemian Coal-measure syncline, the seams all lie at depths exceeding 5,250 feet below the surface, and the working thereof under present industrial conditions is not to be attempted. Some slight extension of the coal-fields, impracticable under present conditions, however, may be looked for in the neighbourhood of Neurode and probably also south of Waldenburg. There is, moreover, a prospect of a somewhat considerable extension at the north-eastern margin of the basin, between Grussau and Landeshut.

L. L. B.

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Western Siberia, comprising the governments of Tomsk and Tobolsk, covers an area of nearly 870,000 square miles, over which is scattered a population of less than 4,000,000 souls. With the single exception of the Altai district (which is Crown property) in the extreme south-east of the government of Tomsk, it is a region of vast plains with an all but uniform slope to the frozen shores of the Arctic Ocean. About one-third of the Altai district is mountainous, the highest summits rising to an altitude of 14 500 feet or so. The massifs there are mainly built up of granites, diorites, porphyries, etc., which have broken into and burst through the Palaeozoic sedimentaries (Silurian, Devonian, and Coal-measures). At the points of contact argentiferous lead and copper-ores occur, and at other localities iron-ores and coal.

The greatest coal-field in Siberia, and, for that matter, in the Russian Empire, the Kusnetzk coal-basin, extends southwards from the neighbourhood of the city of Tomsk towards the Tom river (which divides the coalfield into approximately equal halves) and thence through Kusnetzk nearly as far as the banks of the Upper Kondoma, a southern tributary of the Tom. This coal-belt thus measures about 100 miles in length, with an average breadth of 53 to 66 miles: both in area and in the amount of available coal, it far surpasses the world-renowned Donetz Basin. There appears to be an undoubted connexion between the small coal-basin of Elbashkoye, near the river Berda (which flows into the Ob from its right bank south of the Ima) and the great Kusnetzk basin. The Sudshenka or Sudshenskoye coal-deposits occur at no great distance from the Trans-Siberian Railway, in the immediate neighbourhood of the Kitata and Altshedata rivers. The five most important localities for coal in the Kusnetzk basin are enumerated, and it is pointed out that active mining operations are at present confined to the Batshata and Kolshuginsk deposits, the latter of which is regarded as perhaps the richest in the whole coal-field. The remarkable regularity of the
bedding and the excellent quality of the coal at Koltshuginsk, the mineral being especially suitable for metallurgical purposes and for coking, are noted. The output has well nearly doubled within the last decade, and suggested railway-developments are likely to promote a still faster rate of increase.

The Sudshenka coal-basin has been the scene of mining operations since 1895: the loose texture of the strata and the numerous inruses of water constitute serious difficulties, and it is found necessary to resort to especially elaborate timbering. The mines yield about 100,000 tons of coal annually, and the output is chiefly used up by the Trans-Siberian Railway. The coal contains on an average 1.5 per cent. of sulphur, leaves 2.7 of ash, and yields from 78 to 80 per cent. of coke: the seams in the upper strata are crumbly, while those in the lower are of anthracitic character. The amount of coal in sight is estimated at rather less than 100,000,000 tons.

Mention is also made of the brown-coal deposits in the southern portion of the Mariinsk administrative district, forming part of the so-called "Middle Tshulim Basin." They are not, however, of first-rate importance, and are worked only on a small scale. Lignite crops out at Altimskoye, near the great Ob river. Extensive peat-mosses, as yet untouched for industrial purposes, occur in the north of Western Siberia; it is true that a certain amount of peat is cut in the Kurgan district of the government of Tobolsk, and is utilized as fuel.

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In the steppe-region of Western Siberia, nearly all the lakes are salt. Great numbers of them are scattered over the southern portion of the government of Tobolsk and the southwestern portion of the government of Tomsk. Some of these lakes also yield Glauber's salts: these are got at all seasons of the year, but common salt is "harvested" only from July to September.

L. L. B.


The results of the borings put down in the department of Meurthe-et-Moselle, in search of the prolongation of the Saarbrucken coal-field, were made public in 1905. A boring recently put down on the southern limit of the Saargemunde syncline (instead of on the presumed prolongation of the Saarbrucken anticline), struck two coal-scams at the respective depths of 2,300 and 3,380 (sic) feet below the surface, at Gironcourt-sur-Vraine (about 9 ½ miles west of Mirecourt). The upper seam, 28 inches thick, yields a coal containing 32 per cent. of volatile matter and giving a hard coke with metallic lustre, such as would probably be available for use in steel-works, etc. The lower seam consists of two bands of coal, 16 and 8 inches thick respectively, separated by a 16-inch shaly parting. The barren strata overlying the recognized Coal-measures are 2,237 feet in total thickness, and the Coal-measures themselves have been so far penetrated for a depth of 525 feet: these measures are almost identical in character with the Ottweiler Series exposed in the Abaucourt boring, near Nomeny; they consist of brownish-red and blackish-grey argilaceous shales, with considerable intercalation of pale-grey, occasionally almost white, felspathic grits.

The author points out that he had predicted the occurrence of coal, at about the depths actually noted, in the Gironcourt area, on the western prolongation of the Saargemunde syncline—along which hitherto the only boring that had struck the Coal-measures was at Mont-sur-Meurthe. Here the Ottweiler Series was met with at a depth of 3,936 feet, containing an unworkable fenule of coal. If the continuation of the Gironcourt boring and other new borings should reveal fresh workable seams, the known enormous diminution in thickness westwards of the Triassic (Vosges) grit and the Permian encourages
the hope that a coal-mining industry may arise west of the Moselle valley, at least as far as the boundary of the Haute-Marne. On the other hand, the vast thickness of the barren Triassic and Permian strata on the east, with the consequent impractically great depth to be traversed before reaching the Coal-measures, makes it probable that the region of Mont-sur-Meurthe, Luneville, and Rambergvillers, will for long remain inaccessible to the coal-miner, except perhaps at a very few widely separated localities along its southern margin.

If the Saarbrucken Series really extends as far as the southern limb of the Saargemunde syncline, there is some hope of striking it at shallower depths than 2,300 feet south of Gironcourt, between that locality and the Vittel district.

L.L.B.


Among the ancient crystallines of the Nieder Tauern, between the Euns and the Mur valleys, occur pyritous ores, marked at the outcrop by a brown-weathering "crust." Two such belts, known locally as branden, are worked

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at altitudes ranging from 6,000 to 8,000 feet above sea-level, the so-called Votternbrande being 20 feet thick, and the Neualpnerbrande about 56 feet thick The "country-rock" (which is gneiss) is traversed by vertical, in part quartziferous, veins of calcspars: in the case of the Votternbrande, the calcspars-veins are barren at the hanging wall thereof, but occasionally carry fahlores at the footwall thereof. In the case of the Neualpnerbrande the transverse calcspars-veins mostly carry fahlores, and vein No. 5 bears especially rich silver fahlores, while No. 4 is mineralized with arsenical pyrites and native arsenic. The branden themselves consist of three distinct types of material: (1) partly silicified, much altered chloritic and sericitic derivatives of the various crystalline schists of the district; (2) quartz-lenticles: and (3) bed-like layers and nodules of a crystalline carbonate-rock, with which the nickeliferous ores are predominantly associated. Most of the previous writers on the subject affirm that there is enrichment of the nickel-ore at the intersections of the branden and the calcspars-veins: but the authors found it impracticable to pursue their investigations sufficiently far in the still accessible portions of the old workings, to determine this question beyond dispute. It has also been assumed that the two branden are distinct metalliferous belts, one overlying the other, separated by about 2,000 feet of hornblendic schists: but the authors' map and sections point to the existence of only one belt, ranging from the Votternspitz and sweeping round south-eastwards to the Zinkward.

The nickel-ores are chiefly arsenides and sulpharsenides, with which are associated smaltite (CoAs₂), native bismuth, native arsenic, and arsenical pyrites. It is practically only in the transverse lodes that fahlore, galena, ehalcopyrite, stibnite, and ordinary pyrites occur. The branden are defined as bedded deposits, and are assimilated to the "fahlbands" of Kongsberg, Skutterard, and Snarum in Norway.

An account is given of the numerous adits, by means of which the Schladming deposits were formerly worked. Operations directed to the mining of the nickeliferous ores were started in 1832 and continued, with various interruptions, until 1880; but it is believed that the amount of metallic nickel thus obtained in the course of half a century did not exceed 80 tons.

It would appear, however, that these operations were confined to the uppermost levels, and it is by no means impossible that methodically conducted deep mining would initiate a revival of the mineral industry of the district. L. L. B.

The region here dealt with is a hilly country averaging a height of 1,500 feet above sea-level, and attaining in Monte Pelao a maximum altitude of 2,395 feet. It forms the water-divide of three different river-basins; and the natural water-supply is so conditioned that it combines with the comparatively easy communications and means of transport available by road and railway, to favour the initiation of a mineral-industry directed to the copper-ore deposits. The geology of the region, broadly viewed, is simple enough; a basement-formation of eruptive trachytic rocks is overlain by comparatively undisturbed Tertiary sediments, which are in their turn overlain by basaltic lavas, more or less denuded by atmospheric erosion, etc. The Tertiary strata are most probably of Middle Miocene age, and they include

in descending order a marly, a calcareous, and an arenaceous-tufaceous facies: a well-marked cupriferous horizon occurs at the top of the last-named and at the base of the limestones. The sandy beds are impregnated with carbonates of copper (malachite and azurite), which frequently assume a concretionary character, and the ore-occurrence presents a remarkable analogy with the famous deposits of El Boleo in Lower California. The mineralization does not extend to the overlying strata, but in some places it displays a tendency to penetrate right through the underlying formations down to the trachytic rocks. The designation "trachytic" must, in this instance, not be interpreted too strictly.

The metalliferous deposits may be conveniently divided into a northern and a southern group; beginning with the former and by far the most extensive of the two, it may be premised that exploration-work has not been pushed forward as thoroughly as might perhaps have been expected. Nevertheless, enough is already known to permit of some forecast of the industrial importance of the ores. Details are given of the geological conditions, etc., observed in the neighbourhood of Bessude, Tiesi, Cheremule, and Giave. The southern group includes the deposits of Mara (Cadiz and Sulizzu), differing in some respects from those just enumerated, which may be regarded as originally a single belt parcelled into separate patches by subsequent erosion.

The problem of the genesis of these ores offers some difficulties; but it seems likely that the thinly stratified cupriferous deposits of the northern group originated from the local precipitation of metalliferous carbonates after a process of re-assortment and concentration, following on the alteration of sulphidic ores originally present in the great basement-formation of pre-Miocene trachytic rocks. In the case of the Mara deposits, alteration and mineralization of the trachyte may have occurred after the overlying Miocene strata had been laid down, by the agency of acidic waters charged with cupriferous particles; or else it is permissible to imagine that a certain area of mineralized trachyte may have been superficially decomposed at those points where the cupriferous stratified ores of Mara were subsequently deposited. A picked sample from these latter yielded 8.4 per cent. of metallic copper, but the average content of the entire stratum is estimated at less than 1 per cent. Of the visible trachyte, only a small portion of the mass contains enough copper to repay working, a picked sample yielding 14.37 per cent. of the metal. Nine analyses are tabulated, of samples taken from the cupriferous sandstones of the northern group, in which the percentage of metallic copper ranges from a minimum of 0.13 to a maximum of 19.89. The average for the entire stratum at Cheremule is 2 per cent., and at Tiesi 1.04 per cent. The amount of crude ore in sight in these two districts is estimated roughly at 600,000 metric tons.
Further investigations are needed, before the question of seriously working these deposits can be considered. L. L. B.


This mineral is named after the well-known metalliferous mine of Bosas in Sardinia, worked with inexplicably scant success during a great part of the nineteenth century. But recently mining operations have been resumed there, under the vigorous impulsion of new management. The predominant rocks are Palaeozoic shales and limestones, traversed, fissured, contorted, and otherwise disturbed by a great intrusion of diabase, with which the metalliferous ores are intimately associated. Galena and blende occur most abundantly together with a little pyrite and still less chalcopyrite. The galena is richer in bismuth than any other occurrence of the kind in Sardinia containing 0.11 per cent.; and one variety of blende from the Rosas mine has been found to contain 0.23 per cent. of cadmium. Calamine, smithsonite, hydrozincite, etc., have been worked for the past few years at Rosas, where they are found at the junction of the limestones and the shales. The cupriferous minerals occur more especially among the shaly strata in the form of lodes of small extent: they include malachite, of which the author has seen magnificent specimens, and the new mineral here described. The latter occurs as a pale bluish-green fibrous venule, of silky lustre on fresh fracture, slightly mammilated, and with small bands covered by an intensely green film which can be rubbed off by the finger-nail. The hardness of the mineral is 4-5, and its specific gravity is 4.07. On quantitative analysis it yields the following percentage results:— Oxide of copper, 36.34; oxide of zinc, 33.57; carbon dioxide, 30.44; traces of lead; and 0.21 of water. These proportions may be approximately expressed by the chemical formula $2\text{CuO} \cdot 3\text{CO}_3\text{Cu} \cdot 5\text{CO}_3\text{Zn}$. No mineral hitherto discovered will fit this formula, and the author proposes for this newly found double carbonate of copper and zinc the name of rosasite. It may be noted that, while malachite apparently predominates among the cupriferous ores at Rosas, azurite is of exceptional occurrence.

The author speaks of the mine as an admirable mineralogical museum, but he feels obliged to chant its praises from the industrial standpoint in a minor key. L. L. B.
this region are in the main steeply-dipping hornblendic mica-schists, hornblendites, and augen-gneisses with a general north-and-south trend, and intrusive haplitic and pegmatitic granites (among which the unique occurrence of black felspar is noted, on the summit of a kopje immediately south-south-east of Kolmanskop railway-station). Limestones, varying in colour and texture from banded, dirty bluish-grey masses to white marble, extend in a broad belt southwards

from the Zweikuppenberg, and it is by no means certain that they rightly belong to the schist-complex. The effect of the keen south-south-westerly winds, laden with sharp sand-particles, which blow through the greater portion of the year, is to polish smooth all exposed rock-surfaces, and in steeper rock-faces to excavate cavities occasionally exceeding a yard in diameter. The remains of a much later formation than those above mentioned are especially well seen in the depressions from 330 to 500 feet above sea-level east and north of Elizabeth Bay, and merit perhaps more particular attention because the diamond-occurrences are associated with them. The crystalline schists here are immediately overlain by a greenish-yellow sandy clay, full of fragments of quartz and felspar. Next comes a very fine-grained, thinly-bedded, red and scarcely cohesive sandstone, with occasional thin bands of coarser material. The quartz-granules which make up this sandstone have been identified as mainly belonging to the varieties jasper, chaledony, and agate, and there appears to be no doubt that they were originally components of the amygdaloids in an amygdaoidal diabase. This sandstone, which the author has proved to be of marine origin and of Mesozoic age, attains a maximum thickness of 82 feet, extends over a considerable area, and appears to be even more quickly eroded by the sand-laden winds than the older formations. In places it has been preserved from destruction by an overlying bed of hard onyx-limestone, several feet thick. Among localities for diamonds, besides the Stanch, Kolmanskop, Schmidt, Gehrke, Weiss, Germania, and Zillerthal properties, are also mentioned Nautilus Hill, the narrow Karlshal, and then (56 miles farther south) the territory opposite Plum Pudding Island. On the whole, diamonds may be said to occur in those depressions where Cretaceous strata or rubble material derived therefrom can be proved. The gems are extraordinarily alike in size and general character: they are of about the diameter of small peas, and it takes four or five of them to weigh a carat, although exceptional stones of 4 carats have been recorded. They are usually well crystallized in octahedra, dodecahedra, etc., and their transparency and refringency are good. Predominantly they are colourless, but a good many yellow, and occasionally green and brown diamonds are found. Bort is conspicuous by its absence, and the diamonds of German South-West Africa may be compared with those which occur in the Kimberlite-dykes (but not in the "pipes") of British South Africa. The richest finds have been made in the great depression north of Elizabeth Bay, where indeed the most vigorous prospecting has been carried on. Here the workable belt of diamantiferous gravel attains a maximum breadth of 1,000 feet and an average thickness of 4 inches: it overlies directly the red Cretaceous strata every now and again, but generally a not very thick layer of (apparently barren) gravelly sand intervenes. For the time being the methods of working are of the most primitive description, and manual labour alone is utilized. The average richness of the washable gravel is said to amount to one carat per load (=16 cubic feet of loose material). Garnets of different colours, magnetite, and epidote are found in the concentrates from the washing sieves, but the other minerals (such as ilmenite, chromidiopside, enstatite, etc.) usually associated with the diamond in the South African kimberlites, do not occur. In the northernmost (Schmidt and Gercke) properties the gems run smaller, and six on the average go to the carat. In the Weiss field, a deep basin-like
depression some 875 yards in diameter, the wind has laid bare great stretches of rock, sweeping all the lighter rubble away, while the coarser rubble (and with it the diamonds) has been held fast in the northern portion of the depression: here,

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within an area of 2 ½ square yards, the author picked up six diamonds in the course of a few minutes. But he hastens to caution the reader against any over-sanguine inference as to the richness of the deposits; indeed, he believes that the entire group of diamantiferous occurrences included within the map which accompanies the paper will not be found to hold more than a million and a half of carats, and, according to the optimistic official estimates of the annual output, they would be worked out at the end of a twelvemonth. In a word, the richness and extent of the deposits have been greatly overrated.

The various theories regarding the origin of the Luderitzland diamonds are discussed, and the author avers that the only explanation which will square with all the known facts is the following: the diamond was deposited contemporaneously with the Cretaceous sediments (it is noticeable that where these are wanting, so is the diamond). Of the present diamantiferous gravel, (4 inches thick) an area of 21 ½ square feet represents the concentrates of about 3,530 cubic feet of original Cretaceous strata. Where these have been most eroded and decomposed, there the diamantiferous gravels are richest. The constituents of the Cretaceous sediments (including the diamond) are derived from an area of amygdaloidal diabases, now hidden under the sea, which was especially exposed to denudation in Cretaceous times.


This memoir embodies the results of the investigations conducted by the author in the course of two journeys to the northern portion of German East Africa, between October, 1906, and February, 1908. A short bibliographical list precedes a description of the physical geography of the region, including the Iramba plateau, the Wembere Steppes, etc.; and that again is followed by a detailed account of the general geology. The rocks are all of ancient formation, but granite—either as the fundamental granite underlying all the stratified rocks, or as the intrusive granite piercing the older systems—has perhaps the most widespread occurrence of any. In fact, the other rocks may be described as islands floating in a sea of granite. The ancient crystalline schists (mica-schists, hornblendic schists, quartz-schists, phyllites, etc.) extend in long belts with a constant strike and usually a steep dip. The itabirites (banded ferro-quartzitic schists) which occur in this region are correlated with the Lower Witwatersrand Series of the Transvaal. All the rocks so far mentioned are traversed by innumerable quartz-veins which are most crowded together where the pressure due to tectonic phenomena was greatest. The quartzitic sandstones, conglomerates, and phyllites which crop out in the Ussongo country are unhesitatingly correlated by the author with the Upper Witwatersrand Series. Comparatively thin sandstones of later age (= Lydenburg Series ?) are also observed. The "greenstones" (diortitie and diabasic, etc.), eruptives of various ages, are especially conspicuous in the Ussongo country and in the neighbourhood of Ikoma, and with them are associated the most important gold-occurrences.

The general tectonic structure of East Africa is discussed at some length, especially with reference to the great graben (or rift-valleys). Among the older of these the Wembere depression is of economic importance, as it was here that the rich finds were recently made, which have given rise to the first gold-mine ever opened up in German East Africa.

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Some 6 ¼ miles west of the granite cliff which marks the western margin of the Iramba plateau, a sort of "hog's back" (1 ¼ to 2 miles broad and 7 ½ miles long) is seen rising to a height of about 100 feet above the Wembere Steppe. It is mainly built up of passage-rock from granite into diorite (quartz-diorite) overlain (where these have not been eroded away) by horizontally bedded sandstones and conglomerates and loose sands and gravels. The coarse-grained quartz-diorite gives place on the eastern flank of the northern extremity of this "hog's back" of Sekenke to a more finely granular, less quartzose diorite of later age, which at other points is found to traverse the quartz-diorite in dykes often exceeding 300 feet in thickness. In a belt about two-thirds of a mile broad, along the contact of the two diorites, occur innumerable lenticular quartz-reefs, all of them auriferous, and some sufficiently rich and extensive to repay working on a small scale. Their length ranges from a few yards to a furlong, and their thickness occasionally approaches 10 feet. Two varieties of quartz are recognized in these reefs: (1) bluish-white, hard, homogeneous, with occasional druses and masses of cubical pyrite, with but little gold, if any at all; (2) finely-granular, traversed by small fissures, easily crushed, brownish, pinkish, or yellowish in colour, the real carrier of the gold. The precious metal is here invariably associated with pyrite; and, where that mineral is decomposed, the gold is found in the cavities resulting from the decomposition. Traces of galena have been recorded; and, in one case, a layer of yellowish-brown opal cuts across the reef from wall to wall. Where the lenticles thin out, the percentage of gold therein diminishes, while it increases in the bellying part of the lenticles. Mining operations are still in the initial stage, the greatest depth yet reached amounting to 92 feet; the general water-level of the country is about 60 feet below the surface.

The quartz-reefs probably represent the infilling of fissures which were opened up in the rocks at the time of the upwelling of the later diorite. There seems to be no question as to their considerable antiquity: moreover, the paucity of associated ores, the comparatively low proportion of silver (Ag:Au:1:3), the predominance of pyrite, and the connexion of the quartz-lenticles with the pegmatite-veins, stamp them as belonging to the "ancient pyritic gold-quartz formation."

The dioritic mass of Sekenke is undoubtedly an extension of the quartz-diorite area of the Iramba plateau to the east of it. On the plateau, parallel to the contact-line with the granite ranging from north to south, run numerous dykes of later granite and granite-porphyry. In these dyke-granites auriferous quartz-lodes occur, sufficiently rich to give great encouragement to prospectors when they were proved some 6 years ago. The lodes are confined to the granite, pinching out as soon as they touch any other rock, and they exhibit all the characteristics of infilled contraction-fissures. In thickness they do not generally exceed 3 ¼ feet, although in places a thickness of as much as 16 ½ feet has been observed. The quartz differs greatly in character from that of Sekenke, and the gold is associated with ordinary pyrite and arsenical pyrite. Galena is found in small quantities, but copper-ores (as at Sekenke) are conspicuous by their absence. Their industrial importance is small, and the same-statement will probably hold good of the Kinyangiri gold-occurrences farther east. As in South Africa, the widespread ferroquartzitic schists (itabiritas) would seem to be occasionally auriferous, and gold has been reported in them at Msalala, Ussongo, and Ussindja; also among blocks derived from them at Ssamuye.

In the Kassama valley, at Ngasamo, a day's journey south-eastwards from the British missionary station of Nassa, on Speke Gulf (Victoria Nyanza), among sills of diabase which have been more or less altered into schists, occur lenticles and "nests" of gold-quartz which were at one time worked. The gold, associated with pyrite and
chalcopyrite, and where the last-named is more abundant, the percentage of the precious metal is proportionately higher. The occurrence might repay working on a small scale, if a practical and experienced prospector were to conduct operations with the help of native labour.

At Ikoma, some distance to the east-north-east of the last-described locality, no less than fifteen belts of auriferous quartz-lenticles are associated with diorites, which are of widespread occurrence in that area. Only two belts, however, would repay working, and then on a very small scale. The quartz is richest in gold where its green coloration proclaims the presence of copper: it impoverishes, however, rapidly with depth. The lenticles have a practically vertical dip.

With regard to the auriferous conglomerates, greater expectations were formed at one time in German East Africa than the occurrences would seem to warrant. Describing, first of all, the Ussongo conglomerates, the author points out that they possess no economic value. They are evidently river-deposits of Devonian age at latest, and all that can be said is that possibly workable gold-bearing conglomerates may yet be found in the same group of strata. The Sekenke conglomerates are then described, and such investigations as have been made give little hope that these conglomerates would repay working for gold. It is possible, however, that further search may reveal richer patches than any hitherto recorded among them.

The similarities between the geology and gold-occurrences of South Africa and those of East Africa are dwelt upon in some detail, and the final section of the memoir deals with the prospects that await the gold-miner in German East Africa. In prefiguring these, the author seeks an analogy in Rhodesia. The geological conditions he regards as encouraging. The climate of the plateaux is, if anything, better than that of Rhodesia, though in some places the water-supply is inferior. The difficulties of transport are at present great, but the construction of the projected railways should alter this unfavourable factor to a favourable one. Firewood is fairly abundant, but constructional timber of any value is scarce. Mining operations will probably have to be conducted by several small concerns, only one occurrence having as yet been proved which would admit of working on the grand scale. Labour conditions are favourable, in comparison with those obtaining in South Africa and British East Africa.


The Kalbinsky mountains, or the "Hilly Range" (Kalba is Mongolian for hill), form the south-western spur of the Altai in the district of Semi-palatinsk, between 48° and 50° lat. N. and 80° and 84° long E. of Greenwich. After the warlike nomadic tribes had finally settled down into peaceful Russian subjects in the 'thirties of the nineteenth century, it became possible for Europeans to tap the far-famed mineral resources of the region, but their efforts were almost exclusively directed to the gold-placers. Within the last decade, however, the discovery of auriferous quartz-reefs has, so to say, shifted the axis of mining operations; and, while the placer-industry is gradually diminishing in importance, gold-quartz mining is developing at a rate which arouses the most sanguine anticipations of a brilliant future.

The geology of the district is strikingly similar to the geology of the Altai as a whole, the rocks being mainly granites, quartz-porphyries, porphyrites, etc., and metamorphosed sediments of Devonian and Carboniferous age. A detailed description is given of these, and it is noted that the general strike of the sedimentaries is from north-west to south-east, while the dips are everywhere exceedingly steep. The effect which the granitic intrusions had in
upheaving and dislocating the above-mentioned Palaeozoic strata is discussed, and it is pointed out that the granites themselves, as well as the sedimentaries, were intruded into by the quartz-porphries and porphyrites. The tectonic structure of the region is indeed complicated; and the numerous fissures opened up in the rocks, as a consequence of the tectonic phenomena initiated by the upwelling of the granites, were later infilled with quartz. These auriferous quartz-reefs form at the outcrop white crests which may be frequently traced for miles along the general strike of the rocks, with which they coincide, as also in dip. The region is very poor in timber, and the facilities of transport are "damned with faint praise"; but the extraordinary number, wealth, and continuity of the reefs, the proximity of water and coal, and the abundant supply of Kirghiz labour are all favourable to the development of a great mineral industry. The reefs are most numerous along the immediate flanks of the main range, as it was there that the sedimentary deposits were more especially dislocated and fissured.

A short description is given of the placers, the richest of them being now exhausted. Their thickness, as also their breadth, is comparatively small, this characteristic being due to the peculiar physiography of the region. The precious metal is generally dispersed in a state of very fine division in a loamy sand; but near the heads of valleys it occurs in coarser flakes, and occasionally nuggets have been found (one weighing 61 ounces). The average content of the workable sands varies between 5 and 21 \(\frac{1}{2}\) grains per metric ton, rarely amounting to 30 grains per ton.

As a typical example of the reefs, the Udaly mine (at present the most considerable of those that are in operation) is selected. It is situated a few miles to the east of the station of Sentash, on the southern flank of the Kalbinsky main range. Here the predominant rocks are metamorphosed calcareous clay-slates, traversed by dykes of quartz-porphyry. The mine was opened up in 1904, and now reaches a depth of 246 feet below the surface. It reveals two quartz-reefs each varying in thickness from 20 to 40 inches; in their middle course they coalesce, attaining a joint thickness of 6 \(\frac{1}{2}\) feet, and occasionally as much as 13 feet. A black film, or black specks and dendrites on the quartz, are here very good indicators of a high percentage of gold. The average quantity of precious metal got out from the quartz is from 385 to 460 grains (that is, rather less than an ounce) per ton. Where the reefs coalesce, the proportion is much higher, and there too the gold is frequently visible in spangles and flakes. All the quartz-reefs in the neighbourhood of the Udaly mine are gold-bearing, and some of them are fabulously rich at the outcrop. The ore is very easily worked: it is crushed small and amalgamated, and the slimes are ultimately subjected to cyanidation. This last stage of the process is only carried on in the summer season. Other mines are now being opened up, some miles away to the south-east. The Nikolayevsky and Andreyevsky mines are examples of another type: they are situated some 5 miles to the east of the Karadshalsky posting station, in a granitic tract. Here quartz-stringers are found seaming a highly-decomposed, occasionally kaolinized eruptive rock of dioritic appearance, but mainly consisting of felspar which exhibits a "mother o' pearl" lustre. Both the quartz-stringers and the country-rock are gold-bearing, and the former are so inextricably interwoven with the latter that the whole mass is worked as one rock. The visible gold often occurs in small somewhat angular lumps in the quartz, which is of a very different character from that of the reef-quartz in the Udaly mine. These mines are being successfully worked: the preparation of the ore consists merely in crushing and amalgamation, but cyanidation is apparently dispensed with.

In the Kalbinsky district besides gold, occurrences of iron, copper, graphite, and coal are reported.

L. L. B.
Auriferous Deposits in the Lena Region, Siberia.—By V. A. Obruchev. Explorations géologiques dans les Régions aurifères de la Siberie, 1907, pages 1-312.

The area described in this memoir covers the north-western portion of the Bodaibo basin (Vitim river-system). It is, on the whole, a rugged country, averaging 2,000 feet or more above sea-level in its lowest part, and rising in the Nakataminsky Peak to a maximum altitude of close upon 5,000 feet. It is intersected by a great number of broad river-valleys, both longitudinal and transverse, but the breadth of the valleys is not always proportionate to the importance of the streams that course through them. The physiographic features of the area constitute in fact so much cumulative evidence of its former glaciation. The wide-strewn erratic boulders on the high summits bear witness to the enormous extent and thickness of the ancient ice-cap. When that retreated, local glaciers still persisted throughout long ages in the upper valleys of the Nakatami basin, and to them is assigned the origin of the Upper Boulder-clay of the area.

The rocks are predominantly metamorphosed sedimentaries, mantled over more or less thickly by drift-deposits of pre-Glacial, Glacial, and post-Glacial age. It is noted that the only distinction between the Upper and the Lower Boulder-clay is the greater thickness of the latter. They are separated one from the other by Interglacial sands and gravels, partly of fluvialite, partly of lacustrine origin, and attaining at their maximum the enormous thickness of 164 feet. The Lower Boulder-clay is underlain by morainic boulder-beds, varying in thickness from 6 ½ to 65 feet. The pre-Glacial deposits include gravels, loams, and clays; and the richest, thickest, and most continuous gold-bearing alluvia occur among these. The bed-rock, in the case of the pre-Glacial placers, consists of metamorphic grits and schists, frequently much decomposed down to about 4 inches from the surface. These placers occur either in the actual thalweg of ancient valleys, or along old terraces of erosion. In breadth the pre-Glacial placers are usually proportionate to the breadth of the present valleys, and the average thickness of the auriferous mass ranges from 6 ½ to 8 ¼ feet, rarely attaining 10 or even 13 feet. The gold-yield is fairly considerable, varying from 386 grains to 6,173 grains (or about 13 ounces) or more per ton of alluvia washed. The precious metal is, as a rule, coarsely granular: flattened or rolled granules and flakes or spangles occurring less frequently.

The Interglacial and post-Glacial placers present a different character: the gold-bearing stratum is a deposit really laid down in running water, all the materials of which are more or less rolled and sorted. The distribution of the gold therein is extremely irregular, rich portions continually alternating with barren beds. These placers are not well suited for working, precisely because the irregular distribution of rich strata within a very thick mass is a crowning disadvantage, when associated with the cost of labour, and the high price of stores and equipment (machinery, etc.). The gold is generally in a more finely-divided condition than in the pre-Glacial placers.

The solid rocks are broadly classed as metamorphic grits and schists, the former occupying a vast area on the map. The varieties of grit distinguished as pyritous grits and "brown-spathic" grits maybe destined to assume considerable industrial importance. A few conglomerates, intimately associated with the grits, occur among them in the form of lenticles. The schists include black carbonaceous schists, the contact of which more or less blackens the fingers, phyllites and quartzose schists containing variable quantities of pyrite and brown-spar, etc. Quartz-lodes are of frequent occurrence, 20 to 40 inches, and occasionally 6 ½ to 10 feet thick: some few of them have been traced for several miles, and
all observers are persuaded that from them is derived the placer-gold, more especially as fragments of quartz with gold adherent thereto have been found in the placers. Yet, so far, the actual proof of the existence of rich auriferous quartz-lodes is wanting. The few that are shown to contain the precious metal are not of sufficient importance to repay working. Some of the gold-bearing quartz is ochreous, but this ochre is by no means an invariable indicator of the presence of gold. The author holds that the original matrices of the precious metal are the grits and schists themselves, not the quartz-veins that traverse them. Out of 36 tested samples of grit, 15 yielded gold, though in small quantity. The theory of the concentration of the gold out of these rocks in the placers is explained in detail.

L. L. B.


After some preliminary observations concerning the great antiquity of gold-mining in the Indian peninsula, the author directs especial attention to the Dharwar gold-fields, rediscovered a few years ago (September, 1902), after a period of complete oblivion. No less than 22 ancient shafts have been found, going down to a maximum depth of 140 feet, and it is shown that the native miners had proved and worked the three main reefs. Mining operations in the Dharwar region, now conducted on a grand scale on modern lines, are directed chiefly to depths below that just mentioned (one shaft goes down to 640 feet), and are, in fact, a continuation of the workings begun by the ancient miners. Of the three principal reefs, the middle, dipping 58 degrees eastwards and yielding the largest proportion of gold, is the most actively worked. These quartz-reefs are defined as belonging to the category of "bedded veins," coinciding with the north-and-south strike of the strata of the Dharwar formation among which they occur. The reefs average 1 ¼ to 3 feet in thickness, occasionally attaining a maximum of 4 feet or more; they are sensibly parallel one with the other, being separated by 100 to 200 feet of strata. Roof and floor consist in part of native graphite and graphitic schists, which are interbedded with pink clay-slates, sandstones, and conglomerates. On the whole, the geological relations are much the same as those observed in the Kolar gold-fields, with perhaps the rather notable exception of the graphite-occurrence at Dharwar. The author thinks that no other hypothesis is possible, as to the origin of the Dharwar reefs, than that assigned by Dr. F. H. Hatch for the similar reefs of Kolar—namely, precipitation of quartz and other minerals from solution along channels, fissures, or lines of weakness more or less coincident with the foliation-planes of the country-rock. The hypothetical section drawn by the author conveys the ingenious suggestion

[21]

that the three Dharwar reefs are really one and the same bed, representing the sliced-off remnants of a successive anticline and syncline or S-shaped fold. The bluish milk-white quartz is traversed in every direction by venules of graphite; the gold occurs therein in the native state in spangles, frequently also in crystalline granules and encrustations, coating miniature cracks and fissures within the quartz. Arsenical pyrites, chalcopyrite, iron-pyrites, as also various oxides and hydroxides of iron are, on the other hand, more intimately associated with the graphite. Of the sulphidic and oxidic ores just mentioned, arsenical pyrites is by far the most abundant, the others playing quite a secondary part in comparison therewith.

The paper concludes with a brief description of the manner in which the quartz is broken up, sorted, crushed, and pulverized in the stamp-batteries; the finely-divided material is made to flow over slightly-inclined amalgamated copper-plates, where the biggest
spangles are retained in the form of gold-amalgam. The tailings from the copper-plates contain a considerable quantity of gold and sulphides, and are thoroughly washed in large iron tanks, wherein the particles of greatest specific gravity sink to the bottom. This deposit is taken out and dried, and then undergoes a cyaniding process: from the cyanide the gold is precipitated as a spongy dark brown material on to zinc-bars arranged in wooden boxes.

L.L.B.


During a sojourn of five years at Johannesburg, Dr. Voit has been much preoccupied with this problem, and he has now come to the conclusion that the precipitation-theory alone, of which the original advocates were Dr. Stelzner and Prof. Bergeat, fits in completely with the ascertained facts. Stating that he wishes, as far as possible, to avoid dwelling on particulars which are already known, he refers the reader for these to Prof. Gregory's paper on the "Origin of the Gold in the Rand Banket" (read before the Institution of Mining and Metallurgy in 1906-1907) and the ensuing discussion. The reasons which forbid any idea of the mechanical introduction of the gold into the conglomerates are familiar to those who are interested in the problem; but Dr. Voit desires to lay special stress on the extremely fine state of division of the precious metal in the banket on the one hand, and its association with the pyrites in such wise than it often completely envelopes the pyrite-crystals, visible to the naked eye, on the other hand. Then there is the postulated formation of "pyrite-placers," and finally, the hypothetical rich hinterland whence these comparatively immense quantities of gold were derived. This last supposition is considered by Dr. Voit especially open to attack, since an older formation with auriferous lodes of sufficient calibre to furnish forth the enormous gold-fields of the Rand ought surely to have left some traces of its existence. But older auriferous deposits are of rare occurrence in South Africa, being generally confined to the crystalline schists of the Fundamental Gneiss-formation, and on the whole would hardly repay working.

Dr. Voit admits that, in the first instance, the reasons upon which he grounds his belief in the primary character of the Witwatersrand gold are mainly of the negative order. He points out that (1) true vein-quartz and even gangue-minerals, properly so-called, are practically not to be found in the conglomerates; (2) channels by means of which ores might have been introduced, on the epigenetic theory, are non-existent in these conglomerates; (3) the selective impregnation, on which so much emphasis has been laid is by no means so predominant or universal a phenomenon as it is customary to assert. In this connection the author holds that the abundant occurrence of gold in the so-called "Pyritic Band" (first noted in 1895) militates strongly against the theories of mechanical introduction of the precious metal or later infiltration thereof. He regards the fact, that the numerous fragments of banket found in the "wash-outs" are identical in character and in gold-content with the Main Reef conglomerate, an irrefragable proof that the precious metal was incorporated with the beds among which it occurs at the time of their deposition.

Rejecting as highly improbable the chemical precipitation of such vast quantities of gold, either from sea-water or from river-waters. Dr. Voit seeks to explain the difficulty by assuming that mineralized solutions (analogous to those which have originated so many metalliferous lodes) made their way to the surface during the process of sedimentation of the Witwatersrand Beds. These conglomerates are regarded as a littoral formation, wherein tides and winds played a part (separating, for instance, the pebbles from the sand by rolling them to and fro); and organic matter, represented by enormous quantities of fucoids, was
undoubtedly present, its traces subsisting to this day in the shape of the coaly substance so frequently found in the conglomerates. This coaly substance occurs where the reefs are richest, and in the eastern portion of the Rand the author knows of cases where the banket is literally underlain by small coal-seams. Nor is the carbonaceous material absent from the Pyritic Band, previously mentioned as extremely rich in gold.

There seems to be no doubt that the presence of vegetable matter was one of the principal factors, if not the main factor, in determining the precipitation of the gold. Where shales and quartzites were laid down, in deeper water, the amount of vegetable matter present was not sufficient to determine precipitation of the gold from the impoverished mineral solutions. But, nearer in shore, where plant-remains were deposited in conjunction with the coarser material of the conglomerates, the metallic particles were precipitated from the upwelling solutions (the last manifestations of moribund vulcanicity) direct on the shore-line or in very shallow lagoons. The author’s conclusions may be summarized in his own words:—“Gold was preferentially precipitated by carbonaceous matter; iron-pyrites by complicated chemical processes, involving reduction (? putrefying fucoids engendered hydrogen sulphide) and oxidation. The coaly matter is predominantly associated with the conglomerates, but may occasionally have been deposited with the material forming the quartzites, especially at those horizons where the quartzites zonally replace the conglomerates (Pyritic Band). The upwelling mineralized solutions differed in composition from place to place, and where the conglomerates were laid down the solutions seem to have been enriched, but greatly impoverished where the quartzites and shales were deposited. Long after the deposition of the Witwatersrand formation the beds were subjected to far-reaching metamorphism, whereby also the metallic constituents of the conglomerates underwent, drastic change on the very spot where they had been laid down.”

Dr. J. Kuntz, in controverting these conclusions of Dr. Voit’s, points out that in South Africa the infiltration-theory nowadays holds the field; and he sets himself to show that the facts which are supposed to tell against it can be so explained as to leave the theory unassailable. He says further that, even, with the help of all the carbonaceous material that Dr. Voit invokes, the presence of such enormous quantities of gold as occur in the conglomerates cannot be satisfactorily explained on the precipitation-theory. He enquires also how that theory can fit in with the fact that at great depths the proportion of gold present in the conglomerates universally diminishes, whereas this is easily explicable by the infiltration-theory.

Dr. Voit, in his rejoinder, points out in detail that some of Dr. Kuntz’s contentions are based on an incomplete knowledge of the occurrences cited by him and directly traverses some of the latter’s statements of fact from his (Dr. Voit’s) own observations. He claims, finally, that the precipitation-theory as above sketched out by him accords best with all the known facts.

L. L. B.


In the great longitudinal valley that separates the Central Alps from the northern limestone-Alps the grauwacke-belt is characterized by considerable deposits of spathic iron-ore. This chain of ore-deposits extends more or less interruptedly from Schwaz in the Tyrol to Reichenau in Lower Austria, the most important deposit from every point of view being that of the Erzberg of Eisenerz. The granular, crystalline, spathic ore is invariably associated with limestones, into which it appears to pass by several gradations, such as ankerite. The geology of the region, as might be expected, has been studied by many investigators, with
conflicting results. Their views are quoted and discussed by Dr. Heritsch, and he points out that the accumulative effect of the evidence now available leaves no room for doubt as to the metasomatic origin of the Eisenerz ores. They have, in no sense, the character of bedded sedimentary deposits.

L. L. B.


This mine lies about 125 miles north of Cheyenne, in Laramie County, Wyoming, and is connected by railway with two different lines. "The iron-ores present characteristics which are seldom met with in the ore-deposits of the better known iron-districts of the United States. They consist of two distinct varieties of high-grade haematite: the soft red variety, of greasy texture; and the hard blue haematite, intermixed, affording an ideal character of ore for working in the blast-furnaces." The author considers that the soft haematite is really the outcome of the alteration of the hard variety by the action of surface-waters. The latter variety contains less phosphorus and more silica than the other, in the surface-levels; but, as greater depth is attained, the ore becomes very uniform in quality, with a low phosphorus and silica-content.

The ore occurs in lenticles among highly plicated schists, with which are associated hard, impervious, dolomitic limestones. It seems probable that the haematite has metasomatically replaced the schist, and that the iron-ores were originally present in the latter in the form of pyrite, and, perhaps, magnetite. Deeper than exploration-work has yet penetrated, occurs a dark-grey biotite-schist impregnated with pyrite.

The Sunrise Mine was first worked in the early nineties for copper; the cupriferous deposit proved, however, to be a mere pocket, which was soon exhausted. But indications were found of iron-ore sufficient to justify mining operations directed to that ore alone. These were started in 1900 on a small scale; and, in the following year, under the vigorous impulse of new management, the methods in vogue on the shores of Lake Superior were adopted, opening up an immense ore-body of hitherto unsuspected dimensions. The opencast workings were supplemented in 1903 by underground workings. The extent of the diamond-drill operations may be inferred from the statement that the total number of feet of drilling done by the mining company amounts to 50,648. The output for the year 1901 totalled 97,000 tons, while that for 1906 amounted to 571,000 long tons. Electricity is largely used, as also air-compression; and the arrangements for the comfort and cleanliness of the miners are of the most approved modern type.


This has long been a subject of controversy, the older geologists maintaining the hypothesis of a secondary metasomatic origin, while of late years (1903-1906) several writers have upheld the theory that all the Devonian haematites of Nassau are of primary origin. But the upholders of this latter theory seem to have, wittingly or unwittingly, blinded themselves to certain characteristic features of the deposits, as exemplified, say, in the mines of the Weilburg district.

The author believes that the true explanation will be found in a combination of the old and the new theories. He holds that the so-called Flusseisenstein (flux-ironstone) and the parts still poorer in iron, passing finally into limestone pure and simple, are of primary origin; while the red haematite is of predominantly secondary origin, deriving from the "flux-ironstone." He adduces in detail the evidence which impels him to this conclusion.
There is no question that the original source of the iron is to be found in the neighbouring igneous rocks ("schalstones" and greenstones): the association of such igneous rocks in a decomposed condition with the haematite is too frequent to be set aside as a mere chance occurrence. Enrichment is continuing even nowadays, wherever meteoric waters have access to the decomposed country-rock, as at the outcrop or in fissured strata. The "flux-ironstone" is especially subject to attack by such waters, decomposing even more rapidly than the igneous rocks, and is gradually converted into a loose-textured cavernous haematite.

Summarizing the available evidence, the author depicts the probable succession of events as follows: a seam of "flux-ironstone" was deposited by precipitation from sea-water, more or less interrupted by the deposition of tuff (clastic schalstein), and occasionally passing into limestone. This took place during a period of volcanic activity. Haematite was afterwards formed from the "flux-ironstone" by the agency of meteoric or surface-waters, as above hinted; and at certain points the haematite was silicified by the invasion of waters charged with silica, while at other points it was altered by contact-metamorphism (due to the upwelling of diabasic effusives) into magnetic iron-ore.


The author believes that the lignite-industry is destined to occupy an important place in the future development of the country, but little attention has been directed to it in Portugal thus far. He only cites one locality for jet (Porto de Moz), but speaks hopefully of the prospects of working the deposit to a profit. Lignite occurs in a great many localities; unfortunately, they are not named or described in the paper. The author made a series of experiments, with the view of determining whether

the Portuguese lignites could be used in the manufacture of electric insulators: in the course of these, he found that lignite was utilizable for a variety of different purposes hitherto unsuspected. His initial method is to grind lignite down to as fine a powder as possible: in this state of fine division, it can be easily incorporated with rubber-products, to form a homogeneous material. He advocates the use of lignite, therefore, both in the manufacture of the various qualities of "ebonite" and as an accessory in the rubber-industry. The lignites of Northern Italy, which are now in process of application to various industrial purposes, are, so the author affirms, fully rivalled in quality by the Portuguese lignites.

L. L. B.


The occurrence here described is the only undoubted vein-deposit of manganese so far known in the region. It is found at the village of Malempre, about a mile and a half distant from Manhay. The predominant rocks of the district are the purple Upper Salmian slates, through which occasionally pierce some outcrops of the Lower Salmian quartziferous green slates (all of Cambrian age). Overlying these are a few irregular patches of the Gedinnian (Devonian) covering rocks. The lode cuts through the slates at an angle of about 60 degrees, and dips 45 degrees southwards. It has been proved along the strike for a distance of 60 yards, by a drift at 30 feet below the surface. About the centre of the drift the lode bends abruptly, and attains at that point its maximum thickness of 6 ½ feet and its greatest wealth in metal. The average thickness is 3 ¼ feet,
and the lode becomes poorer as the distance from the above-mentioned flexure increases. In depth the lode has been explored down to 55 ¾ feet, by an incline west of the richest portion, and impoverishment concurrent with increase in depth is also noted. At the flexure, the slates forming the footwall are completely mineralized to a thickness of 30 feet or so, a mineralized mass which tails out eastwards to 5 feet and then ramifies into gradually diminishing venules. The infilling of the lode consists of white quartz and psilomelane: at the flexure, it might be more truly defined as a mass of mammillated psilomelane, within which are disseminated small angular nuclei of quartz. In its poorer portions, the lode is best described as a quartzose breccia, wherein psilomelane plays the part of the cementing-material. The ore in the mineralized slate-mass is of different character and composition. The variation in the latter is shown by the following percentage analysis:

<table>
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<th></th>
<th>Manganese</th>
<th>Iron</th>
<th>Silica</th>
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<td>16.3</td>
<td>15.5</td>
<td>0.36</td>
<td>1.1</td>
</tr>
</tbody>
</table>

The two ores have been worked concurrently, and, after a preliminary sorting, have on the whole yielded only 27 per cent. of manganese.

After a careful consideration of the facts, the author is led to the conclusion that we are here dealing with a fissure mineralized from above. Owing to the action of oxidizing surface-waters charged with carbon dioxide, all the manganese and iron contained in the rocks on the hanging-wall side of the lode were dissolved and reprecipitated in the fissure in the condition of oxides. It would seem that originally a quartz-lode had been formed, that the plication consequent on tectonic phenomena smashed the vein-quartz, and that the metalliferous particles were subsequently deposited around and among the crushed quartz-fragments. The enrichment of the lode at the flexure, and the presence there of the mineralized slate-mass will also fit in with the conditions conceived by the author. There are no certain indications regarding the age of the metalliferous ore. As to the continuation, either in depth or along the strike, of workable ore beyond the few yards already proved the signs are decidedly unfavourable. L. L. B.


In the great trough of the Veitsch in Styria a series of shales and limestones of Carboniferous age are infolded among the Lower Palaeozoic rocks. At the Sattlerkogel, at the contact between the shales (Lower Carboniferous) and the overlying limestones, magnesite-deposits occur which have evidently originated from partial metasomatosis of the limestones by magnesia-laden solutions. In the first phase of alteration dolomite was probably formed; and then, as the solutions still continued to invade the limestones, pure carbonate of magnesia was deposited. Huge masses of dolomite are seen dispersed within the magnesite-deposit, which is moreover traversed by nearly vertical sulphide-bearing quartz-lodes. A detailed description is given of the various minerals found here, in the following order:

Primary minerals: magnesite, primary dolomite, pyrite (in finely divided impregnations in the magnesite), and talc.
Secondary minerals: crystalline quartz, ankerite, aragonite, calcite (rare), rumpfite, mountain-leather, pyrolusite, secondary dolomite with pyrite-inclusions, etc.

Primary mineral of the sulphidic lodes: quartz, amorphous and crystalline; chalcopyrite; arsenical antimony-copper fahlore; pyrite, generally amorphous, rarely crystalline.

Minerals of the ferruginous gossan: malachite, azurite, chrysocolla, limonite, etc.

In all, twenty-four distinct mineral species are described, and five chemical analyses of the magnesite are tabulated.

In the second paper two newly discovered occurrences of magnesite in Carinthia are described. The industrial importance of such deposits at the present day has greatly stimulated prospecting work in the region of the Eastern Alps, the result being that a bed of magnesite 65 ½ feet thick, passing into dolomite and finally into limestone, has been found on the Millstatter Alp, among limestones which are apparently interbedded with highly crystalline hornblende- and mica-schists. The limestones strike from north-west to south-east. At St. Oswald, east of the Lake of Millstatt, a great mass of magnesite occurs on an outlying spur of the Mallnock (6,000 feet above sea-level). The rocks are so very similar in every respect to those of the Veitsch in Styria, that their correlation in age amounts almost to certainty. The alteration of the limestone into magnesite is doubtless due to the same cause in both occurrences. Two analyses are tabulated of the St. Oswald magnesite, and its comparatively high percentage of iron is held to liken it to that of the Kotalp in Carinthia. The Millstatter Alp deposit dates evidently much farther back than the Carboniferous Period. As to the workability of the two Carinthian deposits here described, nothing very definite can as yet be said. In this respect the apparent enormous thickness of some magnesite deposits is very deceptive, and no greater mistake could be made by the prospector than to join up various ascertained outcrops into one supposedly great

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deposit. It is often found that much of the magnesite contains so many impurities (more especially carbonate of lime) that its industrial value is thereby greatly depreciated. Indeed, the author is unacquainted with any magnesite-occurrence wherein the waste-material amounts to less than 30 per cent. of the whole.

L. L. B.


The small hamlet of Vaspatak lies in the southern portion of the Pojana-Ruszka hills, a district famous since time immemorial for its numerous and considerable deposits of iron-ore. Some were worked by the ancient Romans when the country formed part of the Imperial province of Dacia; and Gyalar, in those same forest-clad hills, is even now the most important centre of brown iron-ore mining in Hungary. A deposit there is worked which extends east and west for several miles: the occurrences north and south of it, as, for example, that of Vaspatak, are less remarkable for their extent. The Pojana-Ruszka hills constitute a part of the belt of the Transylvanian Alps, the crest of which forms the frontier between Hungary and Rumania. In October, 1906, the author had an opportunity, of which he made excellent use, of studying in detail the occurrence at Vaspatak, and he precedes this account of his investigations by a bibliographical list comprising 32 entries. The Pojana-Ruszka hills consist essentially of gneisses, mica-schists, and phyllites folded into anticlines and synclines, succeeded by more or less crystalline limestones said to be of various ages and occasionally dolomitic. It must be added, however, that there also limestones (in which great iron-ore deposits occur) are interbedded with the mica-schists.
No fossils have as yet been found in any of the limestones except in those of admittedly Turonian age. The author believes that all the non-fossiliferous limestones are in reality of practically the same age, belonging to a series which was laid down upon the crystalline schists and subsequently underwent plication in common with these.

Within a radius of less than 2 ¼ miles around Vaspatak four occurrences of magnetite have been proved which are partly in direct association with limestones—here regarded as compressed wedges of sediment nipping out in depth, thrust in among the younger crystalline schists. The beginnings of modern mining industry hereabouts date from 1790; the climax of prosperity appears to have been attained in the 'fifties of the last century, but a few years thereafter working was abandoned. Of late years, an attempt has been made to revive the industry; the results achieved were not, however, such as to warrant its continuance. There seems to be little doubt that the ores are defective both in quality and in quantity. A description is given of the four principal occurrences, beginning with the apparently least unprofitable of them (Emilia mines, Nos. 1 to 8). Analyses are tabulated, showing average percentages of metallic iron ranging from 30 to 35. The magnetite (with which magnetic pyrites is frequently associated) occurs with banded garnet-bearing, augitic and hornblendic rocks, in a ferruginous silicate of lime, which is intercalated among mica-schists.

It appears to be practically certain that the ore-deposits of Vaspatak are genetically connected with the metalliferous belt of Gyalar, barely 10 miles away to the north. Southeast of Gyalar, the ore is found in six separate lenticles, some hundreds of yards in length, pretty closely overlying each other, among dolomitic crystalline limestones, forming probably a syncline infolded among the mica-schists. Here brown iron-ore is won in great opencast workings belonging to the Hungarian Government, and is demonstrably a decomposition-product of spathic iron-ore. The last-named has, indeed, been struck at a great depth below the surface, forming a bed at one point 34 feet thick and at another point 27 feet thick. The metalliferous limestone-belt of Gyalar can be followed eastwards through Plotzka for a distance of 5 miles until the mica-schists disappear beneath the covering of Tertiary deposits. Almost exactly at that boundary the iron-ores are won in two great opencast workings, at Telek on the Cserna river. Here limonite, for the most part, and in smaller quantities haematite, siderite, and magnetite occur in various huge lenticles overlying each other, among mica-schists and crystalline, partly silicified, limestones. Westwards the same ore-belt extends through thickly forested country (permitting of few exposures) for a distance exceeding 20 miles, through Buda, Alun, Gruniului, Krivina, and Euszkica. At Gruniului, about midway between the last-named locality and Gyalar, exploration-work conducted in 1905 revealed considerable lenticles of spathic iron-ore, decomposed to limonite in its upper portion, at a depth of 100 feet below the surface. North of Euszkica (where iron-ore mining has been abandoned within recent years), about 9 miles south-west of Gruniului, the limestone contains argentiferous lead-ores, which also were worked at one time.

The author holds that the spathic iron-ore of Gyalar is most probably of epigenetic and proximately metasomatic origin: he thinks that ferruginous “juvenile waters” welled upwards from a deep-lying eruptive mass, out of which they had leached the iron-salts, and, when they reached the infolded wedge of crystalline limestone, their upward progress was accelerated, while they replaced portions of the limestone by spathic iron-ore. Although, at first sight, this hypothesis might not seem to explain adequately the origin of the Vaspatak deposits, careful review of the facts shows that it does also apply to them. The remaining portion of the memoir (21 pages or so) gives an interesting account of the magnetometric
survey which the author successfully carried out of the concession covered by the Emilia mines (Nos. 1-8).


Geologically speaking, this island represents one of the most recent stages of the gradual sagging of the Caucasian mountain-range, and constitutes a direct continuation of the famous peninsula of Apsheron, at the eastern extremity of which it is situated. Barely 5 ¾ miles in length, varying in breadth from 220 yards to about 2 miles, it extends from north-north-west to south-south-east in conformity with the trend of the general plication. The surface is a plane, diversified in the northern portion by hills, saline steppes, and shallow depressions, the general level varying from 26 to 46 feet above that of the Caspian Sea. The climate is exceedingly [sic] damp, yet freshwater springs are conspicuous by their absence.

The island is built of post-Tertiary and Tertiary sediments. The former comprise both aeolian and marine deposits (sands, gravels, shell-beds, etc.); the Tertiaries are represented by post-Pliocene and Middle Miocene deposits alone. The latter, showing signs of considerable disturbance, and consisting of unfossiliferous sandy clays and sands, are overlain unconformably by the post-Pliocene sandstone (with a band of limestone-gravel) and sandy clays. The Miocene deposits constitute an anticlinal fold, the south-western limb of which is but slightly inclined, while the north-eastern limb is steep and in places overthrust. This fold is traversed by innumerable transverse, longitudinal, and diagonal faults and thrusts.

An elaborate descriptive section is given of the Apsheron Peninsula, for purposes of comparison.

The author divides the naphtha-occurrences of Sviatoye Island into three categories, the first including those which have been proved at the southern end of the anticline and in the central saline steppe. With these are associated no less than eleven mud-volcanoes (within a distance of 350 yards) ranged along the transverse fault-fissures; also brine-springs and blowers of natural gas. These occurrences are evidently conditioned by the innumerable fissures traversing extremely loose-textured rocks. To the second category belong the deposits of the sunken north-eastern limb of the anticline: here naphtha collects in every small pit that is dug in the post-Pliocene sands, whereas in the south-western limb not a trace of naphtha is found. To the third category belong the occurrences revealed in the sandstones of the eastern saline steppe, on the north-north-eastern limb of the fold: they are undoubtedly workable. In fact, six borings have been put down by the great firm of Nobel Brothers, and four are in full activity, although the flow of naphtha is irregular.

Reasons are assigned for the statement that the naphtha is of secondary origin, and consequently that no basis exists for the assumption that it is being at the present day projected upwards in vast quantities from great depths. As at Bibi-Eibat and Surakhany, we are dealing here with an oil-reservoir of already ancient date. The naphtha is a thick, blackish-brown fluid, practically odourless and possessing latent dichroism. Its specific gravity at 60° Fahr. is 0.944. According to its physical properties, it falls within the category of tarry oils.


In the first place the author summarizes and discusses the different, occasionally divergent, views which have been expressed by various well-known geologists regarding the
origin of nickeliferous and magnetic pyrite-deposits in general, the occurrence at Sudbury
(Ontario) being cited as the most extensive of the kind in the whole world.

He then describes the geology of the neighbourhood of Varalla, premising that the
nickeliferous deposits of the Piedmontese Alps are associated with the so-called "Ivrea
Zone" of the Italian surveyors—a belt of mostly basic rocks striking from south-west to north-
east, between Ivrea on the Dora Baltea and Locarno on the Lago Maggiore, over a length of
practically 62 miles, with an average breadth of 6 ¼ miles. It lies between the Strona gneiss
on the east and the Sesia gneiss on the west; the former rock exhibits the characteristics of
normal contact-metamorphism, and is, in fact, to be ranged in the category of "injected
schists," while the Sesia gneiss has more the character of the central granite (protogine) and
its contact-products (gneiss-mica schists). The members of the Ivrea Zone range from
norites comparatively rich in silica to highly basic peridotites, their varying composition being
attributed to the fissility of the original basic magma: the peridotites are, in the
neighbourhood of Varallo, more especially associated with the metalliferous deposits, and
pass into gabbros, very frequently banded hornblende-gabbros. The exact chronological
sequence of the gneisses and the rocks of the Ivrea Zone is a much controverted problem,
which still awaits solution.

The number of sulphidic ore-occurrences strewn along the belt from Ivrea to the
Lago Maggiore is very considerable. Attempts have been made to

work a good many of them industrially, but few (and these generally for a short period only)
have proved workable to a profit. Most of these workable deposits are found in the
neighbourhood of Varallo. It is remarkable how dissimilar they are in the ores which they
carry under identical geological conditions: some are fairly rich in nickeliferous magnetic
pyrite, which contains an extraordinarily high proportion of cobalt; in others the cobalt
dwindles to vanishing point; while in yet others chalcopyrite plays a very conspicuous part.
The dissimilarities are still more multifarious when account is taken of the metalliferous
deposits which are industrially unworkable: for instance, there are many, often considerable,
occurrences of magnetic pyrite in this region, of which only small portions have been mined,
because in the remainder the percentage of nickel which gives its chief value to the ore is
too small or else is entirely wanting.

Of all the many nickeliferous deposits mentioned by previous writers as occurring in
the neighbourhood of Varallo, the author was able to trace only five as still accessible. He
hints, by the way, that there has been probably some confusion as to place-names, and that
the same mine has been reckoned two or three times over, under as many different names.
He describes in succession the Cevia or Laghetto mine (massive magnetic pyrite, with a little
chalcopyrite); the Sallabassa mine (yielding a purer ore, containing rather more nickel), 2 ½
miles south of Scopello in Val Sesia; the La Balma mine (nickeliferous magnetic pyrite),
almost in the centre of the Ivrea Zone; the Val di Mengo mine, north-north-east of Cervarolo,
which locality is situated about 3 miles to the north of Varallo; and the Fei mine, above
Doccis in the Val Sesia. The last-named is the most unimportant of the five, and practically
nothing but exploration-work has been done there.

None of the deposits furnish absolutely indisputable evidence in favour, either of the
hypothesis of magmatic differentiation, or of the hypothesis of secondary infiltration. The
abandonment of mining operations for many years past, in the case of some of the deposits,
constitutes an additional stumbling-block in the path of the investigator. Other difficulties are
the decomposition of the sulphidic ores by atmospheric and other agencies tending to
obscure the outcrops, and the masking of possibly instructive sections by the mass of water-
rolled material which mantles much of the area described. The author has nowhere found
gneiss in place in the mines; and although the metalliferous deposits are undoubtedly associated with basic eruptive rocks, which bear in the main the character of hornblendic gabbros, the actual ore-carrier is usually a picrite, characteristically poor in plagioclase and often extremely rich in olivine.

Summing up the available data, the author holds that they could never have formed a sufficient basis for the magmatic differentiation-theory of nickeliferous magnetic pyrite-deposits, a theory which has been postulated for those ores as they occur in Canada, Norway, the Erzgebirge, and the Black Forest. The shape of the ore-bodies recalling lodes, as well as the pyritous secondary quartz-formation observed in the two last mines described by the author, tells in favour of the infiltration-theory. L. L. B.


The working of these shales, which has suffered repeated interruptions, has been resumed within the last two years; but operations are now chiefly directed to the proved extension of the oil-shale field into Swiss territory,

in the neighbourhood of Meride (Canton Ticino). The shale-belt really forms a great curve, trending north-eastwards from the classic locality of Besano across the frontier to Monte San Giorgio, and thence south-eastwards towards the Val Mendrisio. The Besano shales have been regarded as of approximately St. Cassian age, that is, either uppermost Middle Triassic or lowermost Upper Triassic; but the author agrees with Dr. Taramelli in considering them as more exactly equivalent to the Fish Slates of Raibl. The topmost beds of the Lower Dolomite have intercalated among them some thin marly bands, extremely rich in bitumen; these are followed by an alternation of about twenty rather thicker bituminous bands (3 to 4 inches) with bands of limestone remarkably deficient in magnesia, the total thickness of this alternation averaging from 16 ½ to 20 feet. This constitutes the industrially useful portion of the succession, passing gradually into a series of extremely thin calcareous bands, much poorer in bitumen, thence into more thickly-bedded limestones with frequent interbanding of marls, and finally into the typical mottled marls. The fossils are more especially associated with the bituminous beds. Remains of fishes and reptiles are confined to the very richest oil-shales, where they are present in great abundance, while the mollusca (bivalves and ammonites) occur in profusion in the interbanded limestones. It would seem as if there had been a rhythmical recurrence of sudden changes in the life-conditions of the old Triassic sea, and from the remains of the vast numbers of fishes and saurians thus destroyed the oil now distilled from the Besano shales is probably derived. Where fish-remains are abundant, the percentage of bitumen in the shales is high; where the former are scarce, the percentage of the latter diminishes to vanishing-point.

When the Besano shales are submitted to dry distillation, they yield, besides such bye-products as gaseous hydrocarbons, ammoniacal waters, sulphuretted hydrogen, etc., a dense black oil of peculiarly disagreeable odour, containing 5 per cent. of sulphur and from 6.4 to 6.7 per cent. of nitrogen. These percentages are unusual in the generality of bitumens and natural oils, and the author thinks that this may be assignable to the fact that the bitumen of Besano was formed in situ, whereas most of the hydrocarbons found in nature have undergone a preliminary distillation, which divested them of some of their original components, and whereby also they migrated from bed to bed, and were finally concentrated about anticlines and in the formation whence they are now extracted. In the matter of composition, the only shales comparable with the Besano oil-shales are those of the Rhaetic formation at Seefeld in Tyrol. The Seefeld shales, renowned for their fossil fishes and their

Charged by the Austrian Government with the mission of studying the mineral industry of the United States on the occasion of the Centennial Exhibition at Philadelphia in 1876, the author published in the following year his memoir entitled The Petroleum-industry of North America. In diametrical opposition to the opinions then held by the great majority of American geologists, his conclusions were stated as follows: (1) Petroleum is derived from animal remains; (2) it occurs as a primary deposit; and (3) the so-called “oil-lines,” along which there is enrichment in petroleum, coincide with anticlines.

The third conclusion was soon afterwards confirmed by the researches of Orton and I. C. White in America, and by those of Tietze and Paul in Galicia.

The author still retains the conviction that natural oil is predominantly derived from animal remains, and that plants have only borne a share in its formation, according to the extent to which they contain albuminoids and fats. He notes, by the way, that the siliceous tests of Diatomaceae are not found in the petroliferous beds, while the siliceous tests of foraminifera do occur therein. He now divides petroleum-deposits into two categories: (a) the original or the primary; and (b) the secondary. As the strata associated with the oil-bearing beds, in by far the greater number of instances, contain littoral or shallow-sea marine and brackish-water fossils, and as, moreover, brine frequently accompanies the petroleum, the inference that these beds are mostly of marine origin needs no further justification. The annihilation of faunas necessary to furnish the raw material of petroleum was, in the author's view, brought about by changes in life-conditions and environment so sudden that the organisms affected thereby had neither the time for adaptation to the new conditions, nor that for migration to escape them. One agent of catastrophic destruction of a fauna is aeolian dust: if blown into a bay teeming with life, this dust carries with it to the bottom myriads of organisms which it has destroyed. It has been shown that much of the sand of the Apsheron oil-fields near Baku is undoubtedly wind-blown sand, and the very coarsest of such sands are there the greatest, carriers of petroleum. The same phenomena have been observed in Trinidad and Rumanian oil-fields, but too wide an extension of the theory is to be received with caution: for instance, the petroliferous sands of Pechelbronn (Alsace) are undoubtedly fluviatile. There these sands form masses measuring as much as 875 yards in length and 33 in breadth, and from 1 to 43 feet in thickness, amid clay-slates, at six different horizons: they seem to represent ancient sand-dunes, which were partly overwhelmed by the sea. Oscillations of level caused temporary inroads of fresh water (as in the "Everglades" of Florida), and these changes in salinity wrought havoc among the aquatic fauna, at repeated intervals.

Examples are cited from South Australia and Portuguese East Africa of the formation from plant-remains of substances akin to ozokerite, and hence the derivation of petroleum from such plant-remains seems to be all but proved. The process would be pictured as beginning with the drifting en masse predominantly of fungi and algae into a region of lake and swamp, together with marine animal organisms, owing to oscillation of the coast-line. Rapid depression would seal up this drifted material with a deposit impervious alike to oil and to gas.
For the transformation of the fats into petroleum, high pressure (furnished by the gases present in abundance in the decomposing driftage) was a necessary condition. On the other hand, traces of extremely high temperatures (say "white heat") are conspicuously absent from petroleum-deposits, although admittedly there must have been a fairly considerable rise of temperature due to the chemical and other changes that went on therein. The author gave public expression to these views in 1888, and since then Prof. C. Engler, of Karlsruhe, by the distillation of train-oil and mollusca at comparatively low temperature under high pressure, has obtained a petroleum extremely like that of Pennsylvannia. Secondary petroleum-deposits may arise from local migration of the fluid through fissures in the rocks (as, for instance, the Hanoverian oil-field). As to regional migration through the pores of fissureless rocks under the influence of gaseous pressure, this hypothesis is only discussed to be dismissed as untenable. If it were feasible, then the soft, porous Jamma sandstone overlying the oil-bearing Ropianka Series in Galicia, instead of being barren as it is, ought to be saturated with petroleum. The author abstains for the present from dealing with the water-bearing strata which are often associated with oil-horizons; they involve problems which are far more complicated than would appear at first sight.

L. L. B.


The author claims that it is but recently, owing to detailed investigation on his part and successful borings at Tarnawa dolna, Wielopole, and Zagorz, that he has been able to prove the existence of great natural reservoirs of oil in the Oligocene formation which predominates in the Sanok district. He includes in his description an area approximately bounded on the east by the Tarnawa river and the Przemysl road, on the west by the Wislok river, and lying between the Galicio-Hungarian frontier and the range of hills that extends from Tyrawa Woloska (Rozpudzie) towards Mrzyglod. Orographically, this area is divisible into three portions, the southernmost and largest of which is mountainous (reaching altitudes exceeding 2,600 feet above sea-level); the central portion is a high plateau, extending from Sanok itself through Krosno-Jaslo to Gorlice; and the northern portion consists of a picturesque succession of parallel ridges and valleys, the maximum altitude in some cases approaching 2,000 feet above sea-level.

In a range of hills which extends for more than 50 miles through this district from the Dniestr basin, petroleum has been found at many points. The rocks consist, in descending order, of Magura Sandstones and Marls, Menilite Slates with fine-grained and conglomeratic sandstones, cherts, and chocolate-brown "fish-slates" (so-called because of the abundant remains of fossil fishes found therein). Below these come the greenish-blue marls, red mottled clays, calcareous hieroglyphic and fucoidal sandstones and slates of the Lower Eocene, usually regarded as the main locus of the Carpathian petroleum. At Holowiecko, Bandrow, Steinfels, Lodyna, and other localities oil exudes from the chert-layers of the Oligocene menilite-slates, which overlie the petroliferous Eocene. A range parallel to that just described, mapped by the Austrian Geological Survey as Cretaceous, also belongs to the Magura Sandstone Series, and yields traces of oil at several places, although the borings have not yet proved any considerable quantity. With regard to Witrylow, on the left bank of the San, where attempts were made to strike oil 20 or 30 years ago, the author points out that the borings were not carried down deep enough, and that there is every prospect of a great natural oil-reservoir being tapped there. At Humniska the author
recommended boring operations as long ago as 1895, and they have since been carried out with conspicuous success: oil in workable quantities has been got at depths ranging between 1,150 and 1,180 feet, as also natural gas in abundance, which is now used for heating purposes. West of this locality, at Starawies, a pale yellow high-grade oil is obtained, which is utilizable as an illuminant without preliminary refining, and consequently commands a high price. Details are given of the geological conditions (in so far as they are favourable to the occurrence of petroleum) and of boring operations in several other localities; and the author then proceeds to deal with the area that lies between the San

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river and the Hungarian frontier. Here a great anticline, consisting of three parallel folds, ranging from south-east to north-west, at distances apart of 875 to 1,100 yards, typifies the usual mode of occurrence of the petroleum-bearing-Oligocene sandstones, shales, etc., hereabouts. The oil-belt is traced, both north-westwards from Zagorz, and south-eastwards therefrom to Wielopole. The neighbourhood of Zahutyn also is destined, sooner or later, to become the centre of a flourishing oil-industry. The westward extension of the belt through Plowce is described, and some explanation is given of the injurious way in which the possession by the Austrian Treasury and by the diocesan authorities of valuable "naphtha-lands" affects the Galician oil-industry. Small undertakings especially are bled to death, or throttled in their infancy, by inconceivably heavy royalties and merciless taxation. Prospectors had thought the Tarnawa-Wielopole oil-belt too strictly Oligocene to be hopeful from the borers' point of view, until their attention was directed to it by the author in 1896, with immediately successful results. It is true that difficulties arising from the inrush of water are met with at various horizons, but they are by no means insuperable. The natural gas that issues from the oil-wells in great volume is used for firing the boilers above bank.

The curious prejudice that prevails in some quarters against boring for oil in steeply-inclined strata is discussed at considerable length, and it is shown why such steeply-dipping beds are in reality more likely to hold oil than gently-inclined or horizontal strata. The Canadian system of boring at present holds the field in Galicia: down to a depth of 2,600 feet or so the process is quick and sure; but below that depth the cost becomes alarmingly disproportionate to the results achieved. The disadvantage of high costs attaches also to the spray, hydraulic, and other systems of boring, and the author believes that for small diameters at great depth the diamond-bore will yet hold its own for some time to come. More than twenty years ago he counselled resort to deep boring, and those few who followed his advice at Boryslaw, Schodnica, Rogi, etc., have achieved astonishing success.

Continuing, after this digression, the detailed description of the Wielopole-Zagorz oil-belt, the author lays stress on the probable occurrence (besides the three admittedly petrolierous horizons) of a fourth petrolierous horizon, but of Eocene age, and on the enrichment in oil of the north-eastern limb of the Wielopole-Tarnawa anticline. He mentions the occurrence of ozokerite, exuding from a bluish-grey, crumbly, fine-grained, micaceous sandstone, in conjunction with natural gas, at Mijesce Piastowe and Targowiska, near Krosno. The petroleum occurrences in the Bobrka-Wietrzno-Rowne-Rogi anticline are described with great wealth of detail; and the association with them of iodine (the original of which is assigned to the fossil fuocois, etc., found at several localities) is noted. The greatest depth reached by borings on this anticline rarely exceeds 3,300 feet; but the author looks forward to successful results with still deeper borings.

It is hardly possible, in an abstract, to convey an adequate idea of the mass of detailed information embodied in this memoir, the less so, as that information is supplied in a rather difficult form, the author apparently thinking that each sentence should form a paragraph by itself. The general but misleading effect is that of desultoriness, and broad
generalizations (where such occur) are apt to be obscured by the mass of detail. The memoir may be regarded as encyclopaedic, so far as the district with which it deals is concerned.

L. L. B.


In the Eichsfeld district of Hanover, a good many borings were put down in the 'eighties and 'nineties of last century, in the hope of striking the rock-salt and potassium-salt deposits of the Zechstein formation; but they were uniformly unsuccessful, as these salts appeared to have been leached out of the strata at some unknown epoch subsequent to deposition. Within the last three years fresh borings have been undertaken in the same district, and, although they have gone right through the Zechstein into the underlying Palaeozoic grauwackes, they have still failed to strike salt. Farther west, however, in the marginal area of the Leine valley, in the neighbourhood of Norten and Northeim, north of Gottingen, borings put down within the last two years have achieved successful results. One of these, east of Sudheim, struck the potassium-salt deposits of the Zechstein at the unexpectedly accessible depth of 3,005 feet; it had reached the gently haging marginal fault of the Leine rift-valley (graben) at the depth of 2,747 feet, then entering the Zechstein. The rocks which crop out at the surface here belong to the gypsiferous Keuper; below this comes the Muschelkalk; and below that again the so-called Rot Marls. At the base of these last is a thick bed of rock-salt which represents the lowest member of the Trias at this locality, and, owing to the complication introduced by the great Leine fault above-mentioned, it is immediately underlain by a much older bed of rock-salt of Zechstein age. At the Levershausen boring, a little way to the east, the Rot Marls crop out at the surface; but all the salt appears to have been leached out of them in that locality.

The Rot or Lower Triassic rock-salt bed, no less than 820 feet thick, is deeply raddled by impregnations of iron-oxide, and exhibits a coarsely crystalline structure. The inclusions, consisting of grey and mottled, more or less dolomitic marls, anhydrite, etc., increase in number and size towards the base; but potassium-salts of carnallitic type begin also to make their appearance, and finally coalesce into a comparatively thin bed. Below this comes a rock-salt of loose and irregularly granular structure but great purity, with a characteristic pink coloration: it has been identified as the upper (literally "younger") rock-salt bed of the Zechstein. Between the depths of 2,781 and 2,794 feet, this is interrupted by a red and grey clay with which an intimate (so-called "pegmatitic") intergrowth of anhydrite and rock-salt is associated, and at the depth of 2,868 feet it is underlain by the typical main anhydrite of the Upper Zechstein.

Detailed descriptive sections are given of the two borings above mentioned (Sudheim and Levershausen); and also of that put down north-west of Sudershausen, which struck the uppermost beds of the "younger" Zechstein rock-salt at the depth of 1,692 ½ feet, the lower beds at 2,045 feet, and the older rock-salt at 2,601 feet. The same beds were struck at considerably greater depths in the other two borings. These borings confirm the generally admitted fact that the Zechstein salt-deposits of Southern Hanover belong to what is known as the Stassfurt type. Apart from the Sudheim occurrence, the "cover" consists of Bunter sandstones, the middle division of which in this area averages 1,300 feet and the lower division 1,000 feet in thickness. A detailed description is given of the strata, both from the lithological-mineralogical and from the stratigraphical point of view.

The borings in the Eichsfeld district itself are then described at considerable length. A boring south of Immingerode and another south-east of
Duderstadt got down to the Main Dolomite without striking salt; but another south of Fuhrbach struck the "older rock-salt" at the depth of 1,380 feet: it was a bed, 33 feet thick, of brownish-grey, coarsely crystalline, common salt. The absence of the industrially more valuable potassium-salt is conspicuous here, as also that of the "younger" rock-salt. Besides, the "older" rock-salt is elsewhere three times, sometimes six times as thick as at Fuhrbach. The enormous amount of leaching that must have taken place since the original deposition of the beds is dwelt on at length, and the probable causes thereof are discussed.

L. L. B.


Premising that the text-books are full of erroneous statements in regard to these famous deposits, the author gives an account of what he saw in the course of a visit to the district in the late summer of 1907. The small town of Cardona, with its ancient castle, is perched on a hill 660 feet above the valley of the Cardoner, 20 miles north of Manresa station, on the Barcelona and Zaragoza railway. In a lateral valley, a vast semi-circular "quarry" is revealed, showing a thickness of 960 feet or so of rock-salt overlain by a thin crust of gypsum, and this again by an "overburden" of marls, clays, and sandstones. Mining operations, initiated as long ago as the time of the ancient Romans, in conjunction with the unceasing erosion due to atmospheric agencies, have so worn back and hollowed out the originally lenticular salt-mass that the overburden is undermined and forms the roof of a cavern. The lower portion of the exposure is transparent, seemingly unstratified rock-salt; the upper portion consists of thinly-banded salt of various colours, among which are intercalated streaks of gypsum and anhydrite, as also seams of clay and marl. The gypsum gradually increases in proportionate quantity upwards, until it passes into the gypsum-crust already mentioned. A small shaft has been sunk to a depth of 82 feet in the valley-floor, to work the mass of pure unstratified rock-salt which is believed to reach a thickness of 160 feet or more; below this again thinly-banded vari-coloured salt (similar to the upper deposit just described) with gypsum is said to occur. It is noticeable that the banded salt, gypsum, and marl-layers are intensely plicated and overthrust, in contrast with the undisturbed massive salt-bed, and with the marly overburden, which has only been faulted and shattered in places by the leaching-out of the underlying salt. Among the probable causes of the chaotic plication of the banded salt-layers, etc., are the leaching-out of certain thin bands, the alteration of anhydrite into gypsum, the far greater plasticity of the salt as compared with the marl and hence its tendency to sag more easily, etc.

The physical effects of aqueous erosion on the salt of Cardona are described (pitting of the surface into miniature peaks, pinnacles, and ravines), as also the snow-white salt-stalactites seen in the cavernous hollows.

It must be admitted that the economic importance of the Cardona deposits is not as great as of yore. The competition of many other salt-mines; the widespread, almost universal occurrence of "saltings" along the extensive coast-line of Spain; and the distance of Cardona from the railway, are serious obstacles to any considerable development of the industry there nowadays.

L. L. B.

So far as at present known, these deposits occur in the Sierra de Cordoba and the Sierra de San Luis, which may be regarded as one mountain-chain, ranging from north to south over a distance exceeding 300 miles and broadening out from east to west in the latitude of the city of Cordoba to a maximum width of 77 miles or so. These mountains are mainly built up of Archaean gneisses and schists; but granite-masses cover large tracts, and the conspicuous cones of the Tertiary andesitic eruptives are seen from afar, north of the Pampa de Pocho. Great beds of limestone are to be met with practically everywhere; there are also dykes of diorite and gabbro, while in the Pampa de Pocho and the broad longitudinal valleys generally the later sediments of the so-called "Pampa formation" are exposed. Although the author agrees with Dr Bodenbender in regarding some of the granites as the outcome of post-Archaean fissure-eruptions, he holds that other granites form really the core of the Sierras, and that upon them the Archaean gneisses, etc., were subsequently deposited.

The wolfram-ore occurs in the form of lodes, equally in the sedimentary rocks and in the granites, generally near the contact of two different rocks, and often passing from one into the other. There would appear to be some justification here for the saying: "granite is the parent of wolfram." No general strike can be postulated, and similarly the dip is variable, both in direction and in amount. The lodes are intersected and occasionally faulted by veins of quartz and of more recent pegmatite. The gangue is an irregularly-fissured drusy quartz, milk-white with greasy lustre or else transparent. The principal ore is wolframite, with a varying percentage of iron beautifully crystallized in tabular form. Next to wolframite scheelite occurs most frequently, though as a rule only in small quantities. The chief accessory ores are the various sulphides and oxides of iron and copper. Tin-ore, although diligently sought for, does not seem to have been found, except at Mazan, in La Rioja province. Galena was observed by the author at various named localities, and as silver-lead veins were invariably exposed in the immediate neighbourhood, the inference that there is some genetic relationship between these and the wolfram-lodes does not seem very far-fetched. The universal association of mica with the lodes is noteworthy, and the author is compelled to contradict E. Beck's statement as to the absence of tourmaline differentiating the Argentine wolfram-deposits from those of Tirpersdorf (Saxony), since tourmaline is now proved to occur, sometimes abundantly, in association with the former. As regards mineralization, the lodes here described are very irregular—yard upon yard of barren stuff intervening between "nests" of extremely rich ore. The most important mine is that of Los Condores (belonging to a German syndicate), where the lode has been proved over a length of 1,300 yards or more, and will repay working for quite half that distance. The dip approaches the vertical, and the "country-rocks" are gneiss and schist. The workings are perfectly dry, water and timber-supplies are abundant, and a good cart-road links up the mine with a railway-station barely 7½ miles away.

At the San Ignacio mine a lode varying in thickness from 12 to 20 inches has been proved for a length of 660 yards or thereabouts, but nips out in three or four places. It has been so faulted as to convey vividly the erroneous impression that the miner is here dealing with several distinct lodes. Masses of secondarily formed iron-ores are associated with the lode, tout copper-ores play an insignificant part. The wolframite is highly ferruginous; scheelite is seldom found. On the whole, the ore-deposit here is much disturbed and "mashed up."

The Brillante and three associated mines cover an area of 425 acres or so on a high plateau surrounded on all sides by valleys, while some 4 miles away to the south rise the andesitic cones already mentioned. The lodes here truly deserve their name of mantos.
(seams), overlying one another horizontally and presenting the aspect of sedimentary deposits rather than that of fissure-veins: this appearance is probably due to overthrusting connected with the Tertiary eruptive phenomena. Only one lode has been proved for any notable distance, in the eastern angle of the field. The "country-rock" is gneiss, which frequently becomes granitoid and then tends to resemble more a decomposed granite. As the wolframite occurs in the lodes with very little intermixture of associated ores, the process of sorting or hand-picking is far less laborious than at San Ignacio. Nevertheless, the author does not speak hopefully of the prospects of mining on a large scale at La Brillante. In the Sierra Alta (5,000 feet above sea-level) the Rio Jaime cuts through a lode cropping out in both walls of a gorge some 330 feet deep. Here much scheelite occurs, together with wolframite. At the northernmost extremity of the Sierra de Guasapampa, near the llanos (prairies), a great number of wolfram-bearing quartz-lodes occur in the district of Auti, among granites and gneisses. The average thickness is from 4 to 8 inches, but a lode 3 ¼ feet thick is occasionally met with. The economic importance of the Auti deposits is small.

Although Argentina at a recent crisis took a considerable share in the world's output of wolfram, there is reason to believe that the value of the deposits generally has been over estimated.

L.L. B.


The chain of the Cevennes, which ranges through four departments (Lozere, Gard, Aveyron, and Hérault) at an average altitude of 4,000 feet, with summits rising up to 5,500 feet or more, is really a fault-block of granitic, Archaean, and Palaeozoic rocks, forming an island amidst an area of sunken Mesozoic strata. The limiting faults of this block are normal, with frequently considerable downthrows; their hanging wall always consists of ancient slates and schists, the argillaceous decomposition-products of which fill up the fault-fissures. Moreover, as the faults have a very steep hade, they do not afford a very favourable locus for the deposition of metalliferous ores, and, as a matter of fact, they are, if at all, but poorly mineralized. But innumerable secondary faults and fissures, directly related to these limiting faults (or actually prolonging them), occur both within and without the fault-block or Horst of the Cevennes, and with them are associated the metalliferous deposits. These differ greatly in external character, according as they occur among the older rocks or among the Mesozoic and Kainozoic (Tertiary) strata; in the former they are plainly lodes, while in the latter they exhibit variously the features of impregnation-deposits, metasomatic deposits, and mere infilling of cavities. The ores are predominantly sulphidic (sulphides of iron, zinc, copper, lead, arsenic), but among the younger rocks such decomposition-products as limonite and calamine are not unusual. The country-rock (in the case of the Archaean, etc.) being both impermeable and highly siliceous, the outcrops of the lodes are but little decomposed, and on account of the quartzose gangue many stand out conspicuously above the surface.

The zinc-mines of Treves lie west of the Cevennes, in the department of the Gard in a district traversed by a great fault striking northwards and north-eastwards, which cuts off the Palaeozoic and granitic rocks of the Mont Agonal, one of the highest peaks of the Cevennes, from the Mesozoic strata stretching away all but horizontally to the eastwards into the famous region of the causses (limestone-canons). The outcrops of metalliferous ore occur among Middle Liassic limestones, on both sides of a small ravine south of the village of Treves: two categories of ore-body are here distinguishable (1) the impregnation and metasomatic deposits, mineralized with blende and occasionally a little galena, practically confined to the cherty limestones; characteristic of the basal portion of the Middle Liass; and
(2) at a lower geological horizon, the so-called "simple infilling" deposits, where the blende and galena form the cementing-material of a mass of breccia, 20 to 23 feet thick intercalated among non-fissured limestone-beds. A brief description is given of the deposits, and a remarkable resemblance is noted between the Treves ores and the banded ores of the banks of the Meuse and the Moresnet district in Belgium: there is the same succession of layers of blende varying in colour from chocolate-brown to pure white. The comparative scarcity of pyrite at Treves enhances the commercial value of these complex sulphidic deposits.

The Treves ores are undoubtedly of hydrothermal origin, and their genetic relationship with the great fault in the immediate neighbourhood of which they occur is equally undoubted. It was through that fissure that the mineralizing solutions must, on account of the nature of the fault, have percolated upwards until they found an easier way among the more or less porous or fractured Mesozoic strata; and then they circulated among the limestone-beds, producing ultimately therein the phenomena of impregnation, substitution or metasomatosis, etc., to which reference has already been made.

L.L.B.


In contradistinction to the views recently attributed to him by Dr. B. Granigg, the author considers that the hanging-wall portion of the Schneeberg deposits is the outcome of metasomatic replacement of a previously existing limestone-bed, but that the footwall portion partakes of the character of a lode: the hanging-wall portion exhibits remarkable conformity with the bedding of the country-rock, while the footwall portion exhibits equally notable unconformity.

Stress is laid on the resemblance between the first-mentioned portion of the Schneeberg deposits and the ore-occurrence of Moosburg, near Klagenfurth, and those of Inner-Krems and Turrach; now, these have all been derived from the metasomatic replacement of limestones. The conjunction, in one occurrence of metasomatic bedded metalliferous deposits and metalliferous lodes, is by no means uncommon in the Alpine region as might be supposed, and various instances are cited by the author. He adds, however, that much probability attaches to Dr. K. A. Redlich's assumption, that in many cases these so-called "lodes" represent merely the infilling of cavities (? hollowed out in the limestone) rather than true fissure-veins; and it seems not unlikely that the footwall portion of the Schneeberg deposit may prove to be a case in point.

It has been assumed that the zinc and lead-laden solutions which gave rise to the Schneeberg deposits were extremely hot, or may even have

formed part of a granitic magma. But the great abundance of garnet there is calculated to give pause to the investigator who recollects that garnet may equally well be deposited at low temperatures under great pressure, as at high temperatures under merely atmospheric pressure. The green chromiferous mica (fuchsite), resembling in some respects sericite, which is a characteristic associate of many true metalliferous lodes in the East Alpine region, would appear to be absent at Schneeberg itself; but the author has found the mineral in the dolomitic limestone of the Schwarzseespitze above St. Martin, in the neighbourhood.

L.L.B.

The Department of Huancavelica, three out of the four provinces of which are here described, is undoubtedly (from the miner's point of view) one of the most important in the Peruvian Republic: its coal-outcrops are much spoken of, auriferous lodes are of frequent occurrence, and silver-lead ores, argentiferous copper-ores, as also copper- and lead-ores containing both gold and silver, abound. Moreover, workable deposits have been proved of antimony and arsenic compounds, oxidic iron-ores, wolframite, and cinnabar. Innumerable adits attest the former activity of the mineral-industry in the department, an industry directed at that time, however, almost exclusively to gold and silver. A review of the literature of the subject is given, dealing with seventeen separate publications by as many different authors. Beginning with the province of Tayacaja, the northernmost in the department, the author notes that the prolongation of the Oroya-Huancayo railway (now under construction) to Ayacucho will shortly prove a factor of inestimable value in hastening the industrial development of the province. The physiographic relief of the country is very irregular, and the transition from the cold climate of the high altitudes to the sub-tropical heat of the valleys is abrupt. Water for purposes of power-transmission is abundantly available. The igneous rocks of the province include quartziferous diorites, rhyolites, microgranulites, labradorites, diabases, andesites, etc.; while the sedimentary formations are respectively assigned, the slate-series to the Silurian Period, the "red rocks" (marls, conglomerates, etc.) to the Triassic, the grits and limestones to the Liassic Period. A brief historical survey of the mineral-industry in the province is followed by a description of the metalliferous deposits, classified in three groups: (1) the lodes of argentiferous galena; (2) the silver-bearing copper-ores; and (3) the auriferous quartz-lodes. It is admitted, however, that there are intermediate varieties which form a passage from one group into the other. The argentiferous galena and blende occur as well among the slates, as among the limestones and granites; the cupriferous deposits are found among limestones, and particularly in the porphyritic facies of the "red rocks"; while the auriferous quartz-lodes course through the slates. Sulphidic ores predominate, such oxidic ores as are found, playing a very modest part indeed. The gangue presents generally a spathose character, the dominant minerals being calcite and siderite. On the whole, the ores may be defined as of epigenetic origin, having been precipitated from thermal waters. Mineralogically, the most favoured district is that of Paucarbamba, its greatest wealth residing in its silver-lead ores, which usually occur among the slates. A detailed description is given of the Santa-Rosa, Lloquepata, San Julian, San Donato, Adelaida, San Mariano, Domitila, Transvaal, and other lodes belonging to the so-called "Vizcaycha system": they strike generally from north to south, and have an easterly dip. The principal lodes of the "Carhuancho system" (San Antonio and Andreita) dip westwards, and are also described in detail, while the plumbiferous lodes of the neighbourhood of Coris (Titipata, El Manto, etc.) strike from northwest to south-east, and dip variously north-eastwards and south-westwards. Some 6 1/4 miles north-east of Coris, and almost on the banks of the Rio Mantaro occurs the reputedly cupriferous deposit of Casque. After a description of the Providencia silver-lead vein, the author passes on to the district of Colcabamba, best known perhaps for its agricultural productiveness. Therein he describes briefly the silver-lead ores of Pichcas and the argentiferous copper-lode of Carmen, on the Loma ridge. The Huaribamba district is rich in argentiferous copper-ores, but the reported occurrence of mercury is not so far confirmed. Silver-lead and copper-ores are described in the districts of Salcabamba and Pampas, and magnetite also in the latter district. In the Nahuinpuguis district the most important mineral is the coal which occurs in thin seams among dark sandstones of Mesozoic age. A sample taken by the author yielded the following analysis: fixed carbon, 30.45 per cent.; volatile
matter, 28.75; moisture, 2.68; ash, 38.12; heating power, 4,365 calories. At Churcampa in the Locroja district, a rather crumbly coal-seam, 3 ¼ ft. thick, yields a mineral which has the following composition:—Fixed carbon, 29.04 per cent.; volatile matter, 33.18; ash, 29.14; moisture, 8.64; heating power, 4,140 calories. It occurs among very loose-textured sandstones and conglomerates, which are probably of Tertiary age.

In the province of Angaraes the only means of communication are rough pack-roads; the country is rugged, and is traversed by many streams of high gradient from which water for purposes of power-transmission would be easily available. The crystalline rocks and the sedimentary deposits play equally important parts in the geology of the province. The principal mineralized belt includes the Tambraico and Alto-Pongo hill-ranges: besides copper, lead, silver, gold, antimony, arsenic, etc., the ores of rarer metals (such as wolfram) are found, and cinnabar was formerly to be got. The mineral-industry of the province has undergone many vicissitudes and the author states that, unfortunately, at the present day, the tendency to peg out claims for purely speculative purposes is predominant, to the detriment of genuine mining operations. The most important mining field is that of Julcani, in the district of Lircay, yielding silver-lead ores, copper in a quartzo-sideritic gangue, pyrite, and wolfram in a quartzose gangue: the country-rocks are rhyolites and porphyries. In the Pampamali field argentiferous galena and blende, as also sulphidic copper-ores, occur in a quartzose gangue; in that of Sacsalla cupriferous sulpharsenides and antimonides are found, as also rich sulphides in a calcitic gangue; in that of Carhuapata are silver-lead and blende-deposits in a quartzose matrix; and, finally, in that of Vizcachas native silver and native copper have been recorded. Generally speaking, all these metalliferous deposits are of epigenetic origin. Detailed descriptions are given of the San Pedro, Acchilla, Japonesa, and other mines in the Julcani field, as also of the wolfram-deposits of that area. On the assumption that sufficient capital is forthcoming, the industrial prospects are of the brightest. Coal has been reported at two localities in the Lircay district; a sample from one of these was a shaly mineral yielding 24 per cent. of ash, but the coal from the other locality is of better quality.

Huancavelica, the chief town of the province of the same name, it is four days' journey, by the most convenient route, from Callao on the Pacific seaboard, two days being spent in railway-travelling and two in the saddle. The want of a direct road to the coast suitable for wheeled traffic is keenly felt. The province lies on the eastern slope of the Western Cordillera of the Andes, and all its streams make their way by the gorges of Moya and Huancavelica down to the Mantaro, and thence finally to the Atlantic. The smoothed contours of a nevertheless rugged country are indications of comparatively recent glaciation; but nowadays the perpetual snow-line is shifted very high up, and the neve is in fact retreating. The sedimentary formations play a more important part in the structure of the province than the crystalline rocks: the latter are predominantly basic (micaceous andesites, labradorite-augite basalts, melaphyres, porphyrites, etc.). The stratified rocks are highly folded and faulted: they include Jurassic and Cretaceous limestones and grits, as also "red rocks" of Triassic age. Silver-lead and copper-ores are of widespread occurrence; deposits of antimony, arsenic, zinc, and iron-ores also are found. But perhaps the most important mineral asset of the province is its wealth in mercury-ores, especially the Santa Barbara deposit, which occurs at the very gates of the capital city. The principal mining fields are enumerated as follows: Huachocolpa and Carhuapata (epigenetic deposits of silver-lead and copper-ores); Nanantuyo and Sapralla (silver-lead ores); Alto Pongo (argentiferous sulphides of copper); Manta (sulphidic copper-ores); Totoral-Grande
and Chica (argentiferous galena). Detailed descriptions are given of these, as also of the Santa Barbara cinnabar-deposit.

The author admits the existence of coal-seams at various points but none of the outcrops that he has observed promise industrial results of any importance: the seams are excessively thin, and the coal generally is very impure. Magnetite-deposits which seem to promise well have been discovered in the districts of Acoria and Moya.

L. L. B.


The author has been for many years engaged, on behalf of the Rumanian Government, in mining and geological investigations in the politically famous region of the Dobrudsha (Dobrogea). In this memoir he deals with the central and south-eastern portions of the Tulcea district, a land of broad valleys and ancient hill-ranges, upheaved in pre-Cretaceous times. The district is built up of Palaeozoic igneous rocks, crystalline schists, and sedimentaries; of Triassic sandstones, calcareous rocks, and eruptives; of Jurassic limestones; of Cretaceous limestones, marls, and conglomerates; and, finally, of the loess-deposits of Pleistocene age. These formations are described in detail, and the author then proceeds to the consideration of the ore-deposits: these are predominantly iron and copper-ores. The former occur in the form of pyrite, specular iron, magnetite, haematite, and limonite; the latter, rarely sulphidic, are mostly of secondary origin, malachite being perhaps the most widely distributed. Psilomelane is occasionally associated with the iron-ores; and traces of gold and silver are found in certain pyrites, as well as in the cupriferous ores. The pyrites occur in the porphyries and green schists; the specular iron among the quartzites, phyllites, metamorphic schists, and in quartziferous lodes cutting through the granites and porphyries; the magnetite in basic eruptive rocks; and the haematite and limonite practically form the gossan of all the ore-deposits. The cupriferous ores are invariably associated with the iron ores, being in most cases intimately intermingled therewith. The author prefaces his description of the principal ore locations with the remark

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that such exploration-work as has been hitherto accomplished hardly suffices to permit of any definite inference being drawn as to their industrial value.

The Losova deposits are first described: they occur as quartziferous lodes among porphyries, phyllites, and quartzites. Prospecting work has been chiefly directed to the copper-ores. A few analyses are tabulated, and they cannot be termed encouraging.

In the Geaferca-Coslug ridge iron-ores predominate, but there is not at present sufficient evidence available upon which to build any conclusions as to their industrial importance.

Among the later Palaeozoic slates of the Carapelit Hills intrude dykes of porphyry with which are associated ores of copper and iron, in the form of lodes and impregnations; and, moreover, some of the slates are so strongly impregnated with iron-ore as to pass into "iron-schists." The lodes have been proved over a considerable extent at the outcrop, and the actual passage of sulphidic into oxidic ores has been noted. From the ferruginous gossan, the more valuable cupriferous ores have been leached out and swept away by atmospheric agencies. Analyses carried out in the Government Laboratory show the iron-ore to contain 58 per cent. of metallic iron and the iron-schists 38.6 per cent. Geologically speaking, the occurrences in the Amzalar ridge are very similar. There is reason to believe that here richer ores occur in depth, and that a brilliant future awaits these deposits, if they are worked on strictly rational methods.
Among the metamorphic hornblendic and cherty schists of the Kiutuclue ridge pyritous and cupriferous ores occur in association with porphyritic intrusions. The former have been assayed for gold, with results promising enough to justify further prospecting work. Reasons are assigned for the belief that greater quantities of gold may be found deeper down.

An iron-ore deposit, conformably interbedded with the chloritic schists of the Altan Tepe, has a magnificent gossan, consisting in places of limonite with venules of psilomelane, and in places of specular iron-ore and magnetite associated with quartz. The intensely altered country-rock forms a slaggy mass deeply raddled by haematite, and with it occur slates impregnated with specular ore and malachite, enclosing nodules of pure malachite showing passages into cuprite. This gossan has been shown to extend along the strike for 875 yards, with a breadth of about 110 yards, and it has been proved to a depth of more than 130 feet. A shaft has been put down to a much greater depth (300 feet or more'), and has struck an ore-body, 26 ¼ feet in maximum thickness, consisting of cupriferous pyrite. Besides the localities here mentioned, the author observed many occurrences of metalliferous ore which might well repay closer investigation.

L.L.B.

Rare Metals in Peru.—By Eugen Weckwarth. Bol. Ing. Minas, Peru, 1908, No. 63, pages 1-128.

In 1878, Dr. A. Ramondi, in his Catalogue of a Collection representing the principal Mineral Types of the Republic [of Peru], mentioned among the rarer elements only tungsten, molybdenum, lithium, zircon, tellurium, and titanium, and it must be confessed that the known occurrences of compounds containing rare earths and metals have not greatly increased in number since then. Dr. J. Balta in 1896 added thallium and vanadium to the foregoing list; but he omitted to mention either tellurium or titanium, and he did not regard tungsten or wolfram as falling within the category of rare metals.

Latterly, thorium and cerium have been discovered in the beach-sands of Pacasmayo; tellurium, in the form of a bismuthic telluride, in the province of Canta; and a really important deposit of vanadium-minerals, including a new species (patronite or vanadium sulphide), in the province of the Cerro de Pasco. Peru is admittedly rich in a great variety of minerals, and there appears to be little doubt that, when these are more thoroughly known additional discoveries of rare earths and metals will be made. Few prospectors care or know anything about these rarer minerals, their energies being absorbed in the search for gold, silver, copper, lead, antimony, etc. In order to direct attention to the industrial importance of the rare metals, the authorities of the Peruvian Government Survey requested the author to draw up a memoir which should serve as a manual for prospectors in regard to the rarer minerals, and, by arousing their interest in these, indirectly promote the search for such minerals. Accordingly, in this Bulletin No. 63, the author gives an account of the discovery, characteristics, properties and principal compounds of cerium, caesium, didymium, erbium, gallium, germanium, glucinium [now beryllium], indium, yttrium, lanthanum, lithium, molybdenum, niobium, rubidium, selenium, thallium, tantalum, tellurium, titanium, thorium, wolfram, uranium, vanadium, and zirconium, in the order named. He describes also the relations of their salts and the practical methods of recognizing their presence in a given mineral, the manner of separating and determining the rare elements, their application to various industries, their commercial value, etc. Beginning then with cerium, he states that monazite (a phosphate containing about 23 per cent. of that element, together with lanthanum and thorium) was discovered in the Pacasmayo sands in 1901. Although gallium has not hitherto been found in Peru, it seems probable that it will be ultimately discovered, associated with one of the deposits of zinc-blende which are of such widespread occurrence
in that country. Lithium occurs in the waters of various thermal springs, in serpines, in some of the Cordilleran rocks near Morococha, and even in the drinking-water that is supplied to Lima. Reasons have been assigned by Dr Raimondi for the inference that caesium and rubidium are not likely, to be found in Peru.

Molybdenite has been found in eight or nine provinces; but the most important occurrence is that of Runatullo, discovered in the province of Jauja in 1901, and a syndicate was thereupon formed in Lima to conduct exploration-work on this deposit.

The discovery, by means of spectral analysis, of thallium in the sulphidic ores of the Cerro de Pasco, announced by M. P. T. Remy in 1885, still awaits confirmation.

Besides the occurrence of a variety of bismuthic telluride in a mine in the province of Canta, traces of tellurium and cobalt have been found in a chiviatite (bismuthic sulphide) obtained from a ridge near Chiela, in the province of Huarochiri. It is likely that other occurrences of tellurium-minerals will be discovered in Peru, in combinations not only with bismuth, but also with silver, and especially with gold, as, for example, in Carabaya. The abundance of titaniferous minerals, just as in Bolivia and in Chile, is beyond doubt, but little attention has been paid to them in Peru so far. Wolfram-deposits have long been known in various parts of that country, but were first mined for industrial purposes at Lircay in the province of Angaraes. In some of the Morococha mines, province of Yauli, hubnerite is found: it is, a tungstate of manganese, containing 74.12 per cent. of tungstic acid, 23.21 of manganese dioxide, and 1.42 of iron oxides, with a specific gravity of 6.939, hardness ranging from 4.5 to 4.75, and a pinkish or yellowish-grey coloration.

[45]

Patronite, discovered in 1906 in some sedimentary deposits of Minasragra (Cerro de Pasco), constitutes the first-known occurrence of vanadium sulphide in nature, and it contains vanadium in proportions exceeding anything hitherto dreamt of.

L. L. B.


Gold, silver, copper, iron, and coal were mined in the Island Empire as long ago as the seventh and eighth centuries of the Christian Era, and even the petroleum-deposits were worked in those early days. During the fifteenth century and under the rule of the Tokugawa Shogunate, a great number of metalliferous ore-deposits were opened up and actively mined, but this, of course, on the moderate scale appropriate to the comparatively restricted industrial resources and consumption of that time. An extraordinarily rapid development from mediaeval conditions, or what may be almost called a magic transformation, to mining operations conducted on a large scale and on the most approved modern methods, received its initial impulse in the early seventies of the nineteenth century, when the Japanese Government took up in earnest the question of the expansion of the national mineral industry. The State at first worked some mines itself, by way of setting an example of "how to do it"; but these model mines were financially unsuccessful, and they were ultimately sold to private individuals. Under the regime of private enterprise, the mineral industry of the country has since then prospered greatly: the Government has contented itself with codifying the mining laws in 1890, and again has substituted for the ordinances of that year a new, very carefully thought-out, code which came into force in July, 1905. The whole of Japan is thereby divided into five mining districts, at the head of each of which is a Mining Bureau. The minimum area of a colliery-concession is 490 acres and the maximum area of any mining concession whatever is fixed at 490 acres. Mining rights are assignable only to Japanese subjects and to such legal personalities as are recognized by Japanese
law. Mining rights once assigned are indivisible, but they may be inherited and they may be mortgaged.

Rather over two-thirds of the territory of Japan consists of sedimentary formations (among which the Kainozoic deposits, and, longo intervallo, the Palaeozoic deposits play the chief part) while the remaining third consists of volcanic rocks dating from two distinct periods. The geological structure is well defined by the mountain-ranges which trend in two great crescents along the eastern and western coasts respectively striking from Hokkaido in the north-east to the Kyushiu Islands in the south-west, a strike which is traceable even into Formosa. These crescentic ranges have their concavities facing the mainland of Asia. Stockworks of ore and typical metalliferous lodes mostly occur in the volcanic portions of the western (or "inner") range, or in strata invaded by igneous rocks. On the other hand, bedded ore-bodies are more widely distributed among the sedimentary formations of the eastern (or "outer") range, the northern arm of that crescent being especially rich in mineral-occurrences. Cupriferous pyrite-deposits and iron-ores attain a great development in the Chichibu System (the equivalent of our Carboniferous): in fact, sulphidic ores of copper and iron are of extremely wide distribution in Japan. Mention is also made of important oxidic iron-ore deposits, manganese, lead, tin, antimony, gold, and silver-ores.

The coal found in Japan is mostly bituminous, the most important deposits occurring in the later Tertiary formations and none at all in the

series equivalent to our Carboniferous. Some Mesozoic anthracites are known but are of no great consequence. In the province of Ishikari, on the western coast of Hokkaido, occur the most considerable coal-deposits of Northern Japan: they have been actively worked on a grand scale since 1890, and include the four seams of the Yubari field (respectively 3, 4, 6 and 25 feet thick) the thirteen seams of the Sorachi field (all more than 3 feet thick) and the twenty seams or more of the Poronai field (five of which are workable). All these coals are said to be of first-rate quality and those from Yubari and Sorachi are especially suitable for gas-making and coke-manufacture. The Chiku-Ho coal-belt extends for more than 30 miles from north to south through the province of Fukuokaken, and for between 8 and 16 miles from east to west. It accounts for more than half of the total coal-output of the Japanese Empire. The seams are interbedded with sandstones, carbonaceous shales, and conglomerates, and more than ten of them are workable. There are five main seams, ranging in thickness from 2 to 6 feet. The coal in the upper seams is of inferior quality to that in the lower, but is very easily got. Natural coke is found at those places where eruptive intrusions have burst through the coal-bearing formation. The discovery of the Miike coal-deposits dates back more than four centuries, but it is not known at what time they began to be worked. Modern developments on a grand scale may be said to have started in 1889, and the annual output is now believed to exceed a million tons. Four seams have been proved, ranging in thickness from 5 to 25 feet; but, so far, working seems to have been practically confined to the uppermost seam, which averages 8 feet in thickness, and dips only 5 ½ degrees. The second seam, lying from 6 to 10 feet below it, has an average thickness of 5 feet, but does not extend throughout the coal-field. The other seams are very irregularly bedded, and in all probability scarcely workable. Such coal as is worked proves to be of excellent quality, suitable for firing boilers, as also for gas and coke-manufacture. Pumping-machinery is of especial importance in this field, as the amount of water that has to be dealt with daily is enormous. Indeed, according to the Encyclopaedia Britannica the pumping-plant here is the most considerable of its kind in the world. The Takashima coalfield has been known for 200 years, but until the latter years of the nineteenth century only one mine was worked there. Nowadays three collieries planned on modern lines are in
active operation, with a daily output exceeding 1,200 tons. The seams all strike from north-north-east to south-south-west: in the north-eastern portion of the field the dip ranges between 20 and 30 degrees, and in the south-western portion between 30 and 70 degrees. Sixteen seams have been proved, five or six of which (with a total thickness of coal exceeding 40 feet) are worked. The amount of coal in sight is reckoned at 160,000,000 tons. Many of the workings lie deep under the sea, and powerful ventilating installations are found necessary. The Takashima field is really divisible into three—that of Takashima proper, and those of Hajima and Nakanoshima, all 70 nautical miles distant from the harbour of Nagasaki. The total area covers 2,430 acres, and the combined annual output is about 190,000 tons.

Petroleum is almost exclusively confined to the Tertiary beds of the inner-or western crescentic belt, and usually occurs in coarse-grained sandstone which are intercalated between impermeable shales and clay-slates. The oil-deposits are widely distributed, and the province of Echigo, including the five important oil-fields of Higashiyama, Nishiyama, Amaze, Niitsu, and Kubiki, may be regarded as the main centre of the Japanese petroleum industry. The succession of clay-slates and petroliferous sandstones in the Amaze field goes down to a depth of 2,500 feet or more, yielding the best mineral oil to be got in Japan. In the Nishiyama field oil is invariably struck at a depth of 600 feet, and in Higashiyama at depths ranging between 60 and 960 feet. The Totomi oil-field, lying among the Tertiaries of the astern or outer crescentic belt, is comparatively unimportant.

The occurrence of graphite has been proved at numerous localities, but little attention has so far been directed to that mineral in Japan. Sulphur-deposits of considerable size are fairly abundant, the most important sulphur-mines being those of Tsurugizan in the Rikuchu district, and those of Iwaonobori and Rausu in Hokkaido province. A single auriferous placer has been proved in the Esashi district of the last-named province, and the discovery of gold placers in the eastern district, of Formosa is reported.

Statistics are tabulated of the mineral output of Japan during the years 1900 to 1906 inclusive. The production of coal, petroleum, sulphur, iron-ores, and lead has practically doubled within those seven years; and the output of gold, silver, and copper shows considerable increases, while that of antimony and manganese-ore, appears to be subject to great fluctuations.

L. L. B.


The mineral deposits of Algeria and Tunisia are, geologically speaking, of comparatively late age. Since they occur mainly among limestones, marls, and shales, which date back at farthest to the Trias. Eruptive rocks, also of comparatively recent origin, frequently occur in the immediate neighbourhood of, or in intimate association with, the mineral deposits.

Beginning with the iron-ores, it is to be noted that they are mostly of volcanic origin: it is true that there are some few deposits which are undoubtedly sedimentary. At Ain Mokra, etc., in the department of Constantine, magnetites are worked, containing from 1 to 2 per cent. of manganese and 1 to 6 per cent. of titanium. At Tafna, Ras-el-Barud, etc., in the department of Oran, rich crumbly haematites are worked opencast: there is generally an overburden exceeding 160 feet in thickness. At Kristel, 3 ¾ miles distant from St. Cloud station on the Oran-Perregaux railway, are haematite-mines yielding an ore which contains from 42 to 45 per cent. of metallic iron. The Bas-el-Mahden mines, 13 miles north-east of
Nemours, yield a haematite containing 57 per cent. of metallic iron and 7 per cent. of manganese: here the ore-deposit occurs at the contact of Liassic or Triassic limestones with older schists. Geologically identical is the occurrence of Zaccar, near Miliana: the haematite contains on an average from 50 to 55 per cent. of iron and 3 to 4 per cent. of silicon. Very similar also is the occurrence at Temulga (13 miles north-east of Orleansville), which was actively worked until 1876; mining operations have recently been resumed there. On the southern flank of the Jebel Musaya are five lodes of red and brown somewhat siliceous haematite, which vary in thickness at the outcrop from 13 to 50 feet and can be followed up for a distance exceeding 8 ½ miles, as far as Madani. The ore contains as much as 52 per cent. of metallic iron, and difficulties of transport (which are now being remedied) have alone hindered the successful development of a mineral industry here. Cupriferous ores were at one time actively worked in this region, but mining operations in regard to them have been suspended since 1876. At Ain Udrer, 3 ¾ miles from Menerville, a very rich magnetite, containing occasionally, however, as much as 0.7 per cent. of phosphorus, was, until recently, worked by a Swiss syndicate. According to the official statistics of 1904, the number of proved iron-ore deposits in Algeria was then 149.

In Tunisia the difficulties of communication with the seaboard have so far frustrated all endeavours to start mining operations on an adequate scale. Three rich iron-ore fields have been proved: (1) Nebeur, near Kef, 15 ¼ miles distant from Suk-el-Arba, where the ore contains up to 4 per cent. of manganese: (2) Jebel Slata and Jebel Hameina, 25 miles south-west of Kef, yielding an ore which contains from 50 to 55 per cent. of metallic iron; and (3) Jebel Zrissa, between Kef and Thala, where haematite occurs in a great deposit among lead-ores, zinc-blende, and calamine. There is a ferruginous gossan, and the whole occurrence appears traceable to an outburst of eruptive rock-magmas.

Very pure pyrites have also been proved in Algeria, containing as much as 50 per cent. of sulphur; about a dozen of such deposits are known, chiefly in the department of Constantine.

Copper-ores occur principally in the form of carbonates and oxides; these are, of course, in many cases derived from sulphidic ores, such as cupriferous pyrites. Some of the primary sulphidic ores, as, for instance, the Ashaish concession, are being actively worked. At Jebel Uenza, almost on the Tunisian boundary, about 15 miles distant from Clairfontaine station on the Tebessa railway, a great gossan of cupriferous haematite covers lodes of azurite, malachite, cuprite, etc. This is the most important cupriferous mine in the whole of Algeria and Tunisia: numerous heapsteads attest the industrial activity of the ancient Romans here, and the deposits are still being worked, both underground and opencast. A short distance to the north lies the Jebel Bu Kadra mine, where cupriferous heavy spar traverses a mass of cupriferous and manganiferous haematite. At Hassi-ben Henjir (9 miles west of Ain Séfra, in the department of Oran) occurs a massive sandstone, in beds exceeding 330 feet in thickness and containing from 2 to 25 per cent. of metallic copper, intercalated among red marls. The only cupriferous deposit that is now being worked in Tunisia is at Shuishia, 8 miles north of Suk-el-Arba, on the railway from Bona to Tunis.

Calamine-deposits are of widespread occurrence, both in Algeria and in Tunisia: the mineral is extraordinarily diverse in form and in colour. The Gar Ruban mines, near the Moroccan frontier, 18 ½ miles south-west of Lalla Marnia, were worked as long ago as the times of the ancient Romans. The ore is an extremely pure calamine, with very little blende, and yielding 10 ounces or more of silver per ton. Recent attempts to re-open the mines have been hindered by difficulties of transport. The Belgian syndicate of La Vieille Montague works several Algerian zinc-ore deposits, among them those of Warsenis (Ouarsenis), 21
miles south-east of Orleansville. Nearer the surface, the deposits just named consist of calamine in association with haematite and Liassic limestone; it is believed that deeper down they pass into blende. The Hammam N'Bails and Nador deposits (worked by the same syndicate) are among (he richest of the kind in Algeria: they occur among Triassic limestones 12 ⅓ miles south-east of Guelma, in the department of Constantine. A very scarce mineral has been discovered at Jebel Nador, a chlorantimoniate of lead, which has been christened nadorite. A short description is given of the Sakamody deposits (at present unworked, although up to 1903 they yielded 3,000 tons or so of marketable ore), as also of those at Jebel Forer, Guelma. Jebel Masser and Jebel Maaziz, Wasta and Meslula, Bu Thaleb, Bu Faber, Gergur, Jendli, etc. In the year 1904, no less than 157 deposits of zinc-ore and 83 of lead-ore had been proved in Algeria.

In Tunisia the deposits are perhaps equally numerous and important. They are divisible in the Regency into four groups: (1) those situated north the Suk-Afras and Tunis railway; (2) those situated south thereof; (3) those proved in the district of Tunis itself; and (4) those proved in the Thala-Tebessa district. The first group includes plumbiferous and argentiferous calamines, worked by various French and Belgian syndicates. In the second group, perhaps the most important concession (and the oldest granted in Tunisia) is that of Jebba, leased by the Vieille Montagne syndicate. Here calamine and lead-ore deposits occur with limestone intercalated between them. To the fourth group belong the Zaghuan mines, the most extensive mineral concession in the Regency, 37 ¼ miles south of Tunis. Here two enormous deposits of calamine, with which are occasionally associated lead-ore and phosphorite, occur among limestones. The Jebel Ressas deposits, too, are worked actively for zinc and lead.

Many deposits of other ores (not specified) also are known in Algeria and Tunisia, and the important phosphate-deposits are fully described by M. Paul F. Chalon, in his work entitled Les Richesses minerales de l'Algerie et de la Tunisie, Paris, 1907.

L. L. B.


Since the issue of the last official report on this region (in December, 1904) a considerable step forward has been taken in the initiation of a great mineral industry. The output for 1907 (1,645 tons of metallic copper, 1,743 tons of lead, and 1,133,660 ounces of silver) would have been much larger, but for the fact that a great number of mines were still in the stage of exploration or forewinning. Several mines having reached the hydrostatic level of the country, the installation of pumping and winding plants has, of course, become necessary. Meanwhile the general rise in price of the particular metals worked here, as well as the lowering of railway-rates, has favoured the working of ores hitherto regarded as unprofitable. There has been consequently an increased demand for mineral concessions, with the result that the entire district of Morococha is already parcelled out, and prospective concessionaires are directing their attention to various other districts in the same province of Yauli.

An account is given of the work of triangulation carried out by the Government Commission in that province, also of rainfall measurements; this is followed by a brief description of the general geology of Morococha. Roughly pictured, the district forms a great "anticlinal" fold (the nucleus of which, eruptive dacite, has been laid bare by erosion), striking from north-west to south-east. But the structure is complicated by the movements that took place before the complete solidification of the eruptive magma. Limestones, marls, and other
stratified rocks occur on both limbs of the anticline, and the rock-fissures (at right-angles to the anticlinal axis) connected with the moribund phases of eruptivity have been subsequently infilled by metalliferous ores precipitated from thermal solutions. Erosion has followed two main lines in the district—the trend of the axis of plication and that of the general system of fissures.

A detailed description is then given of the metalliferous deposits in the Cerro San Ignacio, the Cerro San Marcelo, the Cerro San Francisco, the Cerro Alpamina, the Cerro Cuncushpata, and the Cerra San Florencio. This is followed by an account of the exploration-work that has been accomplished or awaits accomplishment; also of the methods of working and preparatory smelting of the ores, and of the conditions of labour. The aborigines (so-called "Indians") are described as illiterate and confirmed drunkards; but their adaptability is great, and the institution of schools and hospitals should change the face of the land. In the first Cerro described, the lodes consist of argentiferous tetrahedrite and blende with a quartzose gangue. Here occur the important mines of San Gerardo and Victoria. Similar ores apparently occur in the Cerro San Marcelo, and much is said about the Gertrudis and Yanamina mines there. The San Miguel mine (in the Cerro San Francisco) is perhaps the most important in the district: it has been thoroughly explored, and is being worked on the "square set" system. There are about 150,000 tons of mineral in sight, containing 9 per cent. of copper and a third of an ounce of silver per ton. No less than five well-marked lodes have been proved in the San Francisco mines, on the northern slope of the ridge: the Natividad mine is also working rich deposits; and the great ore-body worked in the Churruca mine is unique of its kind in the district, being lenticular in form, and consisting of a compact mass of oxidic copper-ore, chalcopyrite, and ordinary pyrite. The country-rock is a contact-metamorphosed limestone approximating in appearance to marble. There are galenas, generally rich in silver, in the mines worked by the Sacracancha company on the Cerro Alpamina.

L. L. B.


At the outset it is admitted that the sole mining operations of real economic importance within Swiss territory at the present day are directed to the deposits of rock-salt and asphalt. The other mineral deposits either are too insignificant to rank as industrially important, or the general geological conditions are such as to interpose practically insurmountable obstacles to profitable working. The result is that Switzerland is all but completely dependent on foreign nations for her supply of coal and metals: and yet the metallurgical industry is highly developed in that little country.

Metalliferous ores are of widespread occurrence, especially in the strictly Alpine region, and were formerly worked at many localities. With the single exception, however, of the iron-ore mines at Delsberg (Delemont) in the Jurassic region, nowhere has a continuous mining industry been active from ancient times down to our own day. A recently started auriferous working at Salanfe in the Valais is also cited. Taking a broad view of the country as regards metalliferous ores, it may be said that in the Jurassic region only sedimentary iron-ores occur; in the midlands or central belt (mainly Tertiary) only gold-bearing alluvia occur; while in the Alps almost every well-known metalliferous ore is found in extraordinary variety.

The pisolithic brown iron-ores of the Swiss Jura are described: they are of early Tertiary age, and occur as pockets or as beds in or on the surface of the Mesozoic
calcareous rocks. The best grade of ore contains a maximum percentage of 12 of metallic iron. The high percentage of titanium (2.5 maximum) in the Delemont ores is noteworthy. Here the mines, first opened up in 1840, are still working, and yield annually about 10,000 metric tons of crude ore. The "minette"-ores, which are of such vast extent and importance in Lorraine and Luxemburg, are represented in the Swiss Jura by the poorly ferruginous oolites of the Murchisona series; yet in Canton Aargau (Argovie) even these, containing at most 20 per cent. of brown iron-ore, are worked at the present day.

In the midlands (or central belt) the gold in the auriferous alluvia is derived from the quartz-gravels of the Miocene Nagelfluh of the Napf district,

which contain the precious metal in the form of minute flakes. The gold liberated from the Nagelfluh in the course of erosion is partly reconcentrated in the alluvial sands and gravels of the streams that flow through the Napf district, and is partly carried by these waters to a greater distance—whence the origin of much of the gold formerly washed along the course of the Aare and the Rhine.

Coming then to the Alpine region, the author describes first of all the sedimentary iron-ore deposits of the northern limestone-Alps. Up till 1876 a great bed of compact haematite (5 to 16 ½ feet thick) was actively worked in four mines near the summit of the Gonzen, in Canton St. Gallen; it occurs in the Upper Malm limestones, at altitudes ranging from 4,000 to 5,000 feet above sea-level, and the beds have been much folded and intensely metamorphosed. This haematite contains up to 60 per cent. of metallic iron, and from the amount of crude ore in sight, even now untouched, it is estimated that about a million metric tons of metallic iron could be ultimately obtained. In the Lower Malm (Oxfordian dark shales and Callovian Dogger) iron-ores crop out over a distance of well nigh 2 miles near Erzegg and Planplatten, in the form of huge lenticles of pisolite, averaging 5 feet in thickness, and of iron-shot calcareous shales. It is estimated that 674,000 tons of metallic iron could be got from the 2,280,000 tons of crude ore in sight. From deposits of similar age and character, far away to the south-west, at Chamoson in the Rhone Valley, it is reckoned that between 300,000 and 400,000 tons of metallic iron could be got. A typical analysis is tabulated of the Planplatten ore: its specific gravity is 3.12, it contains 31 per cent. of iron, extracted from 4 per cent. of carbonate; also 4 per cent. of silica, 18 of calcium carbonate, 11 of hydroxides-of iron, and 63 per cent. of oxides, etc. At the junction of the slaty quartz-porphyries of the Mont Blanc massif and the Jurassic limestones, near L'Amone in the Val Ferret (Canton Valais), bands of pyrite measuring as much as 3 ¼ feet in thickness were chiefly worked in the 'seventies for the utilization of the pyrite in the manufacture of sulphuric acid.

The working of the galena-deposits at Goppenstein in the Lotschen valley was resumed by a Berlin syndicate in the year 1900, but has now been once again abandoned: although, in 1902, no less than 3,000 tons of picked ore were sold. The mineral industry in that district dates back three hundred years or more. Several other plumbiferous and also cupriferous silver-bearing ore-deposits are described. A brief account is given of the nickel-ores in the Clemgia ravine, near Tarasp (Lower Engadin): and then the famous gold-bearing pyrites of Gondo, which have been repeatedly the object of active mining operations, claim attention.

High up on the Quadrata Alp in Val Poschiavo is an asbestos-deposit first worked in the 'seventies, then abandoned, and now being worked again. The mineral is stated to occur in long fibres and to be of good commercial quality. Occasionally, too, the Geisspfad asbestos in the Binn Valley (Canton Valais) is worked.
The asphalt-workings of the Val de Travers (Canton Neuchatel) rank among the most important mining enterprises of Switzerland at the present day. The workable asphalt occurs in the upper part of the Urgonian limestone (top of the Lower Cretaceous) in the form of a dark-brown soft mass containing from 9 to 12 per cent. of bitumen: it is from 6 ½ to 26 ¼ feet thick: and the plasticity and yet crumbliness of the rocks make it necessary first to build masonry round three sides of the pillars in the underground workings, then work the pillars away and fill the void thus made with stowing. As the workings extend downwards, continuously increasing quantities of water have to be dealt with. At present the inflow amounts to 1,540 gallons per minute, and is drained off by turbine-pumps. Since 1878, these mines have been worked by a British company, who employ about a hundred men, and export annually from 25 to 30,000 tons of asphalt of first-rate quality.

On the north side of the Rhone Valley, at Fondement and Bevieux, above Bex (Canton Vaud) rock-salt, occurring among the greatly disturbed and bodily overthrust Triassic strata (at Bex the Trias, into which patches of Lias have been wedged, overlies Cretaceous and Tertiary, and is overlain by Tertiary beds, which again are capped by Lias and Trias), is brought to the surface, in the form of brine. The salt is found in great lenticular stockworks 330 feet high, the same in length, and from 65 to 130 feet thick, embedded in anhydrite. Enough brine is got to meet the demand for salt of the entire Canton. A source of natural gas, discovered some time ago in the underground galleries at Bevieux, is utilized for illuminating purposes.

Other saline deposits are described, and it is noteworthy that at Koblenz, near Waldshut, recent boring has disclosed (at a depth of 433 feet from the surface) the presence of a bed of pure rock-salt more than 36 feet thick, among the strata of the Muschelkalk, well-known as saliferous in the neighbouring districts of Switzerland and Suabia. At Schweizerhalle in Canton Basel, and at Rhyburg and Rheinfelden in Canton Aargau, the salt-output was still considerable in 1907: in fact, Switzerland is able to supply her own markets with that commodity, and could without difficulty increase her output.

Although coal has been found at localities without number, it nowhere occurs in Switzerland in such quantity or of such quality as to compete with foreign coal. The few workable seams only repay working where the coal can be utilized on the spot, and where some use can be found for the barren stuff which has to be removed to get the coal. The total annual output in Switzerland amounts to 20,000 metric tons, and the number of workpeople employed in coal-mining averages four score.

The Molasse (Miocene) brown coal of Kapfnach, on the left bank of the Lake of Zurich, has been worked uninterrupted since 1784: it is a poor mineral, yielding 27 per cent. of ash, and containing nearly 4 per cent. of sulphur, and is now got practically as a bye-product, in the course of quarrying materials for cement-manufacture and marl for agricultural purposes. At Chandoline and Grone in Canton Valais, Carboniferous anthracites are still worked: they vary much in quality, but on the whole yield a considerable amount of ash, as much as 25 per cent. L. L. B.


Some preliminary exploration-work on the copper-ores of Abikula, a locality situated on the right bank of the Ludima, was accomplished in 1905; and in the summer of the following year the author visited the "diggings," on his way to the Boko-Songo copper-mines, distant some 9 miles to the north-north-west from Abikula. At this latter place he collected
some specimens of malachite, and describes the predominant rock as being soft red and
green calcareous shales, with which more or less continuous bands of chert are inter-
stratified; there are also grits of a rich reddish-brown colour and brick-red micaceous shales.
From the industrial point of view, the prospect is not encouraging at Abikula, for it is doubtful
whether the ore-deposits would repay working.

At Boko-Songo the well-known copper and lead-ores have long been worked

by the natives, and have been recently described by M. D. Levat in the Annales des Mines
(1907, vol. xi.). The deposits occur in a swampy valley, from 500 to 1,100 yards broad, the
southern wall of which is formed by the lofty hill-range that constitutes the water-divide
between the river-basins of the Congo and the Kwilu-Niari, and also constitutes the Franco-
Belgian frontier in those regions. The workings are opencast, and the natives had
abandoned their mining operations long before the author’s visit. In the western or “little”
mine, the debris which choke up the ancient excavations consist almost entirely of limestone
slightly impregnated with malachite. Compact limonite with some traces of copper is seen at
a few points. The “principal mine” includes three excavations exceeding 100 or 130 yards in
length; here again, investigation is much hampered by the accumulations of debris thrown
out by the ancient miners. Reddish-brown limonite, exhibiting minute traces of copper, is still
seen in place: apparently the natives did not consider it worth working, and in fact the debris
in this “principal mine” consist predominantly of limonite. The eastern or Dienguila(?) mine, 2
½ miles to the east of that just described, near the village of Kwimba, is also choked up with
limonitic debris. It may be noted that the natives have in all probability worked away only the
superficial ores (oxides and carbonates) of copper and lead, and that serious exploration
work will prove the existence of the corresponding sulphidic ores in depth (chalcopyrite,
galena, etc.). The author differs from M. Levat in regard to the geological age (? Devonian) of
the grits which are said to overlie the ore-bearing limestones throughout the Kwilu-Niari
basin, and he considers that there is a stratigraphical break or unconformity between the two
formations. The ore-deposits are most probably definable as “contact-deposits.”

The search made by the author for similar ore-deposits in the neighbouring area
of the Belgian Congo territory was unsuccessful, and he is inclined to believe that there is small
chance of further research yielding more favourable results. L. L. B.
A characteristic which has not escaped any petrographical student of the Equatorial Archaean and Palaeozoic is the extraordinary abundance of oxidized iron in these rocks, in the shape of haematite, magnetite, and ilmenite, sometimes forming masses or lodes of considerable importance. It is admitted however, that in this respect, as in that of cupriferous ores, Uganda cannot stand comparison, so far as present knowledge has attained, with such regions as the Katanga district of the Belgian Congo. The author observes that in the districts of Uganda traversed by him he never found chalcopyrite in any noteworthy quantity, although he came upon several outcrops of the ore (of small importance) in the Ruwenzori range, with accompaniments of bornite and tetrahedrite, and occasionally the decomposition-product, malachite. Neither did he find any precious metals in Uganda.

Although magnetite and haematite are not likely, at any time, to form in the Protectorate the basis of a metallurgical industry, it is far otherwise with limonite, which at some points (with an intermixture of clay) builds up entire hills; in other instances, there are hills of breccia or conglomerate with a limonitic cement, rising to heights of 320 feet or more, as in the neighbourhood of the capital, Entebbe, on the western shore of the Victoria Nyanza. The author refrains, however, from dealing with the "concretionary limonite" of the region of the great lake, as he has already devoted to it a portion of his geological report on the Ruwenzori expedition of the Duke of the Abruzzi: he merely remarks that the outcrop of ore extended for 60 miles and more along the route followed by the expedition. At present, it is used as an excellent building-material for dwellings inhabited by Europeans. He regards it practically as bog iron-ore, and differentiates it from the limonite which occurs at various depths and in varying quantity in the lateritic deposits. He tabulates chemical analyses made by him of the lacustrine limonite or bog iron-ore of Bweya (18 miles distant from the western shore of the Victoria Nyanza), Mitiana (37 miles distant from the same shore), Bujongolo (12 ½ miles west of Mitiana), Entebbe, and Port Florence. They show from 52.37 to 56.62 per cent. of iron peroxide, and from 32 to 35 ½ per cent. of clay or insoluble residue, with occasional traces of phosphorus and titanium. The ubiquitous laterite, which in places attains an enormous thickness, yielded to the author on analysis an average of 20 per cent. of iron peroxide, and manganese was also found to be present in every instance. In places the laterite is extraordinarily rich in micaceous haematite, probably derived from the haematitic sandstones and granular quartzites (itabirites) which abound in some districts. Several bedded deposits of limonite occur within the laterite in the Mwenge district, and generally in the province of Toro (south-eastern region of the Albert Nyanza) at comparatively shallow depths (20 to 70 feet) below the surface, and are worked by the natives to supply their extremely flourishing metallurgical industry.

On the eastern flank of the Ruwenzori range, the limonite has to be sought rather deeper down than in the Mwenge district (say, 100 feet below the surface). The limonite is also worked by the natives in several other districts of the Protectorate, but they seem to have neglected so far the ore-deposit (said to be quite considerable) at Mboga, near the Anglo-Belgian frontier, north of the Ruwenzori range. The lateritic limonite is often accompanied by a white earth, to which the natives have given the name of ironi: it proves sometimes to be pure kaolin, and beds of it in the Mwenge district are as much as 6 ½ feet thick. The author analysed a specimen of the limonite worked by the natives at Butiti, in that district, and found it to contain 82.09 per cent. of iron peroxide, 3.61 of water, and 9.27 of insoluble residue. A managaniferous limonite from the Toro district yielded 74.23 per cent. of iron peroxide and 7.12 of manganous oxide. The managaniferous
limonites pass gradually into a mineral called ntabo, which is really a siliceous ore of manganese and iron; its occurrence is practically confined to the Mwenge district, so far as present research extends. There is, however, reason to believe that manganiferous ore-deposits do occur elsewhere, and will in time constitute a valuable source of wealth for the Protectorate.

L. L. B.


This memoir is preceded by a bibliographical list, confined to non-Russian sources, comprising 24 entries. Some of the authors quoted are said, however, to give full reference to original Russian work on the subject.

The ore-deposits of Western Siberia, not to speak of the gold-placers, are of considerable interest; but in recent decades the output of metals (apart from gold) has diminished alarmingly, and few localities can be cited where mining operations have been carried on uninterruptedly up to the present day. Quite recently, however, some of these long neglected deposits have been prospected anew; and for a few years past, moreover, successful endeavour has been made to work the gold in the lately discovered quartz-reefs, as the yield from the placers has gradually diminished with unadmired regularity.

The region with which the author deals lies entirely to the south of the great Trans-Siberian railway: it is bounded on the west by the Irtish, a tributary of the Ob, on the east by the Yenisei, and on the south by the Chinese (Mongolian) frontier. It includes the mining districts of Semipalatinsk, Tomsk, Achinsk, and Minussinsk. The rocks are predominantly highly-plicated gneisses and ancient crystalline schists, steeply-dipping clay-slates, sandstones, and limestones of Palaeozoic age (Silurian to Carboniferous), into which are intruded later granites and diorites with their porphyritic derivatives.

The auriferous and argentiferous lead, zinc, and copper-ores are in the main restricted to the western flank of the Altai, and constitute a homogeneous group characterized by the occurrence of lodes of galena, zinc-blende, pyrite, and chalcopyrite with a gangue consisting chiefly of quartz and heavy spar. Towards the surface these sulphidic ores tend to pass into a gossan especially rich in silver and copper. Since the liberation of the serfs, silver-mining has greatly declined: convict labour is utilized, but with not very satisfactory results. Among the hundreds of known outcrops, only the Syryanovsk, Riddersk, and Salairsk mines still continue feebly at work. The greatest depths reached do not exceed 660 feet, but it has long been ascertained that the deposits (so far as the precious metals are concerned) impoverish with depth. Recent statistics are given (1901-1905) of the output of silver, lead, and copper from the Altai mines, and serve to accentuate the present insignificance of these mines. It may be noted, by the way, that, although blende and calamine are associated in considerable quantity with the galena-deposits, the zinc-ores in that region seem never to have been worked. The famous silver-mines of Smieingorsk ("Snakehill") had been abandoned since 1860 until recently, when a German syndicate re-opened the workings with the view of making a payable proposition of the gold that exists in the silver-ore to the extent of 10 or 12 dwts. per ton. It is said, moreover, that the hornstone and heavy spar of the old waste-heaps yield as much as 2 ½ ounces of gold per ton. The ores here occur in a "bedded vein," which cuts through the
western limb of a synclinal mass of Devonian strata limited on each side by ridges of biotite-granite. The ore-deposit narrows greatly in depth, and is much interrupted along the strike by compression and faulting. A brief description is given of the very dissimilar ore-bodies of Cherepanovsk; Kolyvansk (22 miles north-east of Smeinogorsk), where the sole occurrence of wolframite in the Altai is recorded from the white vein-quartz of the waste-heaps; Akimovka, Murinska, Chudak, Sugatovsk (where operations were suspended only at the end of 1906), Savodinsk, etc.

Magnetite, with its superficial decomposition-derivatives, is worked opencast at four localities on the left bank of the Abakan (a left-bank tributary of the Yenisei). The ores are associated with eruptive dykes traversing the ancient schists. Red and brown haematite are of widespread occurrence in the form of small nests and bands, chiefly in the Devonian strata. Sphaerosiderite is often found in close connexion with coal-deposits, as, for instance, with those which form the northern extension of the Kusnez coal-field along the Siberian railway. Auriferous quartz-reefs are chiefly known in the eastern portion of the Alatau Mountains, more especially near the headwaters of the Chulim, around the village of Chebaki. They are found, as a rule, to traverse syenites and diorites which are themselves to some extent auriferous, and the reefs may be said to consist of a bundle of parallel "stringers": the yield of gold ranges between 13 and 26 dwts. per ton, diminishing all but invariably as the depth from the surface increases. The beginning of mining operations directed to these quartz-lodes only dates fifteen years back, and it remains to be proved whether they will furnish a sufficient substitute for the moribund placer-industry. The equipment of the mines is modern, and the statistics show a gradual increase in output from 1900 to 1904 (the latest year cited).


In the very first sentence of this memoir the author points out that the great Eifel Fault is the dominant factor in the tectonics of the Franco-Belgian coal-basin. The folding, shearing, overthrusting, and fissuring determined by that great rent in the rocks have had for one result the masking of the southern portion of the coal-basin by formations of pre-Coal Measure age. As the outcome of the investigations pursued from 1896 to 1899 in the Lievin area, numerous borings have been put down in the Pas de Calais, with the view of striking the southern extension of the coal-field beneath the older rocks. Similar investigations are at present being pursued in Belgium; and now the author gives an account of what has been done, with the same object in view, in the neighbourhood of Valenciennes. It may be observed, by the way, that the coal-seams in that region are classifiable into several groups, the mutual relationship of which is either uncertain or unknown. After, a summary of the hypotheses regarding the constitution of the southern extension of the coal-basin in the Valenciennes area, a detailed description is given of the exploration-work carried out previous to the year 1906. Since then the Estreux (E 4) boring was pushed to the depth of 3,551 feet and abandoned on Christmas Eve, 1907: that of Marly railway-station (M3) was abandoned on the same date at the depth of 3,255 feet; and that of Petit St. Sauve (M4) was abandoned at the depth of 3,280 feet on March 17th, 1908. None of these borings—full details of which are given—reached the productive Coal-measures,

[57]

but they have located exactly the course of the Eifel Fault in the neighbourhood of Marly. The stratigraphical evidence accumulated from the exploration-work accomplished in the Valenciennes area is discussed at some length, and the reasons are adduced for believing that the coal-field extends much farther southwards than the areas already worked. It is true
that the depth at which the coal is likely to be proved is very considerable. The extent of this southward prolongation is perhaps most easily to be gauged in the neighbourhood of Quienvrechain, as the position of the axis of the Coal-measure syncline has been determined thereabouts with some approach to precision. There only is the Eifel Fault, near its outcrop, in actual contact with the productive Coal-measures, from which it is separated elsewhere in the Valenciennes area by the barren measures, the Lower Coal-measures, the Carboniferous Limestone, and the Devonian.

L. L. B.


The writer found coal exposed in the bed of a stream, which was then dry. The coal, which was being worked by the natives up the face of the hill by means of quarrying, is in two sections, the first about 6 feet and the second about 3 feet thick, but in each case the base of the seam was not seen. The two sections are separated by 14 feet of undergrowth and scree. The examination of the rocks surrounding the exposed coal revealed the outcrop of a small patch of Damuda rocks, hitherto unsuspected, in the valley near Gilhurria, covered directly with trap at the western end, but passing up into a thin covering of Dubrajpur Sandstones to the east. The whole outcrop is very small, but interesting, inasmuch as it contains combustible coal, and indicates the continuity of the Hura and Dhamni Coal-fields under the trap. The coal itself is of a very uniform quality in both seams. In texture it is of the carbonaceous-shale variety, but is crowded with small fragments of carbonized wood and plant-remains, which give to it its burning power. Although these fragments all lie in a definite direction, there is an absence of any banding or bedding, and in this respect it differs from a true coal. An analysis of the coal showed it to have the following composition:—Moisture, 7.46; volatile matter, 30.94; fixed carbon, 39.67; and ash, 21.93 per cent. There are indications, however, that the percentage of volatile (combustible) matter will be found to be higher in the coal lying some little distance underground.

A. P. A. S.

MINING TECHNOLOGY.


A water-shaft, as above, near the main shaft, 16 feet 5 inches in diameter, had to be sunk by the Gelsenkirchner Bergwerks-Aktien Gesellschaft, under conditions requiring the exercise of extreme care. The octagonal shaft-walls were built in separate sections or panels. For the alternate panels of the eight sides, oblong holes, measuring about 2 feet in the radial direction of the shaft, were dug and boarded up tightly at each of the angles of the octagon for a depth of 14 ¾ feet, extending through the water-bearing strata into the firmer material of the clay beyond. Hay was used as packing, and the water was kept down by pumps. The inner sides of the holes were boarded out smoothly, and the panel-holes were filled with rammed concrete of 1 to 5, which thus formed walls about 20 inches thick. The concrete took about three days to set, after which the other four panels were proceeded with in the same manner, but were carried to a depth of 21 feet.

The core, or material within the walls, was now removed to a depth of about 18 feet. Since the succeeding strata were found to contain a good deal of water, the sinking was continued in the same manner to a depth of about 62 feet, at which point the material was firm enough to allow of the rest of the shaft being sunk as a whole.
Including material and subsidiary operations, the sinking cost about £750. or about £9 10s. per foot, and took about 3 months to complete.

In view of the results obtained, the above-described method is recommended for similar cases of sinkings through strata containing large quantities of water.

A. R. L.


This article discusses the different effects produced by the pressure of the strata overlying a seam that is being worked, and the methods of supporting the roofs of the passages traversing it. Distinction is made between roof-strata which, when not disturbed by faults, etc., are strong enough to carry themselves, and sedimentary strata such as slate and clay, which are more or less plastic. The first-named roof requires only slight timbering to prevent falls of material which may become detached in some way from the surface. In the case of the second kind of roof the sedimentary strata and the coal below them are often in a state of compression, and the coal sometimes assumes a plastic character. In this case the support must be more or less yielding. Reference is made to the ordinary methods of roof-support with props and spars and iron rails. The cost of such work for a roadway 7 ½ feet high by 7 ½ feet wide at the top, is given as from 9s. to 11s., and for a roadway 11 ½ feet wide at the roof and 8 ¼ feet high, with a central line of props, at about 16s. to 18s. per cubic yard for strong framing.

The probable cost for the repair of a collapsed length of roadway is given at about 3s. 7d. for the narrow and about 2s. 8 ½ d. for the broad section, per cubic yard.

A method in use for airways and similar passages through strata under very high pressure is that of polygonal timbering. The airway is made about circular, the spars being so butted as to form, say, an octagon, the angles of alternate octagons being opposite to the middle of the sides of the preceding ones. By packing behind the frames with pieces of timber, etc., the pressure is evenly distributed over the frame. The polygons gradually grow smaller, but their withdrawal and renewal does not present much difficulty. Such constructions are used for air and such like passages, in which regularity of section is desirable. This method is about three times as durable as the ordinary system, but is considerably more expensive to construct.

Iron frames of other than circular form are undesirable for strata under great pressure. Iron rings with longitudinal spars between them and the seam are recommended. Care must then be taken that the spars are periodically removed and replaced before the increasing pressure has wedged them in too tightly.

Stonework and concrete are undesirable for support of roadways subject to high pressure, as masonry is apt to be rapidly pressed inwards. When masonry has for special reasons to be used, wooden bricks built into the walls will give the latter elasticity for a considerable time.

Reinforced concrete should be used with great caution, because the pressures to which it is to be subjected are unknown. Iron also is often subject to chemical changes, and this should not be lost sight of.

However good the methods above described for dealing with passage-ways through seams under high pressure may be, they are able to relieve the latter only very gradually. In view of this it is, in such cases, not advisable to drive a drift to the boundary and work back towards the shaft. The better plan is to work from the shaft and apply the system thoroughly as the work proceeds.
In longwall workings, the various galleries are as far as possible only carried through parts from which the coal has already been worked. This can be done without hesitation, provided that such parts are well filled up with gobbing. When the pressure is very great, the longwall face is kept comparatively narrow, say, about 25 to 30 feet, and the inclines will be made of moderate dimensions. In thick seams under pressure it is thus found practicable to work the coal in layers of comparatively small thickness—the lower ones first—otherwise much breakage occurs, and the costs of timbering become exceedingly high. When drifts have to be made through broad fields under great pressure, it is advisable to keep them as broad as possible, and to fill in their sides with cross-piled timbering and gobbing. In the case of a main passage, the post and lintel construction is flanked at each side by a wall from 4 to 5 feet wide, made up of masonry, cross-piled timber, or timber with masonry filling. Against the coal or rock is a wall of masonry, from 12 to 18 inches thick, and the space of about 3 to 5 feet between this and the thick wall above mentioned is filled up with gobbing. In the case of inclined strata, the arrangement is varied somewhat, the flanking-wall being tied to wooden pillars set firmly in masonry at the rise side of the passage.

If timber only be used for the pillars, the passage must in the first instance be made of ample height, because the roof-pressure will often compress the timber to half its original height. The cost per cubic yard of purely wooden walls is from 10s. to 11s. 6d., and that of walls of timber and masonry combined from 7s. to 7s. 6d. The cost of flanking-walls of the latter description, 8 ¾ feet wide by 16 ½ feet in height, is about £4 14s. 10 ½ d. per cubic yard. In case of heavy pressure these walls are sometimes crushed down to 70 per cent. of their original height, or, when timber predominates, to about 60 per cent., but they then bear the pressure very well.

When the seam is thin, and a subsequent taking down of roof is objected to, it is advisable to make the flanking-walls of carefully-built dry-stone masonry about 5 feet wide. The cost of such specially built walls is from 5s. 4d. to 6s. 1d. per cubic yard. In the Zwickau district, such walls have held well and given satisfaction. Walls of this kind are recommended for inclines.

Where the passage is short or the circumstances are otherwise favourable, in some cases the side-posts of the frame have been dispensed with and the lintel-pieces are borne on pairs of half-round spars running along the masonry at each side.

Flanking-walls such as those described have proved a much better protection for roleyways and main galleries than the pillars of coal formerly left standing for this purpose, which quickly became compressed when subject to severe roof-pressure.

When transverse passages, say in inclined seams, are specially affected by roof-pressure, they are often relieved by the working out of a level zone 60 to 135 feet wide by a length varying with the circumstances of the particular case.

For the support of the shaft, a method has in some places been adopted by which the coal is worked out in strips and replaced by masonry-work, the shaft side being then well timbered. Masonry-work of this kind can become compressed by about 15 per cent.—when further filled with wet sand it compresses by only 2 to 3 per cent. A.R.L.

Influence of Pit-workings upon Tramway Rails.—By —. Korten. Gluckauf, 1909, vol. xlv., pages 865-871:

This article is the result of numerous investigations conducted by the author in cases of claims for damages made by tramway companies and others in the Rhenish-Westphalian coal-mining district, the amounts demanded ranging up to and even over £1,000 per kilometer (0.62 mile).
A subsidence at the surface caused by the fall of the roof in the workings below tends to produce a depression in sandy ground. The sand runs or presses down the slope on each side towards the centre of the depression, so that objects on its surface approach each other or move apart according as they lie at the side or the centre or on one of the slopes between these points. A bed of clay covering the sand will, under the same conditions, be in tension or in compression at the same points.

In the case of tramway lines running along a depression thus formed, relatively little damage is done. When the rails run across the depression, they are, like the clay-covering, in tension or in compression at the corresponding points. In the former case, the butts of the rails begin to open, the fish-plates or buttstraps begin to draw, and the wheels, as they pass, are subject to rocking motion, which wears both straps and rail-ends and causes looseness and knocking.

In the second case, the rails first close up at the butts and then assume a snake-like form, the cross-ties in the meantime either twisting or remaining straight according to their relative position to the sinuosities of the rails. Characteristic appearances show themselves in the bulging out of the pavement, etc., which indicates whether such loosenings of the butts are due to pit-falls or to other causes.

It is shown that the wandering of the rails may also be due to the methods of laying them, to the effects of ordinary work, or to maintenance operations. According to more recent practice in rail-laying, less play is left at the butts than formerly, and the result has been a considerable increase in the frequency of actions for damages preferred against the collieries. It is shown that much of the damage done is due to the cross-ties, which are unable to move in the longitudinal direction of the rails and prevent these from adjusting themselves to tensions and compressions occurring at different points in their length.

The author suggests that it would be worth the while of the mining companies to pay the tramway companies a relatively small sum towards the application of somewhat more expensive appliances, which would allow the cross-ties to move in the direction of the track. A number of different proposed methods for effecting this are illustrated. Attention is also called to damages to walls, bridges, and other structures, for which explanations might be found and a just apportionment of blame arrived at by similar considerations.

A. R. L.


This article first deals with the question of how much heap-room should be provided at a colliery for the various eventualities of mining. An average, taken over 4 years of working, showed the amount of coal teemed to heap to be 9.5 per cent of the whole amount brought to bank. In view of the danger of spontaneous combustion, 23 feet is considered to be the height-limit of a coal-heap; and, taking these two quantities as bases, the dimensions of the oblong site which is found to be convenient for heaping operations may thus readily be computed.

The Kattowitz Aktiengesellschaft fur Bergbau und Eisenhuttenbetrieb, with a daily output of 3,800 tons from three shafts, have two dumping grounds, No. 1, 330 feet long by 132 feet in breadth, and No. 2, 200 feet long by 100 feet in breadth. Coal-washing and screening plant lie between these. The teeming on to No. 1, which can take 40,000 tons, is conveniently effected by women. The coals are picked up again, by means of a revolving walking-dredger, and dropped into wagons, which are run into a lift and raised to the height of the screening-platform. Teeming on to No. 2 takes place from a line of rails 23 feet above the ground. The coal-washing house is connected by means of the lift above referred to and
a line of rails, with a system of subways or galleries in the ground below the No. 2 heap. The latter are traversed by tubs, into which the coals are shot from above.

A comparison between the costs in the years 1904 to 1907 shows that, when the amount reloaded in a year is not less than 15,000 tons, the mechanical systems are both cheaper than that of hand-labour. The total cost per ton for the years 1904-1906, when work exceeded 1,800 tons, was from 1.82 to 1.97d. for hand-work,11.1 to 1.72d for overhead-dredger work, and 1.31 to 1.89d. for the subway system from below; while in 1907, when the work done was less than 10,000 tons, the corresponding figures were 2.64d., 4.25d., and 4.29d.

At the Hillebrandt shaft of the Gottessegen Colliery, at Neudorf, there is, in the vicinity of the screens, a dumping-place, about 900 feet long by 400 feet in width, which can take 190,000 tons of coals. An overhead hanging-railway from the screens runs along one side of the ground, and has a sliding connexion, with a travelling gangway at right-angles to it, reaching across the latter. The gangway has three storeys, the lower for the hanging railway, the middle for a coal-sheet, and the upper for a trolley bearing a grab apparatus, which can be moved round to any point in the hanging-railway, track, and a cabin for the operator. The railway is also arranged round the gangway, so that the trolley can leave the fixed line and run round it. Gangway and trolley are moved by electricity, which is also used for hoisting and lowering purposes.

The hanging-railway is provided with buckets which hold ½ ton each, and are so hung that on meeting a catch arranged at a suitable position on the gangway they tip their contents into the heap below. When the coals are taken up again, they are picked up by the grab and deposited, either directly or through the shoot at the half length of the gangway, into railway trucks below. The hourly delivery of the grab is 100 tons for the smaller kinds of coal and somewhat less in the case of the larger kinds. The cost of the whole arrangement is about £13,500. The costs of working in the years 1905 to 1907 were 6.84d., 6.84d., and 7.44d. respectively. A saving of about £300 a year over hand-work is estimated to have been effected.

In 1907, the Radzionkau Colliery was fitted with a similar arrangement.

The dumping place is about 1,980 feet square, the area being about 40,000 square yards and the amount of coal that can lie on it to a height of 19 feet 7 inches about 200,000 tons. A hanging-railway, 675 feet long and 7 feet 8 inches broad, runs through the middle of the ground in a direction parallel with one of the sides. The two subdivisions thus formed are each traversed by a travelling gangway. The hanging-railway has a rope-railway on each side, which serves as a feeder for bringing in the coals on to the gangway. Each gangway has a width of span of 243 feet and an overhang of 85 ½ feet. so that its length is about 330 feet. The hanging-railway is arranged to run round the gangway with a sliding contact, as at the Gottessegen Colliery and the tipping and grabbing arrangements are of a similar character. The self-tipping buckets hold about 12 ¾ cwt each. Tipping-levers are fixed to each bucket at eight different heights, and corresponding arrangements for acting upon these are made at as many different points along each gangway. In this way the buckets can be automatically emptied—eventually with different kinds of coal—at the eight different points. The speed of the railway is about 26 feet per second, [17.73mph.] and the buckets are kept about 40 feet apart and, when taking coals from the heap, 120 feet apart—so that 300 tons can be teemed or 100 tons taken from the heap, in an hour. The total cost of establishment was about £14,000. Operations have only recently been begun, but the cost of working is probably about 7 ½ d. per ton.

A third arrangement of this kind is the one at the Krug shafts of the Königliche Berginspektion I. of Königshutte. In this case, only coals coming directly from the shaft are
put to heap, and the tubs from the mine have to be run out and tipped without any transfer having taken place. The ground is 460 feet long by about 132 feet broad, and can take 35,000 tons of coal. A gangway connecting shafts Nos. I. and II. had to be made use of: it was provided with a rail, and a second rail-path was formed on a row of piles at about 42. ½ feet distance, so that a path was formed for a travelling-gangway at right-angles to the fixed one. The moving gangway is made of lattice-work, built on two girders, 4 feet 4 ½ inches apart, with a band-conveyor below and a swing-crane with grab above. The latter is at half length of the gangway, and is used to pick up the coal again. The conveyor is about 132 feet long and 5 feet broad, and moves at a speed of about 1 foot per second. The motive power is electric. The contents of the tubs are tipped on to the two conveyors at the rate of 300 tons per hour. The coals are taken from the heap again at the rate of 65 to 75 tons per hour. The cost of installation was £6,900, and the working expenses amount to about 0.4d. per ton when 675 tons are moved. It was estimated that during 1904 to 1906 the above mechanical arrangement effected a saving of from 2 to 3 per cent.

The chief advantages of these installations are the indirect ones that fewer men are required and that greater independence of strikes is attained.

Attention is called to the following differences in the estimates of heap-room required, and to the manner in which earlier experiences have been utilized: —

<table>
<thead>
<tr>
<th></th>
<th>Riedel Benrath</th>
<th>Heckel Radzionkau Colliery</th>
<th>Heckel Krug Shafts</th>
</tr>
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<tbody>
<tr>
<td>Year of Construction</td>
<td>1904</td>
<td>1907</td>
<td>1908</td>
</tr>
<tr>
<td>Daily output in Tons</td>
<td>1,200</td>
<td>2,000</td>
<td>3,800</td>
</tr>
<tr>
<td>Area of Heap-ground in sq. yds.</td>
<td>38,300</td>
<td>39,500</td>
<td>45,500</td>
</tr>
<tr>
<td>Coal that can be heaped (tons)</td>
<td>190,000</td>
<td>280,000</td>
<td>138,500</td>
</tr>
<tr>
<td>First Cost in £ sterling.</td>
<td>13,800</td>
<td>14,300</td>
<td>7,100</td>
</tr>
</tbody>
</table>

A. R. L.


Premising that the percentage of gas in the air of the mine varies not so much with the actual lowness or height as with the rapidity of change of the barometer, and that the increased discharge of gas depends upon the exudation of the air from the pores of the coal, due to decrease of pressure of the air above ground, the author discusses the conditions under which the pressure in the passages varies with the sectional areas and different forms. Thus a length of air-passage roomier than the rest is shown to have a reduction of pressure varying with the square of the difference in the sectional areas of the way.

It appears, further, that with a falling barometer the air in the mine becomes the more rapidly rarefied the greater is the sectional area of the ventilation-shafts as compared with the capacity of the mine-areas traversed by the air. It is not found to make any difference in this respect, whether the current is produced by blowers or by exhausters.

When the barometer is falling, the air in the horizontal part of an airway must become the more rapidly rarefied, the smaller the pressure is in the ventilation-shafts at the beginning of the fall. This points to the desirability of the air-shafts being kept as small as the required speed of the air-current will admit.

Of the three methods of reducing the effect of a fall in the barometer, namely, by throttling the upcast shaft, by an increased blast in the downcast shaft, and by a combination
of these two, the third is considered the more practicable, as giving the least extra work to the fan. Further, it is thought, to be sufficient to provide against half the extreme barometer drop usually met with, smaller amounts of drop than this not being considered dangerous. A combination of blower and exhauster in the downcast and upcast shafts respectively is recommended.

Again, a discharge of gas accelerates the outgoing air and dams back the incoming current at the point in question; and it is considered to be necessary to observe and regulate the air-current in both downcast and upcast shafts, and, in addition, to set up barometers and other means of observation in the mine itself.

A. R. L.


In the course of boring for coal in the above-mentioned area within recent years gaseous emanations have been repeatedly encountered—in some cases, in small quantity, in others, they burst forth in great volume under high pressure, so much so as to cause a disaster at Baumgarten, near Skotschau. It has been hastily assumed in the district that all the emanations of hydrated carbon dioxide originate in the Coal-measures, whereas in reality they comparatively seldom do so. Three categories of gaseous emanations in the Ostrau-Karwin area may be distinguished: (1) carbon dioxide, etc., from the productive Coal-measures; (2) gases from the Ostrau pottery-clay; and (3) gases from the Older Tertiaries, possibly also from the Cretaceous of the Carpathians. Further research will be necessary before any definite opinion can be maintained as to whether these gases are specifically diverse; but diverse they certainly are in their manifestations, for the gases derived from the coal are

not under the same pressure as the other gases, with which, by the way brine is often associated. The author lays it down as an axiom that pit-gas invariably collects where the Coal-measures are in some way air-tight with regard to the overlying formations—the Ostrau pottery-clay and the Older Tertiary shales may well play the part of gas-tight partitions in this respect.

In the Zablacz boring, the occurrence of petroleum was noted in conjunction with pure methane; the presence of iodine and bromine was also observed. In the Klein Kuntschitz boring, after traversing an enormous thickness of pottery-clay, combustible gases were tapped, as also brine charged with iodine and ammonia. Most of the occurrences of natural gas, however have been recorded in the neighbourhood of the Carpathians, within the older Tertiaries, and a few apparently in the Cretaceous. Proceeding from east to west, the author describes first the Alt-Bielitz boring which, at a depth of 2,625 feet in the Tertiary marl, struck a gas-blower, yielding at first 918 cubic feet per minute (diminishing after six months to 212 feet) of a gas consisting of about 95 per cent. of methane and 5 per cent. of hydrogen. At Baumgarten, at a depth of 1,312 feet, an explosively violent gas-blower was struck in the marl (just within the Cretaceous area). The gas burst forth with such force as to hurl heavy masses of iron for distances exceeding 500 yards, and the noise was so great as to be heard for a distance of 8 miles. The composition of the gas was determined as follows: Methane, 96.4 per cent.; carbon-monoxide, 2.2; and nitrogen, 1.4. In the Wojkowitz boring (which went down to 2,460 feet) gas was met with at various depths: between 1,318 and 1,542 feet black shales and limestone occur, and gaseous emanations with oil were reported from these. At Braunsberg, the boring put down in the Older Tertiaries struck combustible gases in considerable volume, at a depth of 574 feet. At Chorin, where a great block of coal (? erratically) embedded in the Older Tertiary marl is worked, an
accidentally ignited gas-blower gave rise to a flame 100 feet high. On analysis, this gas was found to consist of methane, 85.1 per cent.; nitrogen, 13.9; oxygen, 0.7; and carbon dioxide, 0.3. A shaft put down at Kladerub, near Chorin, met with a fissure from which petroleum dripped at the rate of about 1 ¾ pints a day.

The author links up the gaseous emanations herein described with the many occurrences or, at least, traces of petroleum reported from the Moravo-Silesian portion of the Carpathian region. And yet the presence of heavy hydro-carbons has not so far been proved in these gases; moreover, in the case of many active gas-blowers, despite the most watchful attention, it has been impossible to ascertain the actual presence of oil. Out of eleven borings put down in the Carpathian Older Tertiaries, six struck natural gas, and two borings struck gas in the Cretaceous: these gases are of considerable value for heating purposes, although they have not been so utilized up to the present. Their utilization would diminish by so much the cost of putting down borings in the search for coal in those districts of Moravia and Austrian Silesia. As to the duration of the gas-blowers, it may be noted that at Ungarisch-Ostrau emanations of combustible gas have been continuously vented from a hillock for years past.

L. L. B.


A description is given of an outburst of gas of unexampled violence which took place on October 15th, 1908, at a deep boring which was being put down for coal at Baumgarten, north-east of Teschen, in the Ostrau-Karwin basin (Austria). Boring rods to the weight of 7 ½ tons were shot out of the borehole,

30-foot lengths of rod hurtling through the air for several hundred feet and often burying themselves deep in the soil. During the succeeding days the gas issued from the borehole with a hissing sound, in the form of a bluish-white column 100 feet high, visible for 5 miles round. Occasionally fragments of ice of varying size were shot up with the gas. According to an eye-witness, who visited the locality a week after the main outburst, the roar of the escaping gas was so deafening that people could not make each other hear within 370 yards of the borehole. The boring, with a final diameter of 8 inches, had been stopped after passing through 655 feet of overthrust Cretaceous strata and about 1,320 feet of Older Tertiary strata. As there is evidently a considerable depression in the old Carboniferous surface at this point, the Coal-measures would be reached probably much deeper down.

Analysis of the escaping gas yielded the following percentage results: Methane, 96.4; carbonic oxide, 2.2; and nitrogen, 1.4. Among the inferences which the author draws from this analysis, perhaps the most important is that the gas is evidently derived from the Coal-measures, whence it doubtless made its way to the borehole by means of some fissure in the rocks.

By way of analogy, descriptions are then given of similar occurrences observed in Westphalia, as, for example, the outburst of November 1st, 1906, at the Ludinghausen 6 boring, of a hissing column of mixed gas and water which put to flight the workpeople, and was followed by an explosion with a terrific report. The gases no doubt were ignited by a lamp which was left hanging above the boring, and then set fire to the installation. This outburst continued uninterruptedly for three days, being always more violent in the evening, and a strong odour of petroleum was associated with it. The boring had penetrated the Emscher grey marl, at a depth of 2,617 feet. The outburst at the Ascheberg 6 boring was remarkable for its intermittent character, and for the considerable quantities of brine which were shot out with the gases. The pauses were regularly of one hour's duration, and each
outburst seemed to be equally violent with the preceding, although as a matter of fact the volume of issuing gas and brine diminished continuously after each interval. At the beginning of the phenomenon, the boring had reached the depth of 2,989 feet in the pale-grey Turonian marl (? Cuvieri-chalk). After the resumption of boring operations, a single outburst of some violence (of gas unaccompanied by water) took place when the depth of 3,120 feet had been reached: the Coal-measures were struck 528 feet lower down.

In both the Westphalian cases described, there is great uncertainty as to the composition of the gases issuing from the boreholes; but the author thinks that, in some outbursts, one might expect to find, instead of methane, higher members of the marsh-gas series (corresponding to the general formula C_nH_{2n + 2}) or a mixture of various gaseous hydrocarbons, in other words, petroleum-gases. It is noteworthy, in this connexion, that asphalt and petroleum are well known to occur in the Cretaceous basin of Munster, and, less commonly, in the Westphalian Coal-measures themselves.

L. L. B.


The writer describes the most important outburst of carbon dioxide which has occurred in the Gard Coal-field. This took place on July 6th, 1907, at the Nord d’Alaisy Mines, which work a group of seams in which numerous and sometimes very violent outbursts of carbon dioxide have occurred in the Rochebelle concession. The mine was being developed; the sinking, finished

in 1904 at a depth of 650 feet (200 metres) had passed through seven seams of coal varying from 16 to 48 inches (0.40 to 1.20 metres in thickness), and at 630 feet (192 metres) struck the seam called Seam 1 about 16 ½ feet (5 metres) thick. No sudden outburst of carbon dioxide was encountered in the sinking but there was a continuous discharge from the seams struck, and in the winning places in Seam 1, which led to the service of mines imposing regulations against sudden outbursts such as are in force at the Rochebelle Mines.

Fifty sudden outbursts occurred up to the end of 1905, all, except that of July 6th, 1907, without personal injury. The first, that of June 7th, 1905 occurred on shot-firing, and projected 280 tons; the whole mine was filled with carbon dioxide, which also came up both shafts and spread over the surface in a thin layer. Two other outbursts each displaced 500 tons.

In 1906, the shaft was sunk deeper, and on October 25th of that year, at a depth of 836 feet a violent outburst occurred after the firing of a volley of shots. This outburst came from a seam of coal about 5 feet (1 ½ metres) thick, underlying the bed of sandstone in which the shots had been fired. At a depth of about 1,050 feet (322 metres) a seam of coal was reached. Six shots were fired in this seam without causing a sudden outburst of gas: but at about 40 inches (1 metre) further down another round of shots was fired in the coal at 4 a.m. on July 6th, which caused a sudden outburst of carbon dioxide. The foreman, who fired the shots by electricity from the surface, felt a violent blast and heard an intense noise, and an enormous cloud of black dust came out of the shaft, rising to a height of about 120 feet (36 metres). Dust and carbon dioxide also came out of the second shaft through the ventilator, and continued for 1 ½ hours. A bed of dust about 40 inches thick was deposited on the roof of the winding-engine house, and at the shaft-top the dust was about 10 feet (3 metres) thick, and the ground around was black with coal over about 50 or 60 acres. Three workmen were unable to escape from the vicinity of the shaft-top and were killed: one was found buried in dust in the open, and the other two were asphyxiated in the engine-house.
People in houses near the pit were partially asphyxiated, and fowls, birds, and dogs were killed. An area of about 650 by 500 feet (200 by 150 metres) remained inaccessible for 2 hours, and the gas was observable over an area of over 3,200 by 1,600 feet (1,600 by 500 metres). Over 500 tons of coal-dust was collected on the surface, and it was estimated that other 500 tons were spread over the country. The sinking pit was connected with the workings of the mine by two insets at depths of 500 and 680 feet (150 and 208 metres) respectively. The inset at 208 metres was completely blocked with the coal blown up, which penetrated into the workings for 460 feet (140 metres) and 1,774 tons of it was collected in the different galleries. In the shaft, many pipes were twisted and broken, and the shaft itself was filled up for over 160 feet (49 metres). The total amount of projected coal collected exceeded 4,000 tons.

When the shaft was cleared to the point where the outburst occurred, disintegrated (foisonne) coal was found over the whole section of the shaft. After sinking for a metre in the coal, hard coal was found on one side; and for the remainder of the sinking through the coal hard coal was encountered on one side and disintegrated coal on the other. The separation between the two presented a very irregular surface, the section of the shaft being sometimes almost entirely occupied by hard coal and sometimes almost entirely by disintegrated coal. The seam of coal thus traversed by the shaft had a total thickness of about 60 feet (18 metres), the roof and floor having slight inclination. Analyses of the coal gave volatile matter varying from 6.5 to 9.5 per cent.

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The great thickness of the seam was a surprise, and it is assumed to be the 10-metre seam of the Fontanes Pit of the Rochebelle Mines, but considerably thickened. The shaft was only sunk about 16 feet (5 metres) below the seam when a fault was encountered; and it was on the side next this fault that the disintegrated coal was found in the shaft. A gallery was driven at the roof of the seam to find the empty spaces which should have been there; but only small spaces were found, which were filled up with boiler-ashes mixed with water under pressure. Only 2,825 cubic feet (80 cubic metres) of ashes could be forced in.

The exceptional importance of this sudden outburst may be attributed to two causes—(1) the great thickness of the seam, and (2) the large area of the opening by which it was reached, the area of the shaft bottom being more than 97 square feet (9 square metres).

W. N. A.


This paper is mainly a discussion of that part of the Report of the Royal Commission on Mines that deals with the formation of coal-dust in mines, and the measures to be adopted to limit its formation and reduce to a minimum the dangers arising from its presence.

The dissemination of dust in roadways by haulage, screening, and holing is discussed. Under haulage, the following preventive measures are advocated:—(1) The use of dust-tight tubs, special mention being made of those used at the Whitwood and Talk o’ th’ Hill collieries and those at Messrs. Andrew Knowles & Sons’ Collieries. (2) Overloading the tubs is a frequent source of dust, and can be overcome by using covered tubs, of which those manufactured by the Youngstown Car Manufacturing Company (Ohio, U.S.A.) are examples. (3) To construct the roadways so as to reduce to a minimum the effect of vibration and shocks which lead to the dissemination of dust and the deterioration of the coal. It is maintained that it is better to prepare the roadway carefully and choose the materials used than to provide the tubs with buffers, which is impracticable (long rails and metallic sleepers are advocated). (4) Sprinkling the tubs should be copious to be efficacious. In the case of
experiments by H. Bramall, tubs containing 4 cwts. were sprinkled with 5 gallons (22 litres) of water, when it only permeated to a thickness of half an inch, and would have required 11 gallons (50 litres) to saturate the load. Certain inconveniences arise from copious sprinkling which make the coal unsaleable, and render it liable to spontaneous combustion when stored. (5) The effect of the ventilating current and of haulage can be met. By increasing the area of the roadway the velocity of the air-current is decreased without diminishing the quantity of air, whilst horse haulage has advantages.

Screening.—The erection at new collieries of screens at a distance from the mouth of the downcast shaft, sufficient to prevent the dust from being carried down the pit by the ventilating current, is insisted on. In the case of pits with the screens in proximity to the pit-mouth, various plants for the removal of the dust by fans and by washing are advocated, not only on behalf of safety but also from hygienic consideration.

Holing.—To avoid making coal-dust during holing, the operation should be done, as far as possible, in the dirt, and not in the coal.

Ignition of Dust.—It is pointed out that the use of explosives is the most frequent cause of the ignition of coal-dust. As so much depends on the individual entrusted with the care and use of explosives, the author considers it of extreme importance that, only officials who have passed an examination of competency in the use and properties of explosives, and who can present a satisfactory certificate of character, should be eligible for the position of shot-firer. Receipt should be given for every cartridge and detonator taken into the pit, and an account rendered of every cartridge that is used.

The precautionary measures to be adopted in shot-firing are—(1) careful examination for fire-damp, not only in the neighbourhood of the shot but in the surrounding roadways. (2) Watering of the roadways for a distance of 20 yards on each side of the shot-hole, the water to be delivered under pressure and the quantity restricted as much as possible. (3) The position and direction of the shot-hole should be such that the dust in the neighbourhood is not likely to be raised. (4) The proper regulation of the charge, which should not fill more than half the length of the bore-hole, to avoid the chances of a blown-out shot. (5) Great care should be taken in stemming the shot with incombustible material. In specially fiery mines, the firing of single-hots only is strongly advocated. In respect of these precautions, the Belgian regulations are cited.

The author questions whether the system of testing explosives for use in fiery mines is sufficiently rigorous. He advocates the use of permitted explosives only in all mines, fiery or otherwise, and insists on the importance of instructing all miners in the dangers inherent to the use of explosives in presence of dust and fire-damp.

Propagation of Explosions.—Success in preventing the propagation of explosion by coal-dust can only be achieved by its suppression, and not by counteracting its influence.

Watering.—At the best, the efficacy of incombustible dusts and hygroscopic substances is only contingent and their action temporary. Coal-dust should be treated in the same way as fire-damp. The methodical removal of the dust from the roadway as completely as possible will decrease the danger, even though it may not be the most perfect method to adopt. When the coal-dust is removed, the scattering of incombustible dust or watering will increase the safety.

Atmosphere.—It is pointed out that the hygrometric state of the atmosphere has an important bearing on the possibilities of the occurrence of coal-dust explosions. During the last 30 years, the number of explosions occurring between November and March is about 2½ times as great as during a similar period from May; in addition, the explosions which have taken place during the latter period have, with 2 exceptions, occurred when the atmospheric
temperature was below (58° Fahr. (20° Cent.). When the air going down the shaft is at a lower temperature than that in the mine, its temperature is raised, and thereby its humidity decreased, enabling it to take up moisture from the roadways and so to dry the dust. To prevent this, it is necessary to raise the temperature or the hygrometric state of the air. In the author's opinion, the best place is to increase the humidity of the air by spraying it underground with very fine water-sprays, delivered either from movable reservoirs or from jets connected to pipes which traverse the roadways. The use of straw for the purpose cannot be recommended on account of the loss due to condensation, especially if the roadways are extensive. In any case, it is desirable that the amount of water that is used should be restricted to the minimum quantity that is effective, so as to avoid its injurious effects.

L. T. O' S.


On Monday, August 10th, 1908, at 10.45 p.m., an explosion of fire-damp took place in the western district of the Government colliery of Dudweiler, near Saarbrucken, which was in so far unique that it did not occur at the working face, but in a gallery that had been driven 16 years ago which served as a haulage-way and also in part as an airway. The men of the noonday shift were on their way to the shaft in order to get to bank, and no less than thirteen of them were killed on the spot, while four others were seriously injured (two of them ultimately succumbed) and nine suffered more or less slight injury. The loss of life was in part due to asphyxia consequent on the breathing of poisonous gases and in part due to fracture of the skull: the victims were, moreover, seriously injured about the arms and legs, and slightly scorched about the face and head. The two seriously injured men who survived were badly burnt.

At the Dudweiler colliery the seams which are worked belong to the bituminous coal division of the Saarbrucken Coal-measures. There are a great many faults, which enhance the difficulties of working and affect unfavourably the cohesion of the strata. Wolf benzine lamps are used, with an inner gauze of iron and an outer gauze of bronze wire, the air being admitted thereto from above. For every metric ton of output of coal, 235 ¼ cubic feet of methane are evolved, while 256 cubic feet of fresh air are driven through the workings. The foul air that issues from the upcast shaft contains 0.1 per cent. of methane and 0.29 per cent. of carbon dioxide. Seam 10a is well known in the pit as fiery, and in the month of July fire-damp had been noted five times therein, but in the first ten days of August only once. On the day of the disaster, none was noticed, either before or after the explosion, in the workings of that seam. Beads of coke were not found anywhere, and the timbering was not in the least disturbed. In most cases the lamps used by the victims were shattered, and the gauzes had been evidently subjected to moderate red heat. The detonation of the explosion was not observable at the ventilating fan of the upcast shaft: the barometer was at the time going down gradually and continuously.

As the men of the afternoon shift were making their way quickly out of the pit, some of the lamps which they held were extinguished, and those who came hindmost noted that their lamps were "not burning right"—thereupon came a great rush of air, followed by the explosion.

It would seem probable that the fissured strata had got into a state of slight motion (due to the active extension of mining operations), sufficient, however, to expand the fissures and favour the inflow of pit-gas into the workings from Seam 10a especially. The first men of the outgoing shift, as they passed along quickly, holding their lamps low down in the usual fashion, did not touch the stratum of fire-damp; but this soon descended, as brattice after
brattice was flung open, and caused an inrush of the ambient atmosphere to mix with the fire-damp. The lamps of the later comers were extinguished, yet they observed no trace of the presence of dangerous gases; but the hindmost were soon made aware of an unusual condition of the atmosphere. Exactly how the dangerous gases were ignited has not been ascertained, but it is surmised that one of the outgoing pitmen, startled at the sudden evidence of the presence of fire-damp by the incandescence of the gauze of his Safety-lamp, more or less subconsciously swung the lamp about with sufficient violence to initiate the explosion.

L. L. B.

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Lines of reddened and altered sandstone and shale mark out more or less continuously for many miles the position of the main coal-bearing horizon in certain regions of Western and South-Western Colorado. It is claimed by the author that this reddening and alteration is due to the effect produced by the spontaneous combustion of the coal. In some cases, this combustion actually continues at the present day, emanations of steam, smoke, and gases issuing from the rocks along the great ridge between Newcastle (Colorado) and Meeker, as also in the Mancos district near Farmington. The escape of gas is said to be influenced by a rise or fall in the barometer.

The effects of this spontaneous combustion are most pronounced when the coal-seams are thick, or there are many seams along a particular zone; also, in the lignitic or lignitic bituminous coal-areas rather than in the coking-coal areas, and in coal-seams that show a broken, rather than in those that show a compact, face. These phenomena have not, apparently, been observed in the bituminous and anthracitic coal-fields of the eastern States of the Union. In Colorado, the immediate effect on the coal itself is to destroy, at least near the surface, much of its industrial value, by reducing it to ashes, or by locally changing it to a worthless coke, or equally worthless anthracite. Sometimes these injurious effects extend fairly deep down. The hardening and the discoloration of the adjacent strata are described, and it is pointed out that even the oldest phenomena of this combustion are of comparatively recent date, having taken place since the present physiographic relief of the country was established.

The oxidation of the pyrite contained in some of the Colorado coals is inadequate to produce the effects observed, and the real cause of the spontaneous ignition of the scams must be sought in the absorption of atmospheric oxygen, with its consequent "occlusion and compression in the microspores of the coal." The necessary rise of temperature, in order to start ignition, may have been, and may still be, due to the fierce insolation, of those latitudes in summer, and possibly also to forest- or bush-fires.

L. L. B.


The ores, generally rich, are chiefly—before preparation—calamine with 9 to 20 per cent. and blende with 14 per cent. of zinc, and galena with 4 to 14 per cent. of lead; after preparation—calamine with 28 to 34 per cent., blende with 45 to 50 per cent., and smithsonite with 28 per cent. of zinc; galena with 60 to 70 per cent. and cerusite with 55 per cent. of lead.

The four factors—nature of ore, out-turn, content, and loss—permit of appreciating the work of a washery. In Sardinia the out-turn and content are good: but the loss is considerable, varying from 30 to 40, and even 50 per cent., which is unavoidable owing to
the nature of the ore to be dealt with. The preparation consists in picking, crushing, classing and separating.

Picking.—There are two picking operations—one impoverishing the sample by abstracting saleable ore, and the other enriching it by taking out the sterile. It is advisable that these be carried on simultaneously. When the density of the sterile approaches very closely to that of one of the elements to be recovered, its immediate elimination is important, because it renders washing very difficult. Instead of the costly hand-screening, it is better to employ mechanical screens, fed with well-classified products, that can deliver saleable ore and take out the rubbish without too great expense. The best table for hand-picking is the endless band; but when great care is required nothing approaches the fixed bench.

Crushing.—This operation should be performed with the making of as little fine as possible. Three types of crusher are used: (1) those with jaws for ¾ to 1 1/5 inches (20 to 30 millimetres), (2) rollers for 1/8 inch (3 or 4 millimetres), and (3) cannon-ball crushers for below that gauge.

Classification.—At many plants trommels have been superseded by raiters — elongated tables of perforated plate, carried on wooden springs, and having a motion resembling a gallop. The two appliances give equal results; but the raiter is more easily supervised, requires less water, height, and ground-space: it costs less and is not so expensive as regards keep, while also serving as a conveyor. Spitzkasten have also been, nearly everywhere, superseded by the pressure-pipe. Provided with the idrovaglia, or water-separator, the pipe is easily regulated in accordance with requirements.

The screens are generally about 2 ¼ feet (65 to 70 centimetres) long by 1 ¼ feet (35 to 40 centimetres) wide. Their action is regulated by varying the piston-stroke or the speed. The tendency is to increase the speed and reduce the stroke, which increases the production, and thus compensates for the reduced size of the screens. It is indispensable that the screens for a second operation should be distinct from those that receive the ore for the first preparation, because a better separation is effected than when the poor mixed classes are passed over the screens that have produced them. This also applies to tables, the work of which depends essentially on a good classification.

J. W. P.


The author was officially entrusted by the Royal Hungarian Geological Institute with the chemical investigation of the peats of that kingdom. He notes that, with the exception of one or two great undertakings, the peat-deposits of Hungary are still unworked—perhaps, in some degree, owing to ignorance of the industrial value of the material for heating purposes, and also to unwillingness to incur the preliminary expenditure involved in what would, after all, need to be but a very brief study of any given deposit.

He describes the method followed by him in the analysis of the peats, emphasizing the necessity of determining exactly the proportion of organic constituents (compounds of carbon, hydrogen, oxygen, nitrogen, and sulphur) as distinguished from the ash, which includes soluble and insoluble silicates, alumina, potash, magnesia, soda, lime, oxides of iron, carbon dioxide, and sulphates.

The author tabulates the results of experiments carried out with eighty-seven samples of peat, and notes the great differences between calculated values for the calorific power and the values obtained by experiment, the differences ranging between -28.24 per
cent. and +28.22 per cent. He thinks that these differences are easily explicable in the case of peats of varying chemical composition, though rather disquieting in the case of those which are not alone alike in chemical composition but also in structure. He rejects, therefore, the calculated values. The experimentally recorded heating power of these peats ranges from a minimum of 1,270 calories (Baldocz peat) to a maximum of 4,278 calories (Kemeneshogyesz peat); next to the latter may be placed the Szent-Janos (St. John) peat, two samples of which showed respectively a heating power of 4,232 and 4,050 calories.

The Csorna and Keszthely peats yielded respectively 4,131 and 4,009 calories; and three samples from Taska 4,166, 4,150, and 4,000 calories respectively. Batizfal pu peat yielded 4,141 calories, and a peal from Csorba-Moitelep 4,191 calorics. All others yielded less than 4,000 calories. The amount of ash varied from a minimum of 1.64 (sic) per cent. to a maximum of 66.55, and the specific gravity ranged from 0.152 to 0.733.


In 1906, the depth of shaft No. II. of the Rosenblumendelle Collier was increased to 1,740 feet (530 metres), and a pumping plant consisting of electrically-driven high-pressure centrifugal pumps was installed. The pump-chamber was about 66 feet from Shaft No. II and was well protected against the pressure of the surrounding strata by reinforced concrete cushioned against the roof and sides, with ash-concrete and other yielding material. This chamber was provided with spaces below the floor for the pipes, wire-leads, etc. The roof was made tight by means of an iron-sheathed covering of asphaltelt. The plant consists of three separate pumps, A, B and C, each standing on a separate seating-block. A pumps independently from level No. V. and from the one next above it, No. IV. By a special arrangement of connexion-pipes and valves, B and C can pump water separately or together from level No. V. to level No. IV.

Pump C alone raises the water from level No. IV. to bank, while B and C connected together do the same for that of level No. V. A delivers 660, B 1,320, C 1,540, and B and C together 1,430 gallons of water per minute.

There are three rising mains—one from pump A leading from level V. to level IV.; a second from pump C, which passes from level V. to the pit-bank: and a third which passes from level V. to level IV., and, according to the adjustment of the valves, serves as delivery-pipe to pump B or as suction-pipe to pump C.

The pumps are driven by a direct-coupled three-phase motor with sliding contact and short-circuit arrangement. The motor for pump A is supplied with current of 2,000 volts from the colliery power-station, and those of pumps B and C each with current from a private company.

The pump-chamber can be closed by a water-tight door. The floor of the pump-chamber is raised about 20 inches above the ground at the bottom of the shaft, so that, in case all the pumps be put out of action, the watertight door need not be closed until the water in the passages has risen to this level.

From the pump-chamber a pipe-shaft is driven to about a height of 48 feet from the pump-room floor, and connected at its highest point with the main shaft by a transverse passage about 102 feet long. These passages are lined with gravel-concrete, and serve to take the wire leads and as an upcast for the air. An 8-ton travelling crane is installed in the
pump-room. The pipes, connexion, and valves are all in the cellar, and are regulated from the pump-chamber.

Between pumps A and B a shaft of square section leads down to a well, which is connected with the sump by a transverse pipe, 24 inches (600 millimetres) in diameter.

In the main-hall all the pipes are supported at distances of about 328 feet (100 metres) by cast-steel bearing-pieces, the lower parts of which are arranged in the form of stuffing-boxes to allow for play in case of a settling of the shaft. Pipe-guides are arranged at distances of about 110 feet (33 1/3 metres) apart.

The wire cables are wound with steel wire, and are impregnated with a special substance to protect them from the pit air. They lead first to the cellar, and are then carried up to the pump-chamber. The switch-board in the pump-chamber is divided into eight panels, five for the 5,000-volt and three for the 2,000-volt switches. The chamber is in telephonic communication with the switchman at bank, with the supply-station, and with the engineer's cabin. A special arrangement is provided for drying the motor-winding of the electro-motors. The plant is arranged so that extensions can be made at any time.

The total cost of the plant, including mining work, concreting of the pump-chamber and pipe and cable-lead passages, and the switch arrangement at bank amounted to about £11,500.

A. R. L.


The object of air-tight stopping is either to prevent a current of fresh air from getting into the fire area, or to prevent an escape of fumes and gases from the fire area into the workings of the mine. In the Broken Hill Proprietary mine both brick and bag stoppings were used during the last fire; and the following were the chief points that determined the use of one in preference to the other. If the required stopping were to be more or less permanent, and if the area to be blocked were large, bricks were used, being so much lighter and easier to handle than bags filled with skimps. If, however, the air contained much gas, a back stopping was put up. Great difficulty was experienced in getting surface-men, such as bricklayers, to work where there was the slightest trace of gas; miners, however, would willingly do the work, and a bag stopping could be built without skilled labour. In old drives and gangway, where there was the liability of settlement, the bag stoppings were preferable to brick. The slightest movement around the sides or foundations of the latter would cause cracks, thus rendering the brick stopping useless; whereas, in the former, there was a certain amount of elasticity. The brick stoppings consisted of walls plastered air-tight on all sides, containing some small provision, such as a gas-pipe, for taking samples of the confined air behind the stoppings. If the air were good, the difficulty to be overcome was small, whether the stopping were of brick or bag; but when the air was bad the main difficulty arose. For a bag stopping, about twenty men were required; the preparing of the bags and the mixing of the pug was done in the fresh air, and the materials had all to be conveyed to the face. The bag stopping was very easily and quickly built, and in small areas gave great satisfaction. The floor was cleared of all loose stuff, and the stopping laid on a solid bottom. Bags of 60 pounds capacity were filled with skimps, sewn up tight, carried to the face, and placed as close together as possible in layers, reaching from side to side of the drive, the thickness of the stopping depending upon the height required. In drives of 8 or 10 feet high, a layer of four bags wide sufficed. The two outside rows were laid with their longer axis in the direction of the drive, and the two inside rows at right-angles to it. The cracks and inequalities
between the bags were tilled with pug, and the top of each layer levelled off smooth with either gypsum or wet skimps. Another layer was then placed, the only difference between this layer and the first being that the lay of the bags was reversed. This was continued around and above the 10-inch pipe employed for conveying the gas from the temporary stopping and right up to the back. The top of the stopping was the most difficult to build, and for this purpose partly-filled bags were used, then empty bags and bits of bags, until all crevices had been packed and rammed tight. The face of the stopping was then damped and plastered with pug, the plaster kneaded and poked into the cracks and crevices, the joints of the bags all plastered up the plaster worked all over the face, and the surface then coated with a thin wash. The pug used consisted of powdered gypsum, mixed with water into a semi-liquid state.

A. P. A. S.


The author condemns the present methods of teaching mining surveying, as noted in the text-books, as nothing can be more unscientific or less businesslike than unwarranted assumptions of accuracy, say, to the thousandth part of a pound, in a case where there is probably an unavoidable error of 2,000 pounds. He also criticizes the teacher who, for example, attempts to show how to measure the depth of shafts to the hundredth part of an inch, by means of short brass rods screwed together, correcting for temperature, and thinks such precision absolutely necessary.

Geological surveying he considers as a most important part of the mine surveyor's work. Although mining geology, so-called, is taught in schools of mines and universities, the teachers are, almost invariably, devoid of experience underground, and regard mining geology as a minor branch of general geology, a branch that any geologist is capable of taking up offhand. On the surface there is usually only a limited amount of information available, as the formations are often largely hidden; the result is nearly always a small-scale map, accompanied by diagrammatic sections. The information thus obtained is often very valuable indeed, but it is rarely precise enough from the point of view of the metal miner. Underground conditions are almost exactly the opposite, for there is then a wealth of information in a small area, which can be mapped with a precision quite astonishing. The observance of geological facts underground does not, in most cases, call for any very great amount of skill. What is necessary is to be able to distinguish between the various rocks occurring, usually less than half a dozen, and to measure the dip and strike of slides and fault-planes with a fair amount of accuracy. The person most competent to do so is almost always the mine-surveyor or one of his assistants. He plots his results on tracings made from his own maps, so that his department is self-contained. While taking geology he measures the progress in development work, and his observations in the stopes can be largely combined with, those necessary to keep account of the ore-reserves. The author considers the function of a government is to make not the detailed examination of each mine, but the general examination of the whole field; to provide the foundation on which all may build; to identify and classify the rocks; to distinguish between the different geological horizons; and to figure the fossils by means of which they may be identified.

The author deals with the instruments employed in ordinary under-ground
surveying, the most important of which is the tape, as over three-quarters of the errors in ordinary underground traverse are in the taping. He advocates the use of the foot as a simple and familiar unit, one steel tape 150 feet long, for the rodman, and one of 50 feet for the instrument man, each tape to be graduated in tenths and hundredths. He prefers a reel instead of a leather case for the tape, and considers a further improvement is the removal of the zero-mark to about 6 inches from the end. The author also deals with the use of the theodolite and the levelling-rod, and the methods adopted in taking the surveys. He states that the majority of mistakes underground are due to faulty office-work, the field-work being much more trustworthy. In consequence of this, it is now considered good practice, not only that all calculations should be checked, but that they should be checked by an independent person, usually the rodman. The writer is convinced by bitter experience that the only safe way is to work with logarithms and make the checker use traverse tables; mistakes are then practically unknown. It is also a great help if both calculator and checker initial their work, as all mistakes are thus sheeted home.

Although it is most important in surveying to have some idea of the accuracy of the results, where there is a large inherent uncertainty, he condemns any attempt at refinements in either observation or computation. If one is merely concerned with drawing a map and occasionally driving to meet a winze or another drive, accuracy in minutes of angle and hundredths of feet merits nothing but condemnation. The mine surveyor is confronted with much more serious problems, such as setting the timbers for new shafts, which, instead of being sunk, are being raised from a number of levels simultaneously, or establishing side-lines underground, and so on. A.P.A.S.


Several serious accidents having occurred, owing to the platman leaving the plat without first withdrawing the "chairs" from the shaft, the author was led to devise a mechanically-operated system which would obviate such accidents, and be "fool-proof." After several experiments, a comparatively simple and efficient electrical system was devised, which consists of a miniature coloured glow-lamp, one for each level of each shaft-compartment, arranged and placed beside the numbers and arrows corresponding to the various levels on the winding-engine indicators. A large indicating glow-lamp is also installed at each compartment in the various levels, in proximity to the levers for operating the chairs. Upon operating the various levers, an electrical current is completed which instantly indicates at the winding-engine, by the glowing or extinction of the corresponding miniature lamp, the position of the various chairs. At the same time, the large glow-lamp on the plat also indicates in unison with the small lamp on the engine indicator, giving ocular indication of the position of the chairs to the man operating them, and being a visual reminder not to leave the plat without withdrawing the chairs. A further casual advantage is afforded by the increased illumination at the plat from the glowing-lamp, when the chairs are "in", for loading or unloading the cages. The current for operating these lamps may be taken from any convenient lighting circuit from 50 to 120 volts; and the estimated cost of installing the apparatus in a double-compartment shaft of six levels is approximately £75. A. P. A S.

The winding plant that the company have put down at Eygelshoven in Dutch Limburg, practically solves the problem of electrically driving the very various motors required at a colliery.

The generating station comprises a 56-pole 400-kilowatt alternator, driven by a compound engine running at 107 revolutions per minute; two 2-pole 500-kilowatt Riedler-Stumps turbo-alternators, and a 1,000-kilowatt Curtiss turbo-alternator with its own exciter. For exciting the three other alternators, and for lighting, a dynamo driven by a 100-horsepower high-speed engine, with pressure divider, gives 115- and 230-volt current respectively and a transformer set, comprising a three-phase motor driving two dynamos affords continuous current of the same pressures. There are eight boilers heating a superheater which raises the temperature of the steam to above 570° Fahr. (300° Cent.); and a central condensation-plant maintains a mean vacuum of 90 per cent.

The switch-board comprises sixteen panels—one panel for each of the four alternators, for the distribution of the alternating current, and four are reserved for the continuous current. A constant pressure is maintained at the terminals of the generating dynamos by Tyrrell regulators: one serves the 1,000-kilowatt alternator, and a second the three others. The four dynamos are easily coupled in parallel, notwithstanding the 3,000 revolutions per minute of the turbines and the 107 of the engine. A Capell fan is belt-driven at 250 revolutions by an electric motor, and is capable of delivering 105,949 cubic feet with a water-gauge of 2 ¼ inches.

The three-phase current from the generating station actuates the motor of a transformer set, comprising a three-phase motor, a continuous-current generator, and a flywheel. The motor drives the generator which supplies the winder motors; and the flywheel stores up the energy of the three-phase motor during the intervals between lifts, restoring it when winding begins again. In consequence, the three-phase motor takes from the station a current almost constant. The Koepe winder, with friction-drum for the rope and balance-rope, is calculated for a maximum depth of 1,312 feet, a useful load of 2.36 tons in four tubs, and a maximum speed of 39 feet per second. At this speed, it can put out 100 tons per hour.

The mechanical portion of the winder consists of the Koepe drum and its shaft, on which are keyed the rotors of the two motors, the brakes, and the depth-indicator gear. The cages are connected by a single rope that makes 5 ½ revolutions round the drum. The drum-shaft revolves in two plunger-blocks which, as also the two stators of the motors and the brake gear, are carried by a riveted plate-iron frame, so that perfect centering of rotors and stators is ensured. The drum consists of two cast-steel discs connected by a wrapping-plate, cleaded with wood, in which is the spiral groove that receives the rope. The four blocks of the brake are pressed on the pulley by spiral springs, but taken off by a vertical rack, which is raised by spur-wheels actuated by two electro-motors. The emergency brake consists of two levers with blocks, that are pressed by a counterweight against a second pulley until taken off by hydraulic pressure. The drum-shaft transmits motion to the index of the depth indicator, within the graduated circle of

which are mounted an ammeter, a voltameter, and a speed-indicator. The gear that transmits motion to the index showing on the dial the position of the cages in the shaft also acts on the starting-lever of the winding motors; and towards the end of a lift this lever is brought automatically to "stop" by two horns attached to the depth-indicator spindle, while at the beginning of a lift the same lever can only be pushed towards "full speed" if the prescribed acceleration be not exceeded.

The electric equipment of the winder comprises its two motors, the rotary set for transforming three-phase into continuous current, the exciting dynamo and the appliances
necessary for the brake, for driving, security, and measurement. Each of the winder motors, designed for a pressure of 520 volts, gives out 225 horsepower normally, or 420 horsepower maximum while making 76.4 revolutions per minute. The transformer set, which consists of the motor, is in direct connexion with the three-phase circuit, makes 500 revolutions per minute, and gives out 300 horsepower. The continuous-current dynamo that furnishes from 360 to 700 kilowatts to the winder motors, and the flywheel, weighing nearly 12 tons, and having normally a circumferential speed of 328 feet per second, has the double object of—

(1) transforming the three-phase into continuous current, better suited for regulating the speed of the winder motors; and (2) permitting the almost complete regulation of the inevitable variations of load in winding, by excess of energy being stored up in the flywheel.

Starting, speed-regulating, and stopping are effected simply by varying the excitation of the flywheel-set dynamo, and reversing by changing the direction of the excitation current, operated by a single lever, that also puts on and takes off the brake. There are within the engineman's reach two other levers, one of which puts on the emergency brake, while the other actuates the safety interrupter at the switch-board.

Besides the depth-indicator, there are the following safety and measuring appliances:—an automatic, interrupter of the winder-circuit, if a determined intensity should be exceeded; a speed-indicator within sight of the engine-man, and a centrifugal-force interrupter. The winder switch-board comprises—a panel for the 2,200-volt three-phase current supplying the transformer-set motor; another for the 1,040-volt continuous current of the winder motors, and a third for the 520-volt continuous current of the exciting dynamo. The winder is connected with the generating station by two cables, one in reserve.

The underground installation is connected with the station by four strong cables, three down one shaft, and one down another, to provide for accident. Insulation is ensured by several windings of gutta-percha overlaid with pitch, lead-coated and armoured with galvanized iron wire. The four cables terminate, at the 183-metre stage, in four small panels, the bars of which are so interconnected that any one cable can supply any one of five centrifugal pumps, which make 1,450 revolutions per minute. Potable water, capted from a disturbance at the 153-metre stage, is raised to the surface, at the rate of 165 gallons per minute, by a centrifugal pump driven at 2,020 revolutions by a 52-horsepower electromotor. Three other electric motors in different parts of the mine drive, respectively, a secondary fan for ventilating an exploring drift, a transportable air-compressor for supplying pneumatic hammers, and a haulage engine. When current has to be led through places subject to falls, it is transformed from a pressure of 2,200 to that of 250 volts.

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It is claimed that the Eygelshoven installation ranks among the most complete, while not being the least important. The generators at the central station furnish together 3,250 horsepower of three-phase current utilized by twenty-two motors, varying from 3 to 500 horsepower, for the most diverse purposes. J.W.F.


The proving of seams thrown down by a fault in the Pont-du-Loup Concession of the Carabinier Collieres greatly modified the conditions of working: and it became necessary to increase the pumping plant. As electric driving was considered the most advantageous, it was decided to apply that power, not only to pumping but to the various accessory services. Besides the winding engine, there were screening and washing plants, a fan, an underground pump, spoil-tipping arrangement, wire-tramway, etc., driven most uneconomically.
The 600-kilowatt-ampere plant comprises a 3,000-volt triphase alternator with 100-kilowatt exciter, a 100-kilowatt continuous-current generating dynamo in reserve, a motor of 125 horsepower for the fan, a motor of 260 horsepower coupled with a centrifugal pump, and a motor of 75 horsepower for the screen, tip-haulage, etc., the generators being driven by a compound condensing engine, supplied with steam at 142 pounds per square inch (10 kilogrammes per square centimetre) having no other flywheel than the rotor of the alternator.

At the 935-foot level (285 metres) a 9-wheel Rateau centrifugal pump, driven directly at 1,450 revolutions by its squirrel-cage motor, with self-transformer starting arrangement, raises to the surface the water of its own stage and also of those intervening, being capable of lifting 33,000 gallons (150 kilolitres) per hour to the height of 984 feet (300 metres). An elastic coupling neutralizes the effect of any difference in level between motor and pump that may easily occur through heating of the former.

The pumping plant is accompanied by a loud telephone, which is almost indispensable and fully repays its cost. On starting, the motor absorbs about 1.25 the normal current, or 55 amperes; and the alternator is far from being unaffected by this suddenly increased demand because (1) it undergoes its own fall of pressure, (2) the steam-engine slackens speed, and (3) the exciter also slackens—that is to say, three factors vary in the same direction, so that the pressure falls, and also the exciting current. In addition, the consequent diminution of frequency lowers the speed of the pump, so that it might fail in lifting to the surface if the slackening were not noticed in time.

The telephone arrangement comprises an armoured cable, the leads of which connect the several stages with the generating station, while switches permit of telephoning from one stage to another. At each start—and also at each stoppage, when the phenomena occur in inverse order—the man at the pit-bottom announces the start to the engine-man of the generating station, who takes hold of his starting lever, while the electrician seizes the hand-wheel of the field rheostat and observes the voltmeter, when the man at the bottom signals and starts. The speed is maintained at 125 revolutions, and the pressure at 3,100 volts, while less than 30 seconds elapse between the closing of the interrupter and delivery by the pump.

J.W.P.

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For the transport of goods or material for short distances, electric hanging-railways have latterly been much in use. Iron wagons, hung in frames arranged for tipping and driven by electro-motors, are attached to trolleys, which run on the top of an ordinary rail, or on the lower flanges of an I-shaped rail with two pairs of wheels. The current for the motor of the trolley is taken off a special wire which runs above the trolley and returns through the rail, continuous current of from 110 to 220 volts being for the most part in use. The power required on horizontal stretches is 0.06 kilowatt per ton-kilometre.

The simplicity and ease with which the current can be supplied makes the system readily adaptable to all kinds of local conditions. Gradients of 1 in 20 can be dealt with by one motor, whilst gradients between 1 in 20 and 1 in 7 require two motors. For gradients from 1 in 7 to 1 in 2 rack-rails must be used. Electrical appliances for raising and lowering the wagons can be added. The raising and lowering generally takes place at one point of the system, but where there are several loading-places a portable controlling apparatus is used. This system of electric transport can be combined with rope-inclines, in which the wagons automatically leave the electric section of the way and attach themselves to the rope of the incline, at the farther end of which they again pass on to an electric section.

A block system is described, for preventing collisions of the wagons with each other. In this the current is automatically switched off and on, as the wagons leave and enter
successive blocks. A somewhat similar arrangement can be made at the loading stations. These safety-arrangements prevent any acceleration in the speed of the wagons, which ranges up to about 7 feet (2.5 metres) per second. Loads of as much as 2 tons are already at work. The loading of the wagons can be controlled by means of a weighing apparatus, so that a wagon is loaded with the required weight.

ADMINISTRATION AND STATISTICS.


It is important that colliery accidents of all categories, and not merely those due to fire-damp or coal-dust, be described with sufficient detail and properly classified. Their graphic representation by sectors seems more synthetical and suggestive than by the usual rectangular diagrams, because the former show at a glance a whole series of facts, such as the predominance (together, 80 per cent.) of the three main classes of accident, namely, falls of ground, haulage, and in shafts, each denoted by a special hatching.

During 1908, falls of ground accounted for 43.1 per cent. of the accidents and 43.6 per cent. of the deaths. These falls (not including those in the shaft, which come under the latter's head) are classed under the three sub-heads of stone, coal, and goaf, the first of which constitutes more than three-fourths of the cases. Forward stalls entail a far larger number of accidents than do rising stalls: but nothing can be concluded from this fact, because the former method of working is the more general. As might be expected, falls of coal are more numerous in the getting of upthrown seams, notwithstanding the smaller number of working places.

To haulage are attributed 22 per cent. of the accidents and 12.8 per cent. of the deaths. It may appear surprising that haulage on level roads accounts for more than half of the accidents of this class. Allowing men in charge to ride on the tubs would appear to increase the danger, while risk is reduced by restricting this permission to empties; but it is preferable to forbid all riding on tubs, as is the absolute rule in the Liege district.

Of shaft accidents (which constitute 15 per cent. of the whole number and 18 per cent. of the deaths), rope-breakage only caused an infinitesimal proportion. The number of men injured in entering and leaving cages or kibbles is remarkably large; and the danger of shaft-repairs is shown by the many accidents thus occasioned. In staple pits, most of the casualties are due to falls. Accidents connected with passes, winzes, or bingholes (cheminees) are classed apart, because they constitute a special category.

In 1906 and 1907, no fire-damp or coal-dust accident due to explosives had been recorded; but in 1908 two accidents showed once more the danger of high and not antigrisouteux explosives in the presence of coal-dust with a complete absence of fire-damp. These two accidents accentuate the necessity of exercising great care in the selection of firemen. One accident was caused by an attempt to clear a binghole by dynamite, and the other by the thoughtless firing of the last dynamite cartridge (in order to get rid of it) on the very dusty floor of a working. Seven sudden outbursts of gas were unattended by personal accident; but three others caused seven deaths.

Eleven accidents (4.7 per cent. of the whole number, with 2.2 per cent. of the fatalities) were caused by the use of explosives—in one case on a primed cartridge being forced into the shot-hole by a wooden stemmer; in another on a missed charge being drawn; and in a third on the naked electric leads of the detonator of a missed shot being pulled out.
An accident due to asphyxiation by the incomplete detonation of a heavy dynamite charge is the first of its kind in Belgium—at any rate, since 1893.

The numbers of fatalities per 10,000 employed underground and on the surface together, in 1908, was 10.67 in Belgium, against 10.99 in France (1907), 13.2 in Great Britain, and 27.1 in Prussia.

J. W. P.


Of the 32 accidents described herein, which resulted in the loss of 22 lives and in serious injury to 21 of the survivors, two only occurred in or about collieries. The extension of the use of tubular boilers accounts possibly for the fact that 22 of these accidents arose in such boilers. In 10 cases out of the 32 the disaster was wholly or in part due to defects in installation, in 8 to faulty upkeep, in 13 to carelessness or imprudence in use, and in 5 instances the originating cause was not ascertained. It need hardly be pointed out that the assignment of 36 causes for 32 accidents implies that, in 4 cases, the accident was due to a combination of causes.

On February 13th, 1907, at the Villars mine, in the department of the Loire, a very old horizontal boiler (it is, indeed, described literally as "of unknown age"), forming one of a battery of seven, suddenly burst along the seams of a portion which had been renewed in 1900. The entire rear portion of the boiler, 36 feet in length, was hurled backwards, and, ricocheting in successive leaps, came to rest 76 yards or more away. A stoker was killed and an engineman was badly hurt: the damage to property was considerable. The accident is attributed to general weakening of the boiler, the skin of which along a certain line had been worn so thin as hardly to exceed a fifth of an inch.

Four days later, at the Lievin Mine, in the department of the Pas de Calais, a semitubular horizontal boiler with two "sub-boilers" of soft steel, having been superheated owing to insufficient water-feed, split for 11 inches along the top of a sort of "blister" which had formed on the right flank of one of the sub-boilers, and had consequently dragged out and thinned the "skin" to bursting point. One man was seriously injured by burns. Nothing is said concerning damage to property.

Of the other accidents, 5 occurred in railway-engines, 3 on board steamers 1 at an electric power plant, 2 in connexion with threshing machines, and 19 at various factories, workshops, etc.

L. L. B.


Of the 28 accidents recorded, none occurred in or about a mine, one took place at a steel works, and 4 at electric power-plants. The total number of persons killed amounted to 17, and 11 others were seriously injured. In 19 out of the 28 cases the boilers in use were tubular; in 14 cases the accident was assignable to defective upkeep; in 6 to defective installation; in 8 to misuse; and in 5 to unascertained causes. It will be noted that 33 causes are scheduled for 28 accidents, because in some instances (5) an accident was due to more than one cause.

The actual cause of the boiler-accident at the Isbergues steel-works (Pas de Calais) has not been determined, but it may be observed that the manometer tube was obstructed, the safety-valves were overloaded, and some of the riveting was unsatisfactory.

An accident of small consequence took place with a Belleville boiler at a Paris electric-power plant, and the cause thereof was not ascertained. A fatal explosion which
occurred with a vertical tubular boiler at a St. Denis electric-power house was due to excess of pressure consequent on unskilful handling: the taps communicating with the "thermo-siphon" had been kept closed. (It was shown that this boiler could be isolated from all communication with the atmosphere by closing two taps.) At the Chambost-Allieres electric power-plant, the cause of the fatal accident which took place was not determined; but it remains on record that the boiler-plates were of indifferent quality, and that "blistering" in places, with thinning of the plates to one-fifth of an inch, was afterwards noted. The fourth accident described in connexion with electric power-plants was due to superheat, arising from insufficient water-feed. 

L. L. B.


The total value of minerals raised during 1908 is returned at £7,823,745, as against £7,079,708 for 1907, showing an increase of 10.5 per cent. It will be seen that the heavy output of coal contributed the principal share of the increase; but there was also an increase in the production of gold, petroleum, salt, saltpetre, jade-stone, graphite, and magnesite.

The following table has been compiled from the statistics contained in the Report, and shows the quantities and values of the various minerals produced during 1907 and 1908: —

[Table omitted]

There was a slight increase in the quantity of coal exported in 1908, the total being 657,476 tons, with 2,120 tons of coke, against 652,971 tons of coal and 5,174 tons of coke in 1907. Ceylon, as before, was the principal customer, taking 424,060 tons in 1908. Imports at the same time increased on account of a large influx from Natal and Australia during the first half of 1908. The total quantity of coal, coke, and patent-fuel imported in 1908 was 385,323 tons, as against 301,588 tons in 1907.

The average daily attendance at Indian coal-mines in 1908 was 129,173, as against 112,502 in 1907, and the output per person employed in 1908 was about the same, namely, 98.8 tons of coal. The output per person employed below-ground in 1903 was 153.5 tons. The death-rate from accidents at coal-mines in 1908 was 1.37 per thousand employed, as against 0.89 in 1907; the increase being due largely to three serious accidents, one at Khost, in Baluchistan, and two on the Jherria coal-field. 

A. P. A. S.

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 following contractions are used in the titles of the publications abstracted: —


Coal.—The coal-production of Russia, which, after a period of brisk development between 1895 and 1900, fell off again in the years 1901 to 1906, but has since considerably increased.

Of the world's coal-production of 60 milliards of poods,* Russia took the sixth place with 1,357 millions in 1906. According to German official returns, Germany exported in 1906 1,007,553 tons of coal to Russia, worth about £614,350; and in 1907, 836,295 tons, worth about £543,600.

In 1907, 108,957 persons, and in 1908, 118,000 persons were employed in the Russian coal-mining industry.

A chief cause of the recent development of the coal-mines has been the falling-off in the production of naphtha in Baku, which has forced a large number of industrial works to buy coal instead, and this has resulted in considerably raising its price.

Iron.—In the production of pig-iron Russia takes the fifth place, with 166 million poods, the United States of America being highest with 1,582 million poods. The use of iron has diminished in Russia since 1905, the export of pig meanwhile increasing from 50,000 poods in 1905 to 1,188,000 poods in 1906. The export of iron-ore rose from 13,561,000 poods in 1905 to 28,769,000 poods in 1906, and to 55,300,000 poods in 1907.

*1 pood equals about 36 pounds. [Approx. equiv. 3 poods/cwt or 60 poods per ton.]

The proposal was made in 1907-8 to amalgamate the works of nine large iron-manufacturing companies in South Russia into a syndicate. These companies together produce about 240 million poods of raw and finished iron representing about 45 per cent. of the whole Russian production. The proposal has been submitted to the Government, but no answer has yet been given.

The industrial magnates concerned consider that some such amalgamation is absolutely necessary in order to raise the Russian industry, since very few of the companies now work at a profit.

Gold.—In the gold-production of the world, Russia takes the fourth place but has to import considerable quantities for minting purposes. In 1906 the production was 1,839 poods.

Platinum.—The production of platinum in 1905 was 320 poods, and that in 1906 352 poods, the increase in the latter year being principally due to speculative operations.

Silver.—The production of silver is extremely small. The imports in 1905 were 83,000 poods; in 1906, 23,000 poods: the exports being, in 1905, 58,000; and in 1906, 10,000 poods.

Copper.—The import of copper was about double the export, the approximate production being 520,000 poods in 1905, and 636,000 poods in 1906. Zinc was produced in the Dombra district of Poland only, and amounted in 1905 to 483,000 poods, and in 1906 to 586,000 poods.

Manganese occurs in large quantities, but its production is small. It amounted in 1906 to 35.0 poods, and in 10 months of 1907 to 39.2 poods. A. R. L.

Investigations made since 1905 have led to results interesting both to geology and meteorology, to which sciences radio-activity brings fresh resources of a practical nature. The results acquired by Prof. Strutt may be thus summed up:—(1) All the igneous rocks have radio-activity, and also the sedimentary, so far as their composition is due to the igneous rocks; (2) iron contains but little radium, and meteoric iron not a trace; (3) lava, gas, and other volcanic products contain no radium.

The schists and gneiss of the Simplon have shown a more than normal proportion of radium, which accounts for the high geothermic degree observed while the tunnel was being driven. On the contrary, borings in the south of the Pas-de-Calais have revealed a very low geothermic degree, and those in Lorraine again high degrees. The author has thought that it would be interesting, as regards mine-working and also public works, to make radio-active measurements of the rocks passed through by these bore-holes, he had already, on the late Prof. Curie's indications, designed laboratory apparatus for the study of radio-activity; and he has now, in collaboration with two of Curie's pupils, brought out a portable instrument (described and illustrated) that permits of rapidly measuring the radio-activity of minerals as well as of gases and waters.

As the study of radio-activity is destined, before long, to enter largely into all geological and mineralogical research, if is advisable that engineers should have the means and the knowledge necessary for making observations of this nature; and radio-active investigations, concurrently with geological, should be made in all regions.

The disintegration of a few pounds of lead or iron would produce as much effect as do millions of tons of coal, so that the exhaustion of reserves might be regarded with indifference; and the author is firmly convinced that it will eventually become possible to dis-aggregate voluntarily a substance, and thus turn to account the energy accumulated in matter.

J. W. P.


France is now the chief producing country of aluminium, thanks to its waterfalls and its rich bauxite deposit in Provence, the only one of such importance known, and which Sainte-Claire-Deville pointed out as the raw material of this industry. Mr. Heroult made known a practical method for producing the metal, more or less improved by Dr. Kilian and Mr. Arnould, which is now applied without great modification at most works that are generally put up near bauxite mines and collieries. It consists in the chemical and electrolytic decomposition, in a graphite crucible forming cathode, of anhydrous alumina dissolved in a mixture of fluor spar and cryolite, kept fluid by the passage of the current.

The red bauxite of the Var, containing from 60 to 80 per cent. of alumina, is characterized by a very slight silica content, which has not hitherto been noticed in any other variety. The out-turn of bauxite in France now exceeds 200,000 tons. For producing a pound of aluminium it is necessary to treat 2 pounds of alumina, obtained from 4 pounds of bauxite, with great expenditure of electric current, a horsepower only giving from 4 to 5 hundredweight (200 to 250 kilogrammes) of aluminium per annum. France exported 13,316
tons of bauxite in 1908, and more than double that quantity during the first nine months of 1909, while producing 6,000 tons of aluminium and consuming 3,500 tons; but the works are capable of producing double that quantity.

Besides its use for preventing blow-holes in steel ingots and castings, aluminium has given rise to a special metallurgy (aluminothermy) of very refractory ores. For equal conductivity, an aluminium wire is half the weight of a copper wire, so that the use of the former is economical when the price of aluminium is less than double that of copper. In 1908 aluminium cost less than 9d. per pound (2 francs per kilogramme), while its price is falling, whereas that of copper has a tendency to rise. Aluminium wire soon takes on a skin of oxide, which affords good insulation, while laying and connecting up are most easy.

J. W. P.


Gold occurs in Madagascar under two distinct forms—in the alluvia and in the rocks. In the former case it can be separated by means of simple appliances that lend themselves to all difficulties of transport, Gold-mining has hitherto been retarded by want of capital and of transportation facilities. The net production nevertheless exceeds 2 tons per annum.

The very liberal mining law permits anyone to make explorations on all land not otherwise arranged for, on simply making declaration to the Mine Administration; driving a stake (piquet) into the ground in the centre of a circle of 1 ¼ miles (2 kilometres) radius, clear of all other claims; and paying £4 (100 francs) for the first year, £8 for the second, and £20 for the third, after which the exploration permit must be exchanged for a working permit. To guard against abuses, no "piquet" (as the claim is generally termed) can be set up again until two months have elapsed after its abandonment.

For the working permit the area is reduced, with the object of appreciably diminishing the utilizable portion of the above-named circle, and obliging the prospector to cover all the useful parts of his claim by supplementary "piquets de protection." A rectangle is inscribed in the circle, with certain maximum and minimum proportional limits between the long and short sides, while two parallel sides must bear north and south. A tax of 7 per cent. is levied on the gross produce.

The alluvia are constituted by the rich fara-tany (as it is termed in the native language), consisting of pebbles and argillaceous sand, overlain by clayey beds of very variable thickness and overlying a compact clay which has hitherto been regarded as the bed-rock, but contains a small quantity of gold. The content of the fara-tany varies from 1/15th to 1/5 ounce (2 to 6 grammes) or more per ton. The content is generally regarded as barren; but careful examination has revealed the presence of gold in very fine grains, forming a content of about one-tenth the above figures; and this small quantity is sufficient, by diminishing the cost of removal, to render the alluvia commercially workable.

Gold in the native state is contained in several rocks, foremost among them being the auriferous quartz, which has often been worked, with great waste, by the natives. The veins, bearing nearly due north and south, form part of a system of extensive fractures, and are easily discovered, thanks to the torrential rains that prevail for six months in the year. While some of these veins contain only a trace of gold, the content in others varies from, say, 1/6 to 5/6 ounce (4 to 25 grammes) per ton.

A curious formation, consisting of quartz impregnations in the mica-schists, affords quite a rich mineralization. Next in importance comes the auriferous gneiss, specimens of
which have led Prof. Lacroix, of the Paris Natural History Museum, to declare that the gold forms an integral part of these rocks as a constitutive element. Not far from Diego Suarez, in the north of the island, there is an interesting formation, constituted by "spongy" quartz, that has shown itself decidedly rich, the gold production by primitive methods attaining 6,160 ounces (200 kilograms) monthly.

Water-power is abundant, even in the dry season; and the natives, whose wages average 5d. (50 centimes) a day, have shown themselves apt at mining and even at timbering.  

J. W. P.


This paper constitutes an excellent and not too lengthy summary of the present state of knowledge regarding the character and origin of graphite occurrences.

According to the most recent statistics. Austria has outstripped Ceylon in the amount of output; but that island still retains the first place, so far as quality is concerned. Italy comes third, Germany fourth, India fifth, the United States of America sixth, and Mexico seventh; while Japan, Sweden, and Canada, each account for a yearly output of less than 1,000 tons.

The "country rock" of graphite deposits is always an eruptive rock or a crystalline schist (in the broadest sense of the term), but in no case an unaltered sedimentary rock. Graphite deposits assume every possible form,

from irregular pockets or nests to bedded layers or typical dykes. There is no one associated mineral which is typical of all workable graphite deposits without exception. Among the associated minerals the presence of which is detrimental, mica, chlorite, and pyrite may be especially noted, the first-named two being hard to separate from the graphite on account of similarity of physical properties.

The percentage of pure graphite present varies considerably from deposit to deposit. Thus the graphites worked in the felspathic quartzites of the State of New York contain at most from 5 to 15 per cent. of pure mineral; but they repay working even with 2 ½ per cent., on account of the enormous quantity available and the total absence of mica. The Styrian deposits contain from 42 to 87 per cent. of graphite, and are of vast extent; but the associated minerals (such as chlorite and mica) are a great hindrance to the preliminary sorting of the raw material. In Ceylon, even the inferior grades contain from 80 to 85 per cent. of graphite, while the best grades contain from 95 to 98 per cent.

Graphite is but little affected by the ordinary agencies of weathering, though it often loses its lustre at the outcrop. In many cases there is a ferruginous gossan arising from the decomposition of the associated pyrite, but the graphite appears to have been scarcely touched by the consequent liberation of sulphuric acid. Enrichment of graphite has even been observed occasionally in the aureole of the gossan, owing to the solution and leaching-out of the impurities present in the original graphite deposit.

The genesis of graphite deposits is traced to two different sources: (1) the alteration of carbonaceous sediments of organic origin by dynamic, regional, or contact-metamorphism; (2) deposition from molten, hydrated, or gaseous combinations, in which case the carbon is derived from an eruptive magma, of which it was either an original constituent or with which it was incorporated by subsequent melting of organic or inorganic carbonaceous country-rock (coal, bitumen, carbonates). The organic origin of the carbon has been proved beyond doubt in many deposits, such as those of Styria; but an absolutely inorganic derivation is not so easy to prove, and can only be inferred for some deposits with a certain amount of probability.
The question of inorganic derivation is discussed in considerable detail, and it is noted by the way that graphite has been synthetically prepared in the laboratory from a molten solution. Dr. Weinschenk's views as to the pneumatolytic origin of the Bavarian and Bohemian graphite-deposits are vigorously controverted; and the author inclines to the older hypothesis, that they are the outcome of the metamorphism of organic carbonaceous sediments.

L. L. B.

Permian Copper-ores of North-Eastern Bohemia.—By Dr. W. Petrascheck. Verh. k.-k. Geol. Reichsanst., 1909, pages 283-293.

The author has already discussed the question of the genesis of these ores, and fresh evidence, as well as the independent testimony of other observers, confirms his opinion that they are of epigenetic origin. He notes, by the way, that in this region cupriferous ores are dispersed through an enormous thickness of strata (11,500 to 13,000 feet) ranging from the Middle Carboniferous to the uppermost Permian. The following list of localities, with brief descriptions, where copper-ores were found by the author, is given: Biełowes (here the ferruginous thermal springs contain minute quantities of nickel); Parschnitz; Klein Schwadowitz; Hertin (where coal occurs, considerably impregnated with copper); Bohdaschin (certain coal-seams are filmed at the outcrop with malachite); Wustrey, Jibka, Radowenz, Teichwasser (malachitic filming of coal-seams); Bohmisch-Wernersdorf; Qualisch; Rothkosteletz; and Saugwitz. They are admittedly of small industrial importance, but many are of great interest from the point of view of those who care to study the genesis of ores. Although sulphidic ores were observed only among, or in the vicinity of, eruptive rocks, further investigation is quite likely to reveal their presence among other rocks. Many of the malachitic impregnations proved to be good indicators of the neighbourhood of a fault. The ash of certain coals (Klein Schwadowitz) was actually treated at one time for copper and silver. To faulting, in conjunction with eruption, of the Permian Period is traced the immediate origin of all these ores.


Among the rolling plateaux of the Lampongs, the deposits of magnetic and red iron-ores characteristic of the Sumatran mica-schist formation attain a development worthy of close attention. In his conception of the geology of Southern Sumatra, the author differs in some respects from Dr. R. D. M. Verbeek, who mapped much of the Lampongs (mica-schists overlain by a great thickness of laterite) as marine drift, but agrees with him in many essential particulars. The occurrence of seams of lignite, in part metamorphosed into "pitch-coal," among the Tertiary tufts and tuff-derived shales of Ratai Cove and Koloembayan Cove is noted by the way.

The mica-schist formation extends northwards from Lampong Bay almost as far as Goenoeng Soegih, and both eastwards and westwards to the Tertiary volcanic ridges; while from west-north-west to east-south-east it is invaded by pale red granites, with which gneisses are in places associated. Two distinct systems of fault-fissures are described, with which are connected predominantly thermal springs in the coastal region and quartz veins farther inland. Those quartz veins which strike north-westwards are more especially mineralized, yielding, among other metals, gold and silver. In the Tebah area lodes carrying galena, zinc-blende and copper ores also occur. Moreover, certain occurrences of stream-tin appear to be associated with the granitic masses. The author notes that, in various localities,
the auriferous quartz-reefs are accompanied by a considerable ferruginous gossan, which, however, contrary to general experience, only shows impoverishment so far as the precious metal is concerned. In the process of oxidation the gold-and silver-bearing solutions appear to have been leached out into the adjoining mica-schists. It is noticeable also that the metalliferous lodes "string out" very markedly in these schists.

Leaving aside the brown iron-ores of Soekadana as being of no industrial value, the author describes first of all the iron-ores of the Ranggal district, a fairly mountainous area. Here occur bedded magnetites dipping steeply south-westwards, faulted into block-like masses; and generally speaking of enormous thickness, without the objectionable partings or skarn known, for example, to Swedish miners. In texture, the magnetite varies at different horizons from compact to saccharoidal and semi- or holocrystalline; in colour, from bluish grey and steel-grey to blue and deep black. Specular iron-ore, externally very similar to the magnetite, is also described. Both ores contain, on an average, from 67 to 71 per cent. of metallic iron, the highest percentages being characteristic of the compact varieties. The impression that, contrary to the usually understood process, the red haematite in this instance has been derived by reduction (in oxygen) from the magnetite, is irresistible. In places pyrite is found to be associated with the noncrystalline haematite, but, on the whole, sulphur plays a very insignificant part in these deposits, and the same statement (but more emphatically) holds good as regards phosphorus. In brief, the Ranggal ores may be classed among the best "Bessemer" ores, and the calculated amount in sight is some 12,000,000 tons. The Way-waya deposits lie south-west of Goenoeng Soegih, and trend conformably with the pre-Carboniferous strike from west-north-west to east-south-east. Only 835,000 tons of ore are demonstrably in sight: but, considering the probable union in depth of the four known deposits, it is likely that an enormously greater quantity of ore will ultimately prove workable. In many respects, the Way-waya ores are similar to those of Ranggal; but to the more extensive fissuring of the rocks is assignable the presence of a lateritic parting at the hanging wall and a limonitic parting at the footwall. In depth, the ore becomes cavernous, even spongy, and passes into brown haematite, then into earthy limonite, and this again into pale-yellow kaolinic clay (? decomposition-product of the mica-schists). The percentage of metallic iron varies (from below upwards) between 60 and 68.5. Chemical analyses are tabulated of the three main types of ore, showing a gradual decrease of iron oxide in depth, and a corresponding increase of silica, alumina, and water. The successful working of the deposits here described is largely dependent on the facilities of transport, a matter wherein the Ranggal area is more highly favoured than the other. Labour is cheap, and there is some prospect of an agreement as to lower freights from Sumatra to Rotterdam. Moreover, Japan is regarded as a probable importer of these ores.

L. L. B.


In April, 1908, the author journeyed through the frontier districts of the States of Minas Geraes and Espirito Santo, in order to investigate the monazite deposits, especially with the view of determining how far they were likely to meet the future commercial demand for thorium. The area surveyed consisted of a series of small plateaux averaging an altitude of 1,050 feet above sea-level, and separated one from the other by mountain ranges. Hydrographically, it belongs to the river-basin of the Muriahe and the Pomba, two left-bank tributaries of the Parahyba. About two-thirds of the area is thickly clothed with primaeval forest, and no reliable topographical map is as yet available: moreover, the luxuriant
vegetation and the deep-seated weathering of the rocks, going down to many yards below the surface, generally destroy any possibility of exposures of fresh rock. The geological surveyor must, therefore, rest satisfied with what he can see in a few railway-cuttings and in certain stream-beds. Gneissose granites, probably of Laurentian age, varying considerably in petrographical character, are the predominant rocks of the district. In certain dyke-granites, tabular muscovite-micas are worked, under very primitive conditions, at two mines. In the form of boulders and pebbles the author found several other rocks, such as mica-schists, hornfels, quartzites, and arkoses, from the weathering and decomposition of which are derived the placers containing monazite, thorite, gold, zircon, corundum, cassiterite, rutile, spinel, topaz, olivine, titanite, etc. He examined no less than 236 of these placers, 96 per cent. of which were practically at stream-level. Below a peaty layer, followed by a barren layer (entulho) 8 to 80 inches thick, comes the workable cascalho (4 to 48 inches thick), consisting largely of pure white quartz and white clay, together with, the previous minerals. This is usually underlain by granitic bed-rock. Occasionally there are as many as five layers of cascalho in a single placer. The invariably occurring gold is confined to the very lowest stratum, being more especially accumulated in the hollows of the bed-rock. Nuggets are of extremely rare occurrence, and the gold is found as a rule in the form of dust or small flakes, to the extent of 1 ¾ parts per million in a given mass of cascalho. The percentage of monazite averages 2.1, sometimes attaining a maximum of 4.5. Three types of monazite sand are discernible, being in the order of increasing difficulty of separation of the minerals:—(1) Sands with tourmaline, olivine, hornblende, and augite ; (2) sands with zircon; and (3) sands with garnet.

Detailed suggestions are given as to the best methods of prospecting and working these placers; and it is pointed out that where the barren "cover" exceeds 10 feet in thickness, the workable cascalho is less than 10 inches thick, and the percentage of monazite is lower than 0.5, the placer may be regarded as a non-payable proposition. Taking 177 out of the 236 placers examined as workable, the author reckons that 30,000,000 tons (more or less) of cascalho are in sight, which would yield on the lowest computation 100,000 tons of marketable monazite. The evenness of quality of these deposits, their comparative accessibility, the easy conditions of working, the abundance of labour and water-power, the association of other valuable minerals with the monazite, and especially of ores richer in thorium, are all factors which will one day make these placers rank high in the markets of the world. High railway rates, and the somewhat discouraging attitude of the Government towards the industry, are difficulties which will doubtless be overcome in time. Improvements in mining legislation are, as it is, in process of accomplishment.

A brief description is given of the already known monazite-deposits scattered along the sea-coast of the States of Espirito Santo and Bahia, chiefly in order to throw into relief the far greater importance of the placers investigated by the author.

L. L. B.


The author has resided for ten years in the colony, doing chemical and other research work for the French Government, and proposes to publish soon a full account of his investigations. Meanwhile, he gives a summary of them in the paper of which this is an abstract.

Mineral fuel occurs in great abundance (1) in the form of Rhaetic coal along the eastern coast; and (2) in the form of Tertiary lignite of lacustrine origin, in a series of small
deposits dotted along the valley of the Red River and around Lang-Son and Ninh-Binh. The Rhaetic coal is a black, lustrous, brittle mineral approximating in character to anthracite: it contains from 5 to 12 per cent. of volatile matter, 2 to 10 per cent. of ash, and generally very little sulphur. It yields no coke, burns with some difficulty (necessitating furnaces with special grates and artificial draught), and its heating power is equivalent to 8,000 calories. On account of its crumbly nature a good deal of "small" is made in working the coal, very little of which has been utilized so far in the manufacture of briquettes.

The lignite varies in character, and its quality is in many cases spoilt by an undue percentage of sulphur. It is locally used by the natives as fuel, and is

[91] being tentatively introduced on to some lines of railway for firing locomotive boilers.

In the province of Quang-Yen certain blackish-grey oil-shale occurs. No precious gems have been discovered in the colony so far. The limestone of Uralo-Permian and Carboniferous age, the occurrence of which is so widespread in the eastern districts, is remarkably pure. Excellent lime is got from it, and with the admixture of clay a good cement can be made from it. The limestone is also used as building-stone and for paving, etc.; more over it takes a fine polish and can be utilized as marble.

Metalliferous ores are numerously represented. Antimony of fine quality occurs in deposits of limited extent; but the attempt made to work them, some years ago, was unsuccessful, chiefly because of the extreme irregularity of the price of the metal in the European market. Zinc-ores, chiefly in the form of calamine and smithsonite, with which a variable proportion of galena is associated, are especially abundant in the provinces of Quang-Yen, Thai-Nguyen, and Tuyen-Quang. Percentages of 58 and even 64 of metallic zinc are cited from some deposits, with 3 ½ to 10 ounces per ton of silver derived from the associated galena. Many of these deposits were formerly worked by the natives, and now some are being successfully exploited by Europeans. The picked ore is enriched by a preliminary calcination before shipping: 4,000 tons were exported in 1907, and probably double that amount in 1908.

Iron occurs everywhere: to it the entire delta owes its reddish-yellow coloration, and all the streams carry down vast masses of ferruginous particles. Hence, the name of the Red River (Song Koi). Some of the iron-ore deposits appear to be of industrial importance: masses or lodes of magnetite occur in connexion with eruptive and metamorphic rocks in several river-valleys. Nor must the secondary iron-ore deposits derived from the lateritic formation be left out of account. Laterites play, of course, an important part in the superficial geology of Tongking, as in most tropical countries. Several deposits are briefly catalogued, and it is pointed out that all the mineralogical elements necessary for the foundation of a metallurgical industry are available in the colony, as, for instance, manganese deposits and dolomitic limestones; while the iron-ores themselves are of high grade, and contain but little phosphorus.

Wolfram occurs, in conjunction with cassiterite, in the granitic massif of Pia-Wak, west of Kao Bang. The cassiterite yields quite enough tin to justify the hope that, when the deposits of the Malay Straits region are exhausted, the stanniferous deposits of Tongking will assume industrial importance. At present, wolfram is being worked and exported to Europe after preliminary treatment.

Copper-ores are found, chiefly in the form of sulphides, and accessorially as carbonates, in two well-defined regions: (1) that of the middle and lower Black River; and (2) that lying between the Song Luk Nam and the Song Tuong. Important traces of mercury have recently been discovered in the northern frontier-districts, and the metal would doubtless find a market in China.
The numerous gold-placers are either exhausted or so poor as hardly to afford a living to the natives who wash the "pay-dirt." It must be borne in mind, however, that the mineralogical survey of the colony is by no means complete, and it is quite possible that auriferous quartz-reefs may yet be found there. L.L.B.

MINING TECHNOLOGY.


The Vitry-sur-Seine generating-station, with four 9,000-kilowatt Curtis turbo-alternators, has been designed for reducing labour to a minimum. The 13,200-volt three-phase current, with a 25 frequency, is chiefly used for traction by the railway and tramway companies. Part is supplied directly at the bars of the station, and the other part sent, by underground conductors, to sub-stations, where it is transformed to the 600-volt continuous current utilized in the traction motors.

The coal, received entirely by water-carriage, is transferred automatically to the boiler-furnaces. An electric crane, with self-acting kibble, can take the coal from the barge and load it on to the conveyor that leads it to the furnaces, or can stock the coal, or, again, can take it from stock for being sent to the boilers. The conveyor, constituted by endless bands driven electrically, raises the coal from the quay-level to "silos" in front of the boilers and at a sufficient height to fall into hoppers above the Dusseldorf mechanical grate-bars. In this manner, 100 tons can be brought up per hour. The cinder that falls into hoppers is received in trucks, which tip it on to a conveyor, like that for the coal, and is led by it to barges or wagons.

The Babcock-and-Wilcox boilers, certified for a pressure of 199 pounds per square inch (1 kilogramme per square centimetre), are supplemented by superheaters, which raise the temperature to 572° Fahr. (300° C.). Green economizers heat the feed-water to 194° Fahr. (90° C.). The boiler-house and its chimney, 230 feet (70 metres) high, are entirely built of reinforced concrete.

A 300-kilowatt turbo-generator serves to start the whole station, all the auxiliary services which are provided for by electric motors, for the most part asynchronous, supplied by 550-volt three-phase current.


To provide for stoppage of the plant referred to in "River Utilization for Generating Electric Current," owing to too low or too high a water-level in the Dordogne, a steam-raising plant was added that might at first sight be considered unnecessarily elaborate for the short time during which it is likely to be required. But the mechanical stoking and arrangement for bringing up the coal are justified by the difficulty of procuring stokers at short notice in the out-of-the-way locality where the generating station is put up.

Coal-wagons, brought up by a siding, are discharged into the main "silo" by a shaking table, with the aid of a single bucket-chain conveyor. that supplies the hoppers, one in front of each of the sixteen boilers, and also removes the ashes. The conveyor-belt, driven by a 15-horsepower three-phase motor, carries 30 tons of coal per hour, and provides for the daily consumption in 2 ½ hours. The hoppers, holding together 450 tons, are made of reinforced concrete, and terminate in movable spouts.
Each Buttner multitubular boiler, of 310 square yards (260 square metres) heating surface, and 62 square feet (5.7 square metres) grate surface, fed with water at 185° Fahr. (85° Cent.), can vaporize 3.8 tons normally and 4.7 tons with hard stoking. Besides a chimney 197 feet (60 metres) high


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for each bank of eight boilers, each bank is provided with a pressure fan, driven by a 32-horsepower three-phase asynchronous motor at 475 revolutions. A superheater of 861 square feet (80 square metres) surface can raise the temperature of all the steam generated to 100° cent. above that corresponding with the certified pressure, viz. 227 pounds per square inch (16 kilogrammes per square centimetre). The "under-feed" mechanical stokers are driven electrically.

Each of two (eventually three) Curtis turbo-alternators with vertical axis has a power of 3,000 kilowatts at 750 revolutions per minute, and furnishes three-phase current, with a frequency of 50, at 5,500 volts. The steam-consumption per kilowatt-hour is 15.4 pounds (7.002 kilogrammes) with full load and 16.28 pounds (7.4 kilogrammes) with half load.

J. W. P.


These experiments were carried out at Lievin, in accordance with a programme framed, by the French Fire Damp Commission in July, 1908. The first; series dealt with the addition of alkaline salts to explosives, the detonation of which sets free combustible gases among other constituents; and the second, with the effect which the addition of such salts has in making explosives safe in the presence of fire-damp and in that of (coal or other) dust. Numerous photographs were taken of the flames of explosives, detonating either in the open air or inside a mortar, and the most characteristic of these are reproduced in the plates which accompany the paper.

Four explosives, the basis of which was decanitric gun-cotton, were tried; in one case pure, in the others supplemented respectively by 2 per cent. of sodium bicarbonate, 3 per cent. of potassium sulphate, or 3 per cent. of lead nitrate. Similarly, trinitrotoluene was tried pure, and then with the addition of 5 per cent. of potassium nitrate, or 10 per cent. of barium nitrate. Carbite (or kohlencarbonit) was also tried, and in fine the first series of experiments confirmed Mr. Dautriche's statement that the addition of alkaline salts undoubtedly tends to obstruct the ignition of the combustible gases given off by certain explosives on detonation. But the results thus far obtained are not numerous enough or decisive enough to enable one to say which of the above-mentioned explosives producing combustible gases can be rendered perfectly safe by the addition of alkaline salts, and what proportion of such salts is really efficacious.

In the second series, trinitrotoluene grisounites, Favier grisounites, and grisoutines of various composition, were tried with and without saltpetre in the presence of fire-damp inside steel mortars; then again in the form of cartridges in suspension in an atmosphere containing fire-damp; and finally in steel mortars in the presence of coal-dust. The composition of the explosives and the results of the experiments are set forth in a series of elaborate tables. It was shown that safety-explosives with 3 to 6 per cent. of saltpetre are safer in the presence of fire-damp than the explosives from which they derive; in the presence of coal-dust, on the other hand, the results were contradictory, and in many cases the addition of saltpetre was shown to have diminished the safety of the explosive. The
reasons for this are shown to be connected with the physico-chemical (temperature) phenomena accompanying the volatilization of the alkaline salts. The addition of 5 per cent. of saltpetre to the above-mentioned safety-explosives (second series), while it makes them less dangerous to use in presence of fire-damp), does not appear to diminish sensibly their detonating power.

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The author gives the results of investigations in Appalachian coal-mines covering a period from 1898 to 1909. during which time an ever-increasing number of collieries have been ventilated by fans giving air-currents of high efficiency. He considers that the robbing of a mine of moisture is dangerous if carried to a certain point (varying under different conditions in the same locality), and believes that the real solution of the problem of the prevention of explosions is so to control the temperature and humidity of the mine air that a dust explosion will be impossible. The ordinary methods of spraying the dust by means of a car or by pipe-lines, with sprays located at intervals he regards as unsatisfactory, wasteful of water, expensive, and cumbersome. He considers the use of calcium chloride as a deliquescent excellent for haulage ways and partings, but too expensive if used in all working-places, in which most of the dust is generated and where the greatest danger from explosions lies. Whitewashing and the use of shale-dust as a damper for explosive conditions possess merit, but they are, in his opinion, only local preventive measures, and require too much time and supervision to be followed systematically. The results of his investigations may be summarized as follows:—(1) There is a certain condition of the outside air, having a temperature and humidity such that, when it is used in ventilating mines, moisture will neither be deposited in the mines nor carried out of them. This condition he calls the "critical condition," which probably varies slightly, according to latitude, altitude, and the seasons of the year. This range of variation will probably fall between the temperatures of 50° and 60°Fahr. (2) As the temperature of the outside air falls below the critical point, mines will be robbed of moisture by the ventilating current (and vice versa). (3) While this lower outside temperature continues, the mine will become drier, and, in proportion to the difference between this lower outside temperature and the critical point, the rate of drying will be increased or diminished. (4) When the outside temperature is such as to make the ventilating current dry the mine, this effect will be increased by increasing the volume of the current. (5) This critical condition should be determined, and a ventilating and heating system should be adopted which would raise the temperature of the intake air to the mine temperature, and then saturate the air with moisture. A. P. A. S.


On Easter Monday, April 12th, 1909, at about 11.30 p.m., an explosion of fire-damp took place at the above-mentioned colliery whereby five pitmen lost their lives. The scene of the disaster was Seam No. 5, belonging to the gas-coal group, and lying 410 feet vertically below the main or Zollverein Seam: it is over 4 ½ feet thick, dips some 10 degrees northwards, and was not being worked at the time. In the course of the inspections prescribed by the regulations, no emanations of fire-damp had ever been observed, although some slight traces were reported (at another level) to the management on one occasion in the summer of 1908. Seam No. 5 is by no means dusty: the workings were, indeed, uniformly damp, not to say very damp; in fact, the floor was absolutely wet, and an exception, in the case of this seam, from the general rule of water-spraying was allowed.
The last shift for haulage purposes ceased work at 4 p.m. on the preceding Saturday, April 10th. At that time everything connected with the ventilation and the spraying apparatus was in perfect order, nor had the presence of fire-damp been noted. The master shot-firer and the "ventilation-inspector" had received orders to go down the pit at 6 p.m. on the Easter Monday, in order to ascertain whether dangerous gases were present; but the latter (on account of sudden illness in his family) was 4½ hours behind time. Meanwhile, such pitmen as had assembled were waiting at the cross-cut to the sixth level in Seam No. 5, until the "ventilation-inspector" should have accomplished his round of the workings. Six of these men obeyed implicitly their instructions, but the other seven hurried forward immediately into the workings, and four of them paid the penalty of their disobedience with their lives.

The destructive effects of the explosion, the immediate cause of which is traced to the lamps carried by the victims, were considerable. Brattices were destroyed, tubs overturned, timbering wrecked, and where not wrecked it was scorched by flame or encrusted with coke two-fifths of an inch thick. Throughout the workings of Seam No. 5 accumulations of fine dry coal-dust were observed after the disaster. It should be mentioned that, before the final Saturday shift (to which reference was made above), two shots had been fired, and the explosion undoubtedly started from some point in the vicinity of the shot-firing.

A detailed description of the safety-lamps then in use lays stress on certain defects of construction, and as a result of the disaster the use of lamps with enamel reflectors (the type previously in vogue) has been forbidden. Moreover, those whose duty it is to see that the ventilation is in good order, have been instructed, not only to examine the state of the atmosphere at the working-face but also to test carefully for fire-damp the roadways by which the various workings are approached. It would seem that the roof is liable to break down, laying bare fissures or clefts whence dangerous gases may be issuing and accumulating in various cavities and vacant spaces within the workings.

L. L. B.


The author describes the sinking of the Smith shaft in the Swanzy district, near Princeton, Michigan, through about 60 feet of water-bearing strata, after continuous pumping had failed to lower the level of the water during an attempt to sink by the drop-shaft method.

In dimensions the shaft was 21½ by 17½ feet outside, with walls 3 feet in thickness at the bottom and 18 inches at the top. The concrete was started on top of a timber shoe or cutting-edge, which consisted of two layers of 12 by 12-inch fir timber, bevelled on the inside, the bottom stick being shod with a heavy angle-iron, and the whole strongly bolted horizontally and vertically, thus tying all the timber firmly together. The walls were of concrete strongly reinforced with steel bars 1¼ and 1 inch square, spaced 6 to 8 vertically and about 18 inches horizontally apart. The horizontal reinforcement was designed to take the earth and water pressures, while the vertical rods mainly prevented the lower sections of the walls from pulling away from those above during sinking operations. These vertical rods passed down through the timber cutting-edge and anchored the same to the concrete walls. Six feet above this cutting-edge and notched into the concrete wall was the dock, or roof, of what is familiarly called the "working chamber."
The cutting-edge was first assembled at the surface and the inside forms for the first 10 feet built on top. All other forms were built apart from the shaft in sections 6 feet high and of interchangeable design. The form material was 2 by 8-inch tongued-and-grooved plank. After the forms had been placed and concreted to a height of about 18, sinking without air was resorted to until water was encountered, which occurred at a depth of about 5 feet from the surface. Air was then pumped into the working-chamber, and when the water in the working-chamber had been displaced by air, gangs were sent into the shaft, and excavating began.

It was endeavoured to keep the shaft built up above the ground for at least 18 inches all the time, to permit of the use of three sections of concrete forms, the lower set being removed as it reached the ground, and moved up as the material was removed from the interior of the shaft and from under the cutting-edge. The shaft sank of its own weight until it had reached a depth of approximately 40 feet, when it became necessary to apply additional weight. The only available weight that could be procured at that time was wet sand. This was loaded upon the deck in the interior of the shaft, and more added from time to time. In this manner the shaft went down steadily until it reached the ledge, exactly one month from the time that air was first applied. The rock-ledge was first encountered in one corner of the shaft, and proved to have a slope of 3 ½ feet in 20; and, in order to make a water-tight joint, it was necessary to level off this rock and then go down about 2 feet further. Blasting was resorted to as in ordinary excavations. The rock-excavation was completed by January 5th. The inside top timber, comprising part of the cutting-edge, was then removed, and the walls concreted to the rock, thus presenting a solid masonry face from ledge to surface. This joint was tied to the rock-ledge with steel dowels and to the walls above by means of projecting bolts that had previously held that part of the cutting-edge which was cut away and replaced by concrete. Air-pressure was maintained on the shaft for 3 days after the completion of the joint to allow the concrete forming the joint ample time to set before subjecting it to the outside water-pressure. The air-pressure was then gradually reduced to zero. Although subsequent inspections showed that the shaft developed a leakage of about 50 gallons of water in 24 hours, none of it came through the joint.

The second shaft, named the Kidder, was sunk in the same district within half a mile of the Smith shaft. The conditions were, however, somewhat different, the general character of the overburden being the same but deeper, and the ledge more broken up and seamy. It was decided to sink a circular shaft 24 feet in outside diameter, having an inside diameter large enough to provide a rectangular space measuring 14 feet 10 inches by 10 feet 10 inches.

The walls of the shaft were built upon a fabricated steel shoe, 24 feet in outside diameter, riveted to a steel cone-plate on the inside, the slope of which extended to a height of 10 feet, making a circular opening at the top of the chamber or cone of a diameter of 10 feet. To the top of this were bolted steel sections 10 feet in diameter, which were carried up section by section as the structure sank, and through which was operated a clamshell dredge. This dredging cylinder also acted as a wall of the caisson while sinking operations were conducted by the pneumatic process. As the clamshell displaced the material, the shaft settled by its own weight. Care had to be taken to build on the top fast enough to keep the top of the structure always several feet above the surface. This plan of sinking was followed until the shaft had reached a depth of 87 feet, when a stratum of very hard clay was discovered, which the dredge refused to handle. A steel deck or roof was then bolted on to the top of the dredging shaft. This deck in turn supported a Moran airlock, and the shaft was now equipped for compressed-air operations, which were immediately begun and the shaft
carried down, to the ledge, which was found to be 104 feet from the surface. The ledge was so broken up and seamy that it was found necessary to take the shaft a further 9 feet into the ledge, making a total excavation of 113 feet from the bottom to the collar of the shaft, or 103 below water-level.

The wall of the shaft at the top was 2 feet thick, down to a depth of 17 feet; it was there increased to 2 ½ feet to a depth of 50 feet, then increased to 3 feet to a depth of 82 feet, and finally increased to 3 ½ feet to the bottom, 113 feet below the surface. The shaft was strengthened by a system of reinforcing steel, similar to that described in the Smith shaft. In sinking the shaft a weight of 375 tons of pig-iron was required to overcome the excessive friction encountered. The sinking of the shaft occupied a period of exactly 5 months.

The advantages of shaft-sinking through water-bearing ground by the above method are that all surface-water is shut off, doing away with expensive pumping; being of concrete, such shafts are fire-proof; they will never have to be relined or renewed; they are plumbed, and can be completed in a much quicker time than shafts sunk through the same material by ordinary methods.

A. P. A. S.


This shaft, at the time when the writer was preparing his paper, had been sunk to a depth of 692 feet, but it is proposed at a future date to extend the sinking to 850 feet. Concrete was not used for the purpose of excluding water, but was adopted for safety and permanence, to avoid the danger of fire, and the expense of timber replacements. A circular section was decided upon, so as to use the concrete in compression, and thus avoid the necessity for reinforcement. The shaft is 14 feet in diameter, and is divided into seven compartments.

A preliminary opening measuring 6 by 8 feet was first made throughout the entire length of the shaft, and afterwards a timbered shaft 20 feet square was sunk to the ledge, which was about 60 feet below the surface, the overburden consisting of gravel and hard pan. The sets of this shaft required diagonal bracing. Excavation was then carried on for a short distance in the rock, and concreting started at a depth of about 79 feet below the surface. The average concrete lining was 19 inches thick, with a minimum at any point of 6 inches. No attempt was made to trim the walls smooth, as the irregularities of the rock supported the concrete.

The cost of sinking this shaft was a trifle higher than that for a rectangular shaft of the same capacity, and with steel framing; but the small additional cost is abundantly justified by the increased safety and permanence.

A. P. A. S.


At 6.15 a.m. on March 16th, 1907, at the Mathilde shaft of the Gerhard State colliery at Saarbrucken. in consequence of the rupture of a steel wire rope, the cage which was carrying men down the pit for the morning shift

was precipitated to a depth of 660 feet or so, with the result that twenty two persons lost their lives. The total depth of the shaft exceeds 1,387 feet and it is partly lined with brick, partly with cement: it measures in diameter 14 ½ feet, being circular in cross-section. The average daily number of winds was 214, which implies (at 3 minutes per wind) that the winding apparatus was in active operation for 11 hours every day. The winding engine,
constructed at Zweibrucken in 1874, had been transferred to the Mathilde shaft in 1892: the cage was double-decked, weighed something short of 3 tons, and could carry eleven men or two wagons on each deck. The wire-ropes are made of cast steel at St. Johann, and measure in cross-section 4 inches x 9/10 inch, and the factor of security, when the cage was carrying a full load of men, but not loaded wagons, was 9.07:1. In accordance with regulations dating from January, 1902, the wire-ropes are supposed to be severely tested every four months for pliability and for capacity to bear stress and strain. They had been in place since the beginning of October, 1904 and had been tested as aforesaid exactly a month before the disaster. Nevertheless, on March 14th an order had been given out for new ropes, as the ropes used previous to 1904 had been replaced after 983 days' wear, and these had by this time undergone 894 days' wear. It was customary to paint the ropes with a lubricant solution periodically, in order to prevent the formation of rust caused by rainwater, pit waters, and upcast gases. The last "repainting" took place on February 17th, and three (presumably unimportant) fractures of wire were then observed.

On the night preceding the accident no coal or stone was wound, but a good deal of old scrap-iron was brought to bank in successive winds. In the early morning, first with the eastern and then with the western cage, eleven men were taken down to the seventh level; thereafter, the eastern cage took down the first batch of men for the fifth level (22 in number), but, as the western cage was taking down the second batch for that level (also 22 in number), the wire rope by which it was being wound suddenly snapped. It was afterwards ascertained that the fracture extended over a length of 10 feet; the broken strands, divisible into three separate groups, were cleaned with petroleum, and it was then found that they had been greatly weakened by corrosion, no signs of which had been observed previously.

Portions of the broken rope were examined in the Government Laboratory for Testing Materials, and the official report stated that there could be no doubt that the rope was in a very unsatisfactory condition, that it had been so worn and rusted in places that many strands were completely eaten away and at other points only just hung together. Careful inspection and adequate cleansing of the rope should have made this condition of affairs clearly visible to the naked eye. Further, it was established that the regulations concerning daily inspection and testing of the rope had not been observed to the letter: it was shown, however, that certain of these regulations could not be carried out in practice, and, even if they had been carried out, would hardly have prevented the disaster. It was also shown that a certain amount of clumsiness on the part of the man in charge of the winding engine had brought about a sudden stoppage and jar which proved to be the immediate cause of the fracture of the rope.

As a result of the official enquiry, new and stricter regulations for the periodical inspection of winding ropes are now enforced in Prussian mines. L. L. B.


Of the many antiseptics which at one time or another have been proposed for the preservation of timber, two general classes may be mentioned: (1) antiseptic salts of various substances, such as zinc chloride, corrosive sublimate, and copper sulphate; and (2) antiseptic oils, of which creosote or dead oil of coal-tar is most generally used. The most common preservatives in general use are zinc chloride and creosote, and both are excellent antiseptics. The principal value of zinc chloride may be found in its cheapness and its ease of transportation, for it can be hauled in the form of a solid and dissolved at the treating plant. It is liable, however, to leach out of the timber when exposed to moisture, either in the soil or in the atmosphere. It is injected into the timber in the form of an aqueous solution, and
so its subsequent leaching-out is merely a question of time, and the wood is left once more subject to attack. Its use, therefore, is limited to less moist situations. In parts of mines not subjected to a great deal of running water, zinc chloride has efficiently preserved mine-timbers; and in such situations its use is strongly recommended. Creosote, on the other hand, is practically insoluble in water, and so, when a high grade of oil is used and injected into the timber, decay will be postponed almost indefinitely. Its principal disadvantages are its higher first cost, as compared with zinc chloride, and its limited supply. While treatment with creosote has not been found to increase the inflammability of mine timbers, treatment with zinc chloride renders the timbers far more fire resisting than untreated wood.

Methods of applying a chemical treatment may be divided into two classes—those in which the preservative is injected by artificial pressure, and those in which the atmospheric pressure is made to force the preservative into the timber. The non-pressure or open-tank process is much the simpler and less expensive, but not so well suited for the treatment of a variety of species and forms of timber. When timber is to be creosoted under the usual pressure method (Bethell process), it is placed on iron trucks and hauled by cables into large steel cylinders, capable of withstanding high pressure. The doors are closed, and the timber is subjected to a bath of live steam for several hours. This is followed by a vacuum, and finally the cylinder is filled with creosote; the force pumps are then started, and continue until the desired amount of oil has been forced into the timber; the surplus oil is run out, the doors opened, and the treatment is complete.

The preservative process best suited for the treatment of timber by mining companies depends upon the form and species of timber handled and the proportion of sapwood that it contains. A porous wood, such as pine or red oak, is more easily impregnated with a preservative than is a dense species, such as white oak or tamarack. A less expensive non-pressure treatment, therefore, is more suitable for the treatment of these porous woods.

During the past year the U.S. Forest Service has been instrumental in establishing timber-treating plants for three coal-mining and two ore-mining companies. The largest plant is designed for a daily capacity of about 30,000 board feet, and will cost about £2,400,000 (12,000,000 dollars). If required, it could treat 3,000,000 standard railroad ties annually. In these plants ties, poles, and mine timbers have been successfully impregnated.

Over 3 years ago, the Philadelphia and Reading Coal & Iron Company, in co-operation with the U.S. Government Forest Service, inaugurated a series of experiments to test the practical value of preserved timbers. Standard gangway or collar sets were treated with a number of different preservatives applied by several methods. After treatment, these timbers were placed in a gangway of a mine where the average life of timber is but 18 months. By a non-pressure treatment with zinc chloride, the life of the timber has been doubled. The above tests have been conducted on a sufficiently broad basis to produce conclusive results of practical value. At least 500 sets of timber have been treated as described above, and have been compared with an equal number of untreated sets. Moreover, these timbers have been distributed through various parts of the mines, where they were subjected to varying degrees of side and top pressure. The results obtained show that, even when untreated timber is broken by weight in a comparatively short time, its preservation in a sound and strong condition adds greatly to its length of service. Preserved from decay, smaller timbers may often be installed in place of those of larger dimensions which were selected to perform the required work when decayed to a depth of several inches.

A.P.A.S.
Cast-iron Pipe Joints. — Agenda Pont-a-Mousson 1910, page 56.

In cases where it may be dangerous, or merely inconvenient, to melt lead for running into the joints of spigot-and-socket pipes, a good substitute for molten lead is afforded by lead-"tow" (consisting of lead in thread-like particles), which must be laid regularly into the joint-space, and uniformly caulked at each turn of the skein. A joint thus made (even under water) will be light, strong, solid, and homogeneous; but it is important that the caulking be not neglected after each turn.

J. W. P.


The chief quality to be required of a building material is homogeneity, which permits the unity of vibration and acceleration—an indispensable factor in preserving edifices during seismic disturbances. This quality is possessed by reinforced concrete, in addition to those of great strength, continuity, elasticity, and incombustibility. The small metal parts embedded in the mass render it fibrous, while the protecting "gangue" renders its action uniform. The joints may be rigid in the highest degree, so as to defy all movement.

At Messina, in 1908, not a building of reinforced concrete was damaged, however violent the shocks and strains to which it may have been subjected. At San Francisco, in 1906 (says a report of the U.S.A. Geological Survey) the too few buildings of reinforced concrete stood well during the earthquake and the fire that resulted from it. "Concrete, especially reinforced concrete, owing to its great strength and continuity, has proved itself the most satisfactory of materials. Its monolithic structure affords a substance that withstands shocks marvellously, for it moves all in one piece, while opposing the maximum resistance to fire."

For turning to account the sad experiences gained from those two catastrophes, we may introduce still further improvement into the use of a material already classed in the first rank. As regards its structure, attention

will be directed to a judicious and judiciously reinforced partitioning, or panelling (cloisonnement)—a rational combination of the iron and concrete—applicable alike to habitations, public works and buildings, and to marine constructions. Opinions are divided as to whether foundations should be "rooted" (anchored) in the ground or not; but in this, as in many other matters, there is no absolute initial rule, everything depending on the nature of the soil. In this respect the only risk incurred by the indeformable "box" is a canting, which is neither dangerous nor irreparable.

J.W.P.


vol. ii series 6, pages 1-62.

The object of testing metals and similar substances is evidently to discover their properties, which are eminently variable from a utilitarian point of view; and the test method appears to be the means to this end, its mechanism being only the vehicle. It is this principle which guided the author in organizing the metals section at the testing-station of the Conservatoire des Arts et Metiers.

For testing flat mine ropes of Manila fibre up to a width of 20 inches (500 millimetres) there is a machine that can effect the fracture of the whole rope, without the necessity of resorting to longitudinal subdivision. Numerous tests have shown that a new and good rope
can afford a resistance to tensile strain of 8,533 to 9,244 pounds per square inch (600 to 650 kilogrammes per square centimetre) of cross-section, but that after wear the resistance is only 4,977 to 6,400 pounds per square inch (350 to 450 kilogrammes per square centimetre). The elongation, which may attain 15 to 20 per cent., becomes reduced in worn ropes in 9 or 10 per cent.

J.W.P.


For working the 16-foot (5-metre) grey seam and the thinner, less valuable, siliceous brown seam underlying it, the Auboue iron-mine of the Pont-a-Mousson Company, Meurthe-et-Moselle, is equipped for an annual output of 2,400,000 tons, and has three winding shafts. No. 1, downcast, which was sunk by the freezing process, is tubbed with cast-iron rings of 16 ½ feet (5 metres) inside diameter, and is equipped with a steam winding engine which can raise 4,000 tons daily from a depth of 413 feet (126 metres). No. 2, upcast, masonry-lined to 10 feet (3 metres) diameter, is provided with an electric haulage engine, with counterweight, for letting down and bringing up the men. No. 3 is iron-tubbed to 14 feet (4.25 metres) in diameter, and can furnish the same output as No. 1 with a 730-horsepower electric winder.

As the mine produces uniformly and continuously, while the sending off of ore is intermittent, accumulators of large capacity are necessary, of which No. 1 shaft serves three—one, cylindrical, of 800 tons; another, trapezoidal, of 1,100 tons, and the third, of 3,500 tons, provided with Heckel mechanical haulage. The upper floor of the first two is at the bank-level, so that the 1 ½-ton tubs coming up are tipped directly; but the third is at a higher level, and is filled in the following manner. The tubs coming from the bank are tipped into a hopper, whence the ore falls into self-discharging trucks, which are rope-hauled up an incline and brought on to an overhead traveller serving the accumulator. When emptied, the trucks are run down automatically to be again filled.

No. 3 shaft serves a fourth accumulator, of 3,600 tons capacity. On the cage coming up, the tubs are pushed off automatically, and run down by gravity on to a tipping traveller which, moved over the accumulator, can discharge eight tubs at once. The empties are mechanically hauled off the traveller and on to the cage. The accumulators are emptied by traps in the bottom, worked by screws, the ore falling into railway wagons brought underneath.

The underground roads (which are very extensive, because the Mine Administration only permits 25 per cent. of the deposit to be worked) are when not equipped for electric haulage, served by twelve 300-volt continuous-current electric locomotives. Electric rock-drills are used, in addition to hand drills. Besides an underground steam pump, raising 2,861 gallons (13,000 litres) per minute and an emergency pump, there are two electric pumps, each of which can lift 1,100 gallons (5,000 litres) per minute. J. W. P.


Bordeaux, Angouleme, and Perigueux are situated in a region where rivers abound, while there are practically no waterfalls. For supplying this very industrial region with light and power, the Societe d'Electricite du Sud-Ouest has utilized the total volume of the Dordogne, navigable up to Tuilliere, where the central station is established for generating current of 24,000 kilowatts.
Owing to local conditions, a maximum artificial fall of only 39 feet (12 metres) could be obtained. The dam with movable sluice-valves (barrage a vannes mobiles), one of the largest existing, is constituted by nine masonry piers, forming eight openings, that can be wholly or partly closed by the metal valves worked by electric winches. The nine Francis turbines with vertical axis have a normal speed of 107 revolutions per minute, and can work with a fall varying from 19 ½ feet (6 metres) to double that height. With the maximum fall each gives out 3,000 horsepower.

The turbine is coupled direct to a fixed-armature alternator of 1,750 kilowatts capable, at the normal turbine speed, of generating three-phase current of 5,500 volts. The 56 poles of the revolving inductor, designed for being excited by continuous current of 125 volts, are fixed to the periphery of a magnetic cast-iron fly-wheel 15 feet (4.59 metres) in diameter. The alternators have an efficiency of 94 per cent. with full load and 91 per cent. with half load.

The 50,000-volt current is transformed to that of 13,500 volts at three sub-stations, for serving the main centres, the nine principal transformers being of monophase type.

Instead of having been, as usual, erected progressively to meet growing requirements, this plant was laid down from the commencement for the whole power required, so that the various sections could be proceeded with simultaneously; and the whole was brought into operation, without hitch, in the spring of 1909.

J. W. P.

[103]


The author states that the application of the electrical current as a source of heat-energy in the reduction of iron-ores would a short while ago have scarcely been seriously considered. Its possibility has now, however, been more than demonstrated; and Dr. Richards describes the work of several investigators in the development and operation of this method of manufacturing pig-iron on a practical commercial scale, and gives particulars of various experiments carried out by the Canadian Government and Swedish investigators.

A. P. A. S.

[104]


Compiled by PERCY STRZELECKI.

The barometer, thermometer, etc., readings have been supplied by the 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 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 and non-fatal explosions have been obtained from H.M. Inspectors of Mines.

The times recorded are Greenwich mean time, in which midnight
equals 0 or 24 hours.

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**TABLE I.-SUMMARY OF EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1909.**

<table>
<thead>
<tr>
<th>Mines-inspection District</th>
<th>Fatal Accidents</th>
<th>Non-fatal Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Deaths</td>
</tr>
<tr>
<td>Cardiff</td>
<td>1</td>
<td>27</td>
</tr>
<tr>
<td>Durham</td>
<td>2</td>
<td>169</td>
</tr>
<tr>
<td>Ireland</td>
<td>0</td>
<td>0</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</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Scotland, East</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Do. West</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Southern</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Stafford</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Swansea</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Yorkshire</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>20</strong></td>
<td><strong>227</strong></td>
</tr>
</tbody>
</table>

[105]

**TABLE II.-LIST OF FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1909.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 19, 12.20</td>
<td>Ackton Hall</td>
<td>Yorkshire</td>
<td>Yorkshire</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Feb. 1, 3.15</td>
<td>Littleburn</td>
<td>Durham</td>
<td>Durham</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>&quot; 3, 5.45</td>
<td>Calderbank (No.2 Pit)</td>
<td>Lanark</td>
<td>Scotland, West</td>
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<td>Durham</td>
<td>Staffs Highway</td>
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<td>Stafford</td>
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<tr>
<td>Mar. 25, 10.45</td>
<td>Montagu Fire-clay</td>
<td>Northumberland</td>
<td>Newcastle</td>
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<td>Yorkshire</td>
<td>Yorkshire</td>
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<tr>
<td>June 27,13.45</td>
<td>Ferniegare (No. 1 Pit)</td>
<td>Lanark</td>
<td>Scotland, West</td>
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<tr>
<td>Aug. 3, 13.30</td>
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<td>Graig Merthyr</td>
<td>Glamorgan</td>
<td>Swansea</td>
<td>5</td>
<td>1</td>
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<tr>
<td>&quot; 5, 22.0</td>
<td>Gateside (No. 2 Pit)</td>
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<td>Glamorgan</td>
<td>Cardiff</td>
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<td>Swansea ..</td>
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TABLE III.-LIST OF NON-FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1909.

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<td>Glamorgan</td>
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<td>Ross (No. 1 Pit)</td>
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<td>Northumberland</td>
<td>Newcastle</td>
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<tr>
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<td>Aucinhawvie (No. 5 Pit)</td>
<td>Ayr</td>
<td>Scotland, West</td>
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<td>Pentyrch</td>
<td>Glamorgan</td>
<td>Cardiff</td>
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<td>Swansea</td>
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<tr>
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<td>Torycoed</td>
<td>Glamorgan</td>
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<tr>
<td>Feb. 1, 7.15</td>
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<td>Worcestershire</td>
<td>Stafford</td>
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<td>Garthshore (No. 1 Pit)</td>
<td>Dumbarton.</td>
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<td>Cumberland</td>
<td>Newcastle</td>
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<td>11, 10.30</td>
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<td>Glamorgan</td>
<td>Swansea</td>
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<td>Montgomeriefield (No. 1 Pit)</td>
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[106]

TABLE III.-Continued.

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<td>Loftus</td>
<td>Yorkshire</td>
<td>Durham</td>
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<td>Swansea</td>
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TABLE III.-Continued.

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<td>County</td>
<td>Mines-inspection District</td>
<td>No. of Persons Injured</td>
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1909

TABLE III.-Continued.
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Table IV.—Barometer. Thermometer, etc., Readings, 1909.

[Tables omitted]

[i]

[Drawing of Neville Hall]

[ii]

[Graph: Membership from 1953-1912]

[iii]

THE NORTH OF ENGLAND INSTITUTE
OF
Mining and mechanical Engineers

ANNUAL REPORT OF THE COUNCIL
AND
ACCOUNTS FOR THE YEAR 1909-1910;
LIST OF
COUNCIL, OFFICERS AND MEMBERS FOR THE YEAR 1910-1911;
ETC.
1909-1910.

[Seal]

NEWCASTLE-UPON-TYNE: PUBLISHED BY THE INSTITUTE.
Printed by Andrew Reid & Company, Limited, London and Newcastle-upon-Tyne.
1910

[iv]

CONTENTS.
A great national sorrow, the death of His Most Gracious Majesty King Edward the Seventh, has marked the past year. As loyal and faithful subjects, and as members of an Institute honoured by a Royal Charter of Incorporation, the Council forwarded an address to His Majesty King George the Fifth on May 14th, 1910. An acknowledgment from His Majesty was received through the Secretary of State for the Home Department, dated May 28th, 1910.

The following table shows the progress of the membership during recent years:

<table>
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<th>Year ending August 1st.</th>
<th>1907.</th>
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<td>942</td>
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<td>926</td>
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<tr>
<td>Associate members</td>
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<td>209</td>
<td>210</td>
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<td>Subscribers</td>
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<td>Totals</td>
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</table>

The slight increase in the membership is a matter for congratulation. The additions to the register number 84, and the losses by death, resignation, etc., 81, a net increase of 3 resulting.


The resignations (35) include the following: Honorary member: Arthur Henry Stokes. Members: Alfred Atkinson, George Bradford, John Henry Chilcote Brooking, James Chapman, Christopher Robert Corning, James Gibson Dees, Sothisenes Doise, Richard Percival Forster, F. Augustus Heinze, Thomas Hewitson, Edmund Louis Hope, Edward

The following gentlemen (36) have ceased to be members during the past year:


The Library has been maintained in an efficient condition during the year: the additions, by donation, exchange and purchase, include 324 bound volumes and 9 pamphlets, reports, etc.: and the Library now contains about 12,161 volumes and 405 unbound pamphlets. A card-catalogue of the books, etc., contained in the Library renders them easily available for reference.

Members would render useful service to the profession by the presentation of books, reports, plans, etc., to the Institute, to be preserved in the Library, and thereby become available for reference.

Exchanges of Transactions have been arranged, during the year, with The Smithsonian Institution, the University of California, the University of Illinois, and the Victorian Institute of Engineers.

The courses of lectures for colliery engineers, enginewrights, and apprentice mechanics have been, continued at Armstrong College, Newcastle-upon-Tyne. The lectures are delivered on Saturday afternoons, and the three years' course embraces the following subjects:


Several colliery-owners have paid the fees (£1 10s. per annum) and railway expenses of pupils attending the classes from their collieries. During the past year, the lectures of the Michaelmas Term on Machine Drawing were attended by 34 students, and on the Chemistry of Fuel by 37 students, 34 of whom sat for examination and 34 passed; and during the Epiphany Term, the lectures on the Strength of Materials were attended by 32 students, and on Experimental Mechanics by 34.
students, 30 of whom sat for examination and 25 passed. Certificates have been awarded to the following students, who have completed the three years' course: Messrs. P. Bateson, H. Beardmore, T. C. Cook and S. H. Wainwright. The first and second prizes for the Session 1909-1910, have been awarded to Messrs. P. Bateson and H. Beardmore, respectively.

During the past year a supplementary volume to An Account of the Strata of Northumberland and Durham, as proved by Borings and Sinkings, has been completed and published, and it is hoped that the members will complete their sets of this work by purchasing copies, and by so doing return to the Institute a portion of the great cost which has been incurred in preparing and publishing this exhaustive and valuable addition to the account of the strata of the two counties.

Mr. Thomas Douglas continues to represent the Institute as a Governor of Armstrong College, and Mr. John H. Merivale, in conjunction with the President (Mr. T. E. Forster), represents the Institute on the Council of the College.

Mr. Thomas Edgar Jobling has been appointed to represent the Institute upon the Board of Directors of the Institute and Coal Trade Chambers Company, Limited.

The President continues a Representative Governor upon the Court of Governors of the University of Durham College of Medicine during his term of office.

Dr. P. Phillips Bedson and Prof. Henry Louis represented the Institute at the International Congress of Mining, Metallurgy, Applied Mechanics and Practical Geology, held in Dusseldorf from June 19th to 23rd, 1910; whilst Mr. T. E. Forster acted upon the Committee of The Institution of Mining Engineers appointed to make arrangements for the representation of that Institution at the Congress, and at the request of the Council brought forward the question of the desirability of holding the next Congress in England.

Mr. T. E. Forster also represented the Institute upon the Committee of The Institution of Mining Engineers appointed to consider what evidence should be presented, and arrange for a witness or witnesses to give such evidence, before the Home Office Committee on Electricity in Mines.

Mr. William Charles Mountain will represent the Institute at the Conference of the Delegates of the Corresponding Societies of the British Association for the Advancement of Science, to be held in Sheffield, commencing on August 31st, 1910: and Mr. Johan August Brinell will represent the Institute at the Eleventh International Geological Congress, to be held in Stockholm in August, 1910.

The representatives of the Institute upon the Council of The Institution of Mining Engineers during the past year were as follows: Messrs. R. S. Anderson, William Armstrong, R. C. Aubrey, W. C. Blackett, A. G. Charleton, Benjamin Dodd, T. E. Forster, J. W. Fryar, William Galloway, Reginald Guthrie, Samuel Hare, A. M. Hedley, T. E. Jobling, J. P. Kirkup, Philip Kirkup, C. C. Leach, Henry Louis, George May,

[viii]


Under the will of the late Mr. John Daglish, funds have been placed at the disposal of Armstrong College for founding a Travelling Fellowship, to be called the "Daglish" Fellowship, candidates for which must be nominated by the Institute. Mr. Berent Conrad Gullachsen was in January, 1910, awarded the Fellowship, and suitable arrangements for his gaining knowledge and experience abroad have been made.

G. C. Greenwell gold, silver and bronze; medals may be awarded annually for approved papers "recording the results of experience of interest in mining, and especially where
deductions and practical suggestions are made by the writer for the avoidance of accidents in mines."

G. C. Greenwell silver medals have been awarded to Sir Henry Hall, I.S.O., for his paper upon "Coal-dust to date, and its Treatment with Calcium Chloride," and to Mr. Robert Nelson for his paper upon "Electricity in Coal-mines."

Prizes have been awarded to the writers of the following papers, communicated to the members during the years 1908-1909 and 1909-1910:

"Sinking the John Shaft at Hamsterley Colliery, through Sand and Gravel, by means of Underhanging Tubbing." By Mr. John Cummings, M.I.M.E.
"A Natal Colliery Explosion, and Underground Fires in Fiery Mines." By Mr. William Taylor Heslop, M.I.M.E.

The papers printed in the Transactions during the year are as follows:

"Fence-gates for Winding-shaft Cages." By Mr. Charles Arthur Crofton, M.I.M.E.
"Sinking the John Shaft at Hamsterley Colliery, through Sand and Gravel, by means of Underhanging Tubbing." By Mr. John Cummings, M.I.M.E.
"Electric Shot-firing." By Mr. James Douglas, M.I.M.E.
"Some Results of Experiments made to Test the Effect of Sprayers upon the Moisture of Main Roads at Brandon Colliery." By Mr. T. L. Elwen, M.I.M.E. "Automatic Cage Tub-stops." By Mr. T. Campbell Filters, M.I.M.E.
"The Cunynghame-Cadman Gas-detecting Device." By Mr. E. A. Hailwood.
"A Natal Colliery Explosion, and Underground Fires in Fiery Mines." By Mr. William Taylor Heslop, M.I.M.E.
"Electricity at the Shamrock I. and II. Colliery, Herne, Westphalia, Germany." By Mr. Henry Moore Hudspeth, Assoc. I.M.E.
"The Ignition of Coal-dust by Single Electric Flashes." By Prof. W. M. Thornton, Hon. M.I.M.E., and Mr. E. Bowden.
"The Electrification of Murton Colliery, County Durham." By Mr. F. Seymour Wood, M.T.M.E.
"Blyth Harbour."

In connection with the General Meeting held upon June 11th, 1910, a visit was paid to the Electrical Engineering Theatre of Armstrong College, when Prof. W. M. Thornton and his assistants gave a number of demonstrations of the ignition of coal-dust by single electric flashes.

An Excursion meeting was held at Blyth. on July 7th, 1910.

The thanks of the Institute have been sent to the owners of collieries, works, etc., visited during the year.

The Committee appointed, with Mr. Stanley Smith as Secretary, to report upon the Carboniferous Limestone Formation of the North of England, with Special Reference to its Coal He-sources, is carrying out its investigations.

The collection of safety-lamps has been loaned to the Brussels Exhibition.
The Geological Society of London, supported by this and many other societies, has presented an appeal to the Lords of His Majesty's Treasury against the recent increase in price of the hand-coloured edition of the one-inch maps issued by the Geological Survey of the United Kingdom.

The rooms of the Institute have been used, during the year, by the Newcastle-upon-Tyne Association of Students of the Institution of Civil Engineers; the Newcastle District Telephone Society; the Newcastle-upon-Tyne Economic Society; the Newcastle-upon-Tyne and Gateshead Gas Company; the Northumberland and Durham Provincial Committee of the Surveyors' Institution; and the Foremen's Mutual Benefit Society.

The Council, in reporting that the North-eastern Railway Company had granted reduced railway-fares to members attending general or excursion meetings of the Institute, expressed the hope that the concession would lead to an increased attendance at the meetings. They regret that no material increase has resulted, but trust that in the future a larger number of members will avail themselves of the privilege.

The Institution of Mining Engineers has now entered upon its twenty-second year, and the members are to be congratulated upon its continued success. Meetings were held in Newcastle-upon-Tyne in September, 1909, and in London in June, 1910. The Twentieth Annual General Meeting held in Newcastle-upon-Tyne was largely attended, and the best thanks of the members are due to the committee who made the arrangements, to the owners of collieries and works open for inspection, and to all those who by their services contributed to the holding of the meeting, which was in every way a success.

[Annual Report of the Finance Committee]

The Finance Committee submit herewith a statement of accounts for the twelve months ending June 30th, 1910 duly audited.

The total receipts were £2,925 16s. 1d. Of this amount £54 6s. represents subscriptions paid in advance, leaving £2,872 10s. 1d. as the ordinary income of the year, compared with £2,888 1s. 2d. in the previous year. The amount received for ordinary current-year subscriptions was £2,240 7s., and arrears £203 10s., as against £2,287 7s. and £222 8s. respectively in the year 1908-1909. Transactions sold realised £23 15s. 6d., as compared with £21 14s. 1d. in the earlier period; and the sum received for interest on investments was £353 17s. 7d. the amount in the former year being £356 12s. 1d.

The expenditure was £2,988 18s. 3d., that for the previous year being £2,994 18s. 3d. The sum of £108 expended in connection with the Committee appointed to Report upon the Carboniferous Limestone Formation of the North of England, with Special Reference to its Coal Resources, £288 143. 7d. for the publication of the Supplementary Volume to An Account of the Strata of Northumberland and Durham, as proved by Borings and Sinkings, and £44 19s. 4d. for expenses of meetings, may be regarded as special expenditure.

From the above figures it will be seen that the expenditure exceeded the income by £63 2s. 2d., and deducting this amount from the balance of £430 4s. 2d., brought forward from the previous year, leaves a credit balance of £367 2s.

During the year the Institute and Coal-trade Chambers Company, Limited, decided to issue new shares for the purpose of providing for the cost of the alterations to the Building. These were offered to the shareholders in proportion to their existing holdings, and it was decided that the proportion allotted to the Institute should be accepted. This proportion amounted to 28 shares of £20 each, which were issued at 5 premium of £4, or £25 in all. The first payment of £280 was made during the year, and this, deducted from the credit balance of £367 2s., leaves a sum of £87 2s. to be carried forward.
The names of 36 persons have been struck off the membership list in consequence of non-payment of subscriptions. The amount of subscriptions written off was £191 8s., of which £81 17s. was for sums due for the year 1909-1910, and £109 11s. for arrears. It is probable that a considerable proportion of these amounts will be recovered and credited in future years. Of the amount previously written off, £39 17s. was recovered during the past year.

T. E. Forster, President.

August 6th, 1910.

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THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS:
GENERAL STATEMENT, JUNE 30TH. 1910.

LIABILITIES.

<table>
<thead>
<tr>
<th>Description</th>
<th>£ s. d.</th>
<th>£ s. d.</th>
<th>£ s. d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subscriptions paid in advance during the current year</td>
<td>53 6 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The George Clementson Greenwell prize fund</td>
<td>100 0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less, paid for medals</td>
<td>70 1 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital</td>
<td>12,541 13 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ASSETS.

<table>
<thead>
<tr>
<th>Description</th>
<th>£ s. d.</th>
<th>£ s. d.</th>
<th>£ s. d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance in Treasurer's hands</td>
<td>89 7 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less, due to bankers</td>
<td>3 6 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outstanding accounts due from authors for excerpts</td>
<td>1 0 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrears of subscriptions</td>
<td>287 16 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>179 shares in the Institute and Coal-trade Chambers</td>
<td>4,100 0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Company, Limited (at cost)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28 new shares in the Institute and Coal-trade Chambers</td>
<td>280 0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Company, Limited (first call)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institute and Coal-trade Chambers Company, Limited</td>
<td>1,400 0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mortgage)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>£340 consolidated 0 per cent. preference stock of the</td>
<td>499 17 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newcastle and Gateshead Water Company (at cost)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>£450 ordinary stock of the Newcastle and Gateshead Gas</td>
<td>487 13 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Company (at cost)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Of the above amount, £1,710 is due to life-subscriptions account.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of Transactions and other publications. as per stock account</td>
<td>332 9 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Books, pictures, maps, furniture and fittings</td>
<td>5,150 0 0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We have examined the above balance-sheet with the books, vouchers and securities relating thereto, and certify that, in our opinion, it is correct. We have accepted the assets,
books, pictures, maps, etc. and Transactions and other publications, as valued by your officials.

JOHN G. BENSON AND SONS,
CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne,
July 23rd, 1910.

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The Treasurer in Account with The North of England Institute of Mining and Mechanical Engineers
For the Year ending June 30th, 1910.

Dr.

<table>
<thead>
<tr>
<th>Description</th>
<th>£</th>
<th>s.</th>
<th>d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 30th. 1909. To balance of account at bankers</td>
<td>347</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>&quot; in Treasurer's hands</td>
<td>80</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td>&quot; outstanding accounts due from authors for excerpts</td>
<td>1</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>430</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>June 30th. 1910. To dividend of 7 (\frac{1}{2}) per cent. on 179 shares of £20 each in the Institute and Coal-trade Chambers Company, Limited, for the year ending June 30th, 1910</td>
<td>268</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>&quot; interest on mortgage of £1,400 with the Institute and Coal-trade Chambers Company, Limited</td>
<td>46</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>&quot; dividend on £340 consolidated 5 per cent. Preference stock of the Newcastle and Gateshead Water Company</td>
<td>16</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>&quot; dividend on £450 ordinary stock of the Newcastle and Gateshead Gas Company</td>
<td>18</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>&quot; interest on deposit account</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>353</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>To sales of Transactions</td>
<td>23</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>To Subscriptions for 1909-1910 as follows:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>747 members @ £2 2s.</td>
<td>1,568</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>81 associate members @ £2 2s.</td>
<td>170</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>181 associates @ £1 5s.</td>
<td>220</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>40 students @ £1 5s.</td>
<td>50</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40 new members @ £2 2s.</td>
<td>84</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9 new associate members @ £2 2s.</td>
<td>18</td>
<td>18</td>
<td>0</td>
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<tr>
<td>18 new associates @ £1 5s.</td>
<td>22</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>10 new students @ £1 5s.</td>
<td>12</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2,152</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>33 subscribing firms</td>
<td>117</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>2 new subscribing firms</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2,274</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Less, subscriptions for current year paid in advance at end of last year</td>
<td>34</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2,240</td>
<td>7</td>
<td>0</td>
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<tr>
<td>2 members, paid life-compositions</td>
<td>51</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2,291</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Add, arrears received</td>
<td>203</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2,194</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>Add, subscriptions paid in advance during current year</td>
<td>53</td>
<td>6</td>
<td>0</td>
</tr>
</tbody>
</table>
Cr.

<table>
<thead>
<tr>
<th>Description</th>
<th>£</th>
<th>s</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>By salaries and wages</td>
<td>496</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>„, insurance</td>
<td>13</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>„, rent, rates and taxes</td>
<td>31</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>„, heating, lighting, etc.</td>
<td>50</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>„, furniture and repairs</td>
<td>8</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>„, bankers’ charges</td>
<td>21</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>„, library</td>
<td>35</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>„, printing, stationery, etc.</td>
<td>165</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>„, postages, etc.</td>
<td>77</td>
<td>19</td>
<td>3</td>
</tr>
<tr>
<td>„, incidental expenses</td>
<td>61</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>„, travelling expenses</td>
<td>13</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>„, prizes for papers</td>
<td>7</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>„, reporting of general meetings</td>
<td>12</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>„, library catalogue</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>„, Committee to report upon the Carboniferous Limestone Formation of the North of England, with Special Reference to its Coal Resources</td>
<td>108</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>„, supplementary volume to An Account of the Strata of Northumberland and Durham, as proved by Borings and Sinkings</td>
<td>288</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>„, expenses of meetings</td>
<td>44</td>
<td>19</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>1,445</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>By The Institution of Mining Engineers</td>
<td>1,335</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>“ “ “ “: Guarantee Fund</td>
<td>212</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>1,548</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Less, amounts paid by authors for excerpts</td>
<td>4</td>
<td>19</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>1,543</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>2,988</td>
<td>18</td>
<td>3</td>
</tr>
</tbody>
</table>

By balance:

Paid on account of 28 new shares in the Institute and Coal-trade Chambers Company, Limited (first call, leaving to be paid £420) | 280 0 0

Balance in Treasurer’s hands | 89 7 4

Less, due to bankers | 3 6 0

86 1 4

Outstanding accounts due from authors for excerpts | 87 2 0

86 1 4

367 2 0

£3,356 0 3


Dr.
To 935 members, 51 of whom have paid life-compositions.

881
3 not included in printed list.

887 @ £2 2s. 1,862 14 0
2 paid life-compositions 51 0 0

To 103 associate members.
9 of whom have paid life-compositions

94 @ £2 2s 197 8 0
To 210 associates, 1 of whom has paid a life-composition.

209
5 paid as members.

204 @ £1 5s 255 0 0
To 54 students @ £1 5s 67 10 0
To 34 subscribing firms 119 14 0

To 40 new members @ £2 2s 84 0 0
To 9 new associate members @ £2 2s. 18 18 0
To 18 new associates @ £1 5s 22 10 0
To 10 new students @ £1 5s 12 10 0
To 2 new subscribing firms 4 4 0

3,008 9 0
To subscriptions paid in advance

53 6 0
-------------
£3,061 15 0

[xv]

Cr.

<table>
<thead>
<tr>
<th>PAID</th>
<th>UNPAID.</th>
<th>STRUCK OFF LIST.</th>
</tr>
</thead>
<tbody>
<tr>
<td>£</td>
<td>s.</td>
<td>d.</td>
</tr>
<tr>
<td></td>
<td>£</td>
<td>s.</td>
</tr>
<tr>
<td></td>
<td>d.</td>
<td></td>
</tr>
</tbody>
</table>

By 747 members, paid @ £2 2s. 1,568 14 0
106 ,, unpaid @ £2 2s. 222 12 0
1 ,, excused payment @ £2 2s. 2 2 0
3 ,, dead @ £2 2s 6 6 0
30 ,, struck off list @ £2 2s 63 0 0

887
2 paid life-compositions 51 0 0

By 81 associate members, paid @ £2 2s. 170 2 0
12 ,, unpaid @ £2 2s 25 4 0
1 ,, struck off list @ £2 2s 2 2 0

By 181 associates, paid @ £1 5s. 226 5 0
19 ,, unpaid @ £1 5s 23 15 0
4 ,, struck off list @ £1 5s 5 0 0

94

By 40 students, paid @ £1 5s. 50 0 0
13 ,, unpaid @ £1 5s 16 5 0
1 ,, struck off list @ £1 5s 1 5 0

By 33 subscribing firms, paid 117 12 0
1 ,, excused payment 2 2 0

34
By 40 new members, paid @ £2 2s. 81 0 0
By 9 new associate members, paid @ £2 2s. 18 18 0
By 18 new associates, paid @ £1 5s. 22 10 0
By 10 new students, paid @ £1 5s. 12 10 0
By 2 new subscribing firms, paid 4 4 0

By arrears
203 10 0
109 11 0

By subscriptions paid in advance
53 6 0

----------
2,325 15 0 287 16 0 81 17 0
203 10 0 109 11 0
2,529 5 0

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2,582 11 0 287 16 0 191 8 0
287 16 0
2,582 11 0

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£3,061 15 0

[xvi]

LIST OF COMMITTEES APPOINTED BY THE COUNCIL 1910-1911.

Finance Committee.
Mr. W. C. Blackett. Mr. T. Y. Greener Mr. John Simpson
Mr. Thomas Douglas. Mr. T. E. Jobling Mr. J. B. Simpson
Mr. T. E. Forster. Mr. George May. Mr. J. G. Weeks

Arrears Committee.
Mr. W. C. Blackett. Mr. T. Y. Greener Mr. John Simpson
Mr. Thomas Douglas. Mr. T. E. Jobling Mr. J. B. Simpson
Mr. T. E. Forster. Mr. George May. Mr. J. G. Weeks

Library Committee.
Mr. R. S. Anderson. Mr. A. M. Hedley. Mr F. R. Simpson
Mr. J. B. Atkinson. Mr. J. P. Kirkup. Mr. John Simpson
Mr. T. E. Forster. Mr. George May. Mr. J. G. Weeks
Mr. Henry Palmer.

Prizes Committee.
Mr. W. C. Blackett. Mr. C. C. Leach. Mr. John Simpson
Mr. T. E. Forster. Mr. A. D. Nicholson Mr J. G. Weeks
Mr. Samuel Hare. Mr. Henry Palmer.

Committee to Report upon the Carboniferous Limestone Formation of the North of England, with Special Reference to its Coal Resources.
Mr. J. B. Atkinson. Mr. T. E. Forster. Mr. A. D. Nicholson
Mr. David Burns Mr. J. P. Kirkup. Mr. F. R. Simpson.
Mr. W. Cochran Carr. Prof. G. A. L. Lebour.

Reference Committee for Papers to Read
(a) Coal-mining.
Mr. R. W. Berkley. Mr. T. E. Forster. Mr. Henry Palmer
Mr. W. C. Blackett. Mr. T. Y. Greener. Mr. John Simpson
<table>
<thead>
<tr>
<th>Committee</th>
<th>Members</th>
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<tbody>
<tr>
<td>(a) Civil Engineering</td>
<td>Mr. Benjamin Dodd. Mr. Philip Kirkup. Mr. J. B. Simpson.</td>
</tr>
<tr>
<td>(b) Metalliferous Mining</td>
<td>Mr. R. Donald Bain, Mr. A. M. Hedley. Mr. A. L. Steavenson.</td>
</tr>
<tr>
<td>(c) Geological</td>
<td>Mr. R. S. Anderson. Mr. R. Donald Bain. Prof. G. A. L. Lebour.</td>
</tr>
<tr>
<td>(d) Mechanical and Electrical Engineering</td>
<td>Mr. Sidney Bates. Mr. J. P. Kirkup. Hon. C. A. Parsons.</td>
</tr>
<tr>
<td>(e) Chemical</td>
<td>Prof. P. Phillips Bedson. Mr. R. W. Berkley. Dr. G. P. Lishman.</td>
</tr>
<tr>
<td>(f) Civil Engineering</td>
<td>Mr. J. H. B. Forster. Mr. W. C. Mountain. Mr. A. L. Steavenson.</td>
</tr>
<tr>
<td>(f) Chemical</td>
<td>Mr. T. E. Forster. Mr. F. R. Simpson.</td>
</tr>
</tbody>
</table>

N. B.---- The President is ex-officio on all Committees.

OFFICERS, 1910-1911.

PAST-PRESIDENTS (ex-officio).

Sir LINDSAY WOOD, Bart., The Hermitage, Chester-le-Street.
Mr. JOHN BELL SIMPSON, Bradley Hall, Wylam, Northumberland.
Mr. ADDISON LANGHORNE STEAVENSON, Durham.
Mr. THOMAS DOUGLAS, The Garth, Darlington.
Mr. GEORGE MAY, Clervaux Castle, Croft, Darlington.
Mr. WILLIAM ARMSTRONG, Elmfield Lodge, Gosforth, Newcastle-upon-Tyne.
Mr. JOHN GEORGE WEEKS, Bedlington, Northumberland.
Mr. WILLIAM OUTTERSON WOOD, South Hetton, County Durham.
Mr. THOMAS WALTER BENSON, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne.
Mr. JOHN HERMAN MERIVALE, Togston Hall, Acklington, Northumberland.
Mr. THOMAS EMERSON FORSTER, 3, Eldon Square, Newcastle-upon-Tyne.

PRESIDENT.
Mr. MATTHEW WILLIAM PARRINGTON, Wearmouth Colliery, Sunderland.  
VICE-PRESIDENTS. 
Mr. JOHN BOLAND ATKINSON, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne.  
Mr. RICHARD DONALD BAIN, H.M. Inspector of Mines. Durham.  
Mr. THOMAS YOUNG GREENER. West Lodge. Crook, County Durham.  
Mr. CHARLES CATTERALL LEACH, Seghill Colliery, Seghill, Dudley, Northumberland.  
Mr. HENRY PALMER, Monks Holme, Corbridge, Northumberland.  
Mr. FRANK ROBERT SIMPSON, Hedgeheld House, Blaydon-upon-Tyne, County Durham.  

RETIRING VICE-PRESIDENTS (ex-officio).  
Mr. WILLIAM CUTHBERT BLACKETT, Acorn Close, Sacriston, Durham.  
Mr. JOHN SIMPSON, Heworth Colliery, Felling, County Durham.  

COUNCILLORS.  
Mr. ROBERT SIMPSON ANDERSON, Highfield, Wallsend, Northumberland.  
Mr. CUTHBERT BERKLEY, Highfield House, Durham.  
Mr. RICHARD WILLIAM BERKLEY, Marley Hill, Swalwell, County Durham.  
Mr. WILLIAM COCHRAN CARR, Benwell Colliery, Newcastle-upon-Tyne.  
Mr. BENJAMIN DODD, Percy House, Neville’s Cross, Durham.  
Mr. MARK FORD, Washington Colliery, Washington Station, County Durham.  
Mr. SAMUEL HARE, Howlish Hall, Bishop Auckland.  
Mr. ARTHUR MORTON HEDLEY, Blaydon Burn, Blaydon-upon-Tyne, County Durham.  
Mr. THOMAS EDGAR JOBLING, Bebside, Northumberland.  
Mr. AUSTIN KIRKUP, Mining Office, Bunker Hill, Fence Houses.  
Mr. JOHN PHILIP KIRKUP, Burnhope, Durham.  
Mr. PHILIP KIRKUP, Leafield House, Birtley, County Durham.  
Mr. JOHN MORISON, 14, Saville Row, Newcastle-upon-Tyne.  
Mr. WILLIAM CHARLES MOUNTAIN, 8, Sydenham Terrace, Newcastle-upon-Tyne.  
Mr. ARTHUR DARLING NICHOLSON, H.M. Inspector of Mines, Red Hill, Durham.  
Mr. JOHN HODGSON NICHOLSON, Cowpen Colliery Office, Blyth.  
Mr. SIMON TATE, Trimdon Grange Colliery, County Durham.  
Mr. ERNEST SEYMOUR WOOD, Cornwall House, Murton, County Durham.  

TREASURER.  
Mr. REGINALD GUTHRIE, Neville Hall, Newcastle-upon-Tyne.  
HONORARY SECRETARY.  
Mr. JOHN HERMAN MERIVALE, Neville Hall, Newcastle-upon-Tyne.  
SECRETARY.  
Mr. LAWRENCE AUSTIN, Neville Hall, Newcastle-upon-Tyne.  
AUDITORS.  
Messrs. JOHN G. BENSON and SONS, Newcastle-upon-Tyne.  
BANKERS.  
LLOYDS BANK LIMITED (LAMBTON’S BRANCH), Grey Street, Newcastle-upon-Tyne.  

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LIST OF MEMBERS,  
AUGUST 6. 1010.  
---------  
PATRONS.  
His Grace the DUKE OF NORTHUMBERLAND.  
The Most Honourable the MARQUESS OF LONDONDERRY
The Right Honourable the EARL OF DURHAM.
The Right Honourable the EARL GREY.
The Right Honourable the EARL OF LONSDALE.
The Right Honourable the EARL OF WHARNCLIFFE.
The Right Reverend the LORD BISHOP OF DURHAM.
The Right Honourable LORD ALLENDALE.
The Right Honourable LORD BARNARD.
The Right Honourable LORD RAVENSWORTH.
The Very Reverend the DEAN AND CHAPTER OF DURHAM.

---------------

HONORARY MEMBERS (Hon. M.I.M.E.).

* Honorary Members during term of office only.

1*JOHN ROLAND ATKINSON, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne. Date of Election Aug 4, 1888
4*Prof. PETER PHILLIPS BEDSON, Armstrong College, Newcastle-upon-Tyne. Feb. 10, 1883
5 THOMAS BELL, 40, Esplanade Road, Scarborough. Dec. 12, 1896
6 JOSEPH DICKINSON, 3, South Bank, Sandy Lane, Pendleton, Manchester. Nov. 24, 1894
7 Prof. WILLIAM GARNETT, London County Council Education Office, Victoria Embankment, London, W.C. Date of Election June 11, 1892
8*JOHN GERRARD, H.M. Inspector of Mines, Worsley, Manchester. June 14, 1902
10*Dr. WILLIAM HENRY HADOW. Armstrong College. Newcastle-upon-Tyne. Feb. 5, 1897
11*SIR HENRY HALL, I.S.O., H.M. Inspector of Mines, Rainhill, Lancashire. March 4, 1876
13*Prof. GEORGE ALEXANDER LOUIS LEBOUR, Armstrong College, Newcastle-upon-Tyne. Transactions, etc., sent to Radcliffe House, Corbridge, Northumberland Nov. 1, 1879
14*JOHN DYER LEWIS, H.M. Inspector of Mines, Glanrhyd, Sketty Road, Swansea. Dec. 11, 1904
15*Prof. HENRY LOUIS, Armstrong College, Newcastle-upon-Tyne. Transactions sent to The Librarian, Armstrong College, Newcastle-upon-Tyne Dec. 12, 1896
18 DANIEL MURGUE, 1, rue St. Honore, St. Etienne, Loire, France Date of Election June 20, 1908
22*Prof. HENRY STRoud, Armstrong College, Newcastle-upon-Tyne. Nov. 5, 1892
23*JETHRO JUSTIMAN HARRIS TEALL, Director of the Geological Survey of the United Kingdom, 28, Jermyn Street, London, S.W. Aug. 3, 1901
24*Prof. WILLIAM MUNDELL THORNTON, Armstrong College, Newcastle-upon-Tyne. Feb. 12, 1910
26*Prof. ROBERT LUNAN WEIGHTON, Armstrong College, Newcastle-upon-Tyne. April 2, 1898

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MEMBERS (M.I.M.E.).

Marked* have paid life composition.
<table>
<thead>
<tr>
<th>Name</th>
<th>Address/Position</th>
<th>Date of Election and of Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Abbott, Henry Arnold</td>
<td>H.M. Inspector of Mines, 1 Highbury, West Jesmond, Newcastle-upon-Tyne</td>
<td>Feb. 13, 1904</td>
</tr>
<tr>
<td>2 Abel, Walter Robert</td>
<td>Scottish Provident Buildings, Mosley Street, Newcastle-upon-Tyne</td>
<td>Dec. 8, 1906</td>
</tr>
<tr>
<td>3 Aucutt, Sidney</td>
<td>The Barrett Gold-mining Company, Limited, Kaapoche Hoop, Transvaal</td>
<td>Dec. 10, 1904</td>
</tr>
<tr>
<td>4 Adair, Hubert, Gillfoot</td>
<td>Egremont, Cumberland</td>
<td>April 8, 1905</td>
</tr>
<tr>
<td>5 Adams, George Francis</td>
<td>Inspector of Mines in India, Dhanbad, E.I. Railway, Manbhum District, Bengal, India</td>
<td>Aug. 5, 1905</td>
</tr>
<tr>
<td>6 Adams, Henry Hopper</td>
<td>c/o H. Gilfillian, Jun., 108 and 109, Victoria Arcade, Auckland, New Zealand</td>
<td>April 10, 1897</td>
</tr>
<tr>
<td>7 Adams, Phillip Francis Burnet Burnet</td>
<td>Surveyor-General for the Orange River Colony, Government Office, Bloemfontein, Orange River Colony, South Africa</td>
<td>Oct., 12, 1901</td>
</tr>
<tr>
<td>8 Adamson, Thomas</td>
<td>Jheriah P.O District Manbhoom, Bengal, India</td>
<td>Feb. 10, 1894</td>
</tr>
<tr>
<td>9 Ainsworth, Herbert</td>
<td>P.O. Box 1553, Johannesburg, Transvaal</td>
<td>Feb. 14, 1903</td>
</tr>
<tr>
<td>10 Ainsworth, John W.</td>
<td>Bridgewater Offices, Walkden, Manchester</td>
<td>Dec. 14, 1895</td>
</tr>
<tr>
<td>11 Aldridge, Walter</td>
<td>Hull, Trail, British Columbia</td>
<td>Feb. 8, 1908</td>
</tr>
<tr>
<td>13 Allan, Philip</td>
<td>Mina de San Dominigos, Mertola, Portugal</td>
<td>June 10, 1905</td>
</tr>
<tr>
<td>14 Allison, J. J. G.</td>
<td>Woodland Collieries, Butterknowle, County Durham</td>
<td>A.M. Feb. 13, 1886</td>
</tr>
<tr>
<td>15 Andersen, Carl,</td>
<td>Sandy, Lincoln County, Nevada, U.S.A.</td>
<td>Oct. 8, 1894</td>
</tr>
<tr>
<td>16 Anderson, Robert</td>
<td>Hay, Apartado Postal 866, Mexico, D.F.</td>
<td>Aug. 4, 1894</td>
</tr>
<tr>
<td>17 Anderson, Robert</td>
<td>Simpson, Highfield, Wallsend, Northumberland (Member of Council)</td>
<td>S. June 9, 1883</td>
</tr>
<tr>
<td>20 Angwin, Benjamin</td>
<td>3, Penlu Terrace, Tuckingmill, Camborne</td>
<td>Nov. 24, 1894</td>
</tr>
<tr>
<td>21 Appleby, Harry</td>
<td>Walton, c/o The St. John del Rey Mining Company, Limited, Villa Nova de Lima, Estado de Minas, Brazil, South America</td>
<td>Oct. 8, 1898</td>
</tr>
<tr>
<td>22 Appleby, William</td>
<td>Remsen, Minnesota School of Mines, The University of Minnesota, Minneapolis, Minnesota, U.S.A.</td>
<td>April 14, 1894</td>
</tr>
<tr>
<td>23 Archer, Thomas</td>
<td>Mardale Parade, Gateshead-upon-Tyne</td>
<td>July 2, 1872</td>
</tr>
<tr>
<td>24 Archer, William</td>
<td>Victoria Garesfield, Lintz Green, County Durham</td>
<td>A. Aug. 6, 1892</td>
</tr>
<tr>
<td>25 Armstrong, George</td>
<td>Herbert Archibald, Castle View, Chester-le-Street</td>
<td>S. April 7, 1867</td>
</tr>
<tr>
<td>26 Armstrong, Henry</td>
<td>Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne</td>
<td>A.M. April 14, 1883</td>
</tr>
<tr>
<td>27 Armstrong, William</td>
<td>Elmfield Lodge, Gosforth, Newcastle-upon-Tyne (Past-President, Member of Council)</td>
<td>M. June 8, 1889</td>
</tr>
<tr>
<td>28 Arnold, Thomas</td>
<td>Castle Buildings, Llanelly</td>
<td>M. Aug. 6, 1870</td>
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<tr>
<td>29 Ashmore, George</td>
<td>Percy, 109, Lansdowne Place, Hove, Brighton</td>
<td>April 13, 1907</td>
</tr>
<tr>
<td>30 Athron, Harold</td>
<td>Vivian, Moorland House, Haight, Wigan</td>
<td>Feb. 13, 1897</td>
</tr>
<tr>
<td>31 Atkinson, John</td>
<td>Boland, H.M. Inspector of Mines, 2, Devonshire Terrace, Newcastle-upon-Tyne (Vice-President, Member of Council)</td>
<td>Oct. 11 1902</td>
</tr>
<tr>
<td>32 Attwood, Alfred</td>
<td>Lionel, Remolinos, por Pedrola, Provincia de Zaragoza, Spain</td>
<td>Aug. 5 1905</td>
</tr>
<tr>
<td>33 Aubrey, Richard</td>
<td>Charles, Salisbury House, The Fosse Central, Leicester</td>
<td>Feb. 5 1870</td>
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<td>34 Baare, Fritz</td>
<td>Bochum, Westphalia, Germany</td>
<td>Aug. 3, 1907</td>
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<td>35 Bagnoi, Ugo</td>
<td>Orbetello, Italy</td>
<td>Feb. 8, 1908</td>
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<tr>
<td>36 Bailes, Thomas</td>
<td>Jesmond Gardens, Newcastle-upon-Tyne</td>
<td>Oct. 7, 1858</td>
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<tr>
<td>37 Bailey, Archibald</td>
<td>Duncan, c/o S. G. Bailey and Company, Limited, Stafford Mills, Stroud, Gloucestershire</td>
<td>Oct. 8, 1898</td>
</tr>
<tr>
<td>38 Bailey, Edward</td>
<td>Trenholm, Penjaboengan, Padang, Sumatra (West Coast), Netherlands East Indies</td>
<td>A.M. June 13, 1896</td>
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<td></td>
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<td>M. June 12, 1897</td>
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</table>
39 Bain, Richard Donald, H.M. Inspector of Mines, Durham (Vice-President, Member of Council) 
40 Bainbridge, Emerson, 47, Upper Grosvenor Street, London, W 
41 Bainbridge, Emerson Muschamp, Shipcote, Newbiggin-by-the-Sea, Northumberland 
42 Baldwin, Ivo William, Oakleigh, Ruardean, Mitcheldean, Gloucestershire 
43 Barber, George Marriott, c/o Tracey Brothers, Medellin, Antioquia, Republic of Colombia, South America 
44 Barker, Matthew Wilson, Clyncoed, Laurie Park Road, Sydenham, London, S.E 
45 Barnard, Robert, 53, York Road, Birkdale, Southport 
46 Barnes, James, Heddon Greta, via West Maitland, New South Wales, Australia 
47 Barrass, Matthew, Wheatley Hill Colliery Office, Thornley, County Durham 
48 Barrett, Charles Rollo, Whitehall Hall, Pelton Fell, County Durham 
49 Barrow, William, Seaton Burn Colliery, Dudley, Northumberland 
50 Barrs, Edward, Cathedral Buildings, Newcastle-upon-Tyne 
51 Bartholomew, Charles William, Blakesley Hall, near Towcester 
52 Bartlett, George Pilcher, The Motories, Durban, Natal, South Africa 
53 Bates, Matthew John, Highbury, Stocksfield, Northumberland 
54 Bates, Sidney, The Grange, Prudhoe, Ovingham, Northumberland 
55 Bateson, Walter Remington, Casilla 755, Antofagasta, Chile, South America 
56 Bawden, William, Plashetts, Northumberland 
57 Bell, Harold Percy, Pendlebury Colliery, Bentley, near Walsall 
58 Bell, Joseph Fenwick, Bunker Hill, Fence Houses 
59 Bell, Reginald, Shildon Lodge Colliery, Darlington 
60 Bell, Walter, c/o Pyman, Bell and Company, Hull 
61 Bell, William, Plaschettts, Northumberland 
62 Bell, William Ralph, Wearmouth Colliery, Sunderland 
63 Bell, William, Inglenook, Beechdale Avenue, Westcliff-on-Sea, Southend-on-Sea, U.S.A 
64 Bennet, Alexander Richard, Dundee Coal Company, Limited, Talana, Natal, South Africa 
65 Bennett, Alfred Henry, Bedminster, Easton, Kingswood and Parkfield Collieries Limited, East on Colliery, Bristol 
66 Bennett, Henry, 12, Tavistock Road, Callington, Cornwall 
67 Benson, Thomas Walter, Collingwood Buildings, Collingwood Street, Newcastle-upon-Tyne (Past-President, Member of Council) 
68 Berkley, Cuthbert, Highfield House, Durham (Member of Council) 
69 Berkley, Richard William, Marley Hill, Swalwell, County Durham (Member of Council) 
70 Bigg-Wither, Harris, The Mount, Gathurst, Wigan 
71 Bigge, Denys Leighton Selby, 27, Mosley Street, Newcastle-upon-Tyne 
72 Bigland, Hubert Hallam, The Stones, Whitley Bay, Northumberland 

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77 Bigland, John, Henknowle, Bishop Auckland
78 Bird, Edward Erskine, c/o George Elliot and Company, Limited, 16, Great George
Street, Westminster, London, S.W
79 Blackett, William Cuthbert, Acorn Close, Sacriston, Durham (Retiring Vice-President,
Member of Council)
80 Blaiklock, Thomas Henderson, Bebside Colliery, Bebside, Northumberland
81 Blandford, Thomas, Main Street, Haltwhistle, Northumberland
82 Bonniwell, Percival Ormond, Cardeeth, 32, Rylett Crescent. Ravenscourt Park, London, W.
83 Bookless, James, 14, Wilson Terrace, Broughton Moor, Maryport
84 Borlase, William Henry, Greenside Lodge, Glenridding, Penrith
85 Bowen, David, The University, Leeds
86 Bowler, Francis, Ouston Colliery Office, Chester-le-Street
87*Bracken, Thomas Wilson, 40, Grey Street, Newcastle-upon-Tyne
88 Braidford, William Jun., South Garesfield Colliery, Lintz Green, County Durham
89 Bramwell, Hugh, Great Western Colliery, near Pontypridd
90 Breakell, John Edwin, Glenthorne, 4, Cedar Road, Teddington, London, S. W.
91*Brinell, Johan August, Jernkontoret, Stockholm, Sweden
92 Broad, Wallace, Changsha, Hunan Province, China
93 Brodigan, Charles Bernard, P.O. Box 3, Brakpan, Transvaal
94 Bromly, Alfred Hammond, c/o Taylor and Howat, Apartado 232, Mexico, D. F.
95 Broome, George Herbert, State Coal Mines, Mines Department, Melbourne, Victoria,
Australia
96 Brough, Thomas, New Seahani Colliery, Sunderland
97 Brown, Douglas Philip, The Old House, Sowerby, Thirsk
98 Brown, John Coxnell, Westport Coal Company, Limited, Denniston, New Zealand
99 Brown, Robert Oughton, Elswick Collieries, Newcastle-upon-Tyne
100 Brown, Ralph Richardson, Pekin Syndicate, Limited, Honan, North China
101 Brown, W. Forster, Cefn Coed, Malpas, Newport, Monmouthshire
102 Browne, Robert John, Bhowra Colliery, Jheria, E.I.R., Bengal, India
103 Browning, Walter James, c/o Rio Tinto Company, Limited, Provincia de Huelva, Spain
104 Bruce, John, Port Mulgrave, Hinderwell, Yorkshire
105 Bryham, William, Bank House, Wigan
106 Buckle, Christopher Ernest, Elmwood, Denville, Havant
107 Bull, Henry Matthews, Bengal Coal Company, Limited, Mohuda, B.N.R., Manbhoom
District, India
108 Bullman, Harrison Francis, Leazes Hall, Burnopfield, County Durham
109 Bunning, Charles Ziethen, c/o The British Vice-Consul, Pandemia, near Constantinople, Turkey
110 Biers, Herbert Thomas, c/o Edward Riley and Harbord, 16, Victoria Street, Westminster, London, S. W.

Date of Election and of Transfer

90 Breakell, John Edwin, Glenthorne, 4, Cedar Road, Teddington, London, S. W. April 25, 1896
91*Brinell, Johan August, Jernkontoret, Stockholm, Sweden June 9, 1900
92 Broad, Wallace, Changsha, Hunan Province, China April 28, 1900
93 Brodigan, Charles Bernard, P.O. Box 3, Brakpan, Transvaal Oct. 13, 1906
94 Bromly, Alfred Hammond, c/o Taylor and Howat, Apartado 232, Mexico, D. F. Nov. 24, 1894
95 Broome, George Herbert, State Coal Mines, Mines Department, Melbourne, Victoria, Australia Oct. 9 1897
96 Brough, Thomas, New Seahani Colliery, Sunderland S. Feb. 1, 1873
98 Brown, John Coxnell, Westport Coal Company, Limited, Denniston, New Zealand June 11, 1898
99 Brown, Robert Oughton, Elswick Collieries, Newcastle-upon-Tyne Feb. 8 1908
100 Brown, Ralph Richardson, Pekin Syndicate, Limited, Honan, North China Aug. 3, 1907
101 Brown, W. Forster, Cefn Coed, Malpas, Newport, Monmouthshire S. Aug. 6,1887
102 Browne, Robert John, Bhowra Colliery, Jheria, E.I.R., Bengal, India M. Aug. 5, 1893
103 Browning, Walter James, c/o Rio Tinto Company, Limited, Provincia de Huelva, Spain Feb. 10, 1906
104 Bruce, John, Port Mulgrave, Hinderwell, Yorkshire Oct. 12,1907
105 Bryham, William, Bank House, Wigan S. Feb. 14, 1874
106 Buckle, Christopher Ernest, Elmwood, Denville, Havant A.M. Aug. 7, 1880
107 Bull, Henry Matthews, Bengal Coal Company, Limited, Mohuda, B.N.R., Manbhoom M. June 8, 1889
108 Bullman, Harrison Francis, Leazes Hall, Burnopfield, County Durham Dec. 8, 1900
109 Bunning, Charles Ziethen, c/o The British Vice-Consul, Pandemia, near Constantinople, Turkey Feb. 10, 1900
110 Biers, Herbert Thomas, c/o Edward Riley and Harbord, 16, Victoria Street, Westminster, London, S. W. April 9,1904
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<thead>
<tr>
<th>Name</th>
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<tr>
<td>Burn, Frank Hawthorn</td>
<td>9, Sandhill, Newcastle-upon-Tyne</td>
<td>S. Feb. 9, 1889</td>
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<tr>
<td>Pattishall House, Towcester</td>
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<td>A. Aug. 4, 1894</td>
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<td>111</td>
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<td>M. Aug. 3, 1895</td>
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<td>Burnett, Cecil Alfred</td>
<td>Ranelagh Cottage, High Wycombe</td>
<td>S. Aug. 4, 1894</td>
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<td>M. Aug. 3, 1901</td>
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<tr>
<td>Bittes, Charles</td>
<td>College Avenue and Fifty-ninth Street, Oakland, California, U.S.A</td>
<td>A.M. Aug. 4, 1894</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M. Aug. 3, 1901</td>
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<td></td>
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<td>Carnegie, Alfred</td>
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Indwe, Cape Colony, South Africa

153* Collins, Hugh Brown, Auchinbothie Estate Oihce, Kilmacolm, Renfrewshire
April 14, 1894

154 Collins, Victor Buyers, Lewis Street, Islington, via Newcastle. New South Wales, Australia
June 11, 1904

155 Colquhoun, Thomas Grant, The Durban Navigation Collieries, Limited, Dannhauser, Natal, South Africa
Dec. 14, 1898

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Date of Election and of Transfer

156 Commons, Robert Edden, 9, Queen Street Place, London, E.C.
Nov. 24 1894

157 Comstock, Charles Worthington, Boston Building Denver, Colorado, U.S.A.
June 10, 1905

May 8, 1869

Oct. 9, 1897

Feb. 12 1898

161 Cook, John Watson, Binnie Hall, Bishop Auckland
Oct. 14, 1893

162 Cooke, Henry Moore Annesley, The Balaghat Goldmining Company, Limited, Coromandel P.O., Mysore State, South India
Dec. 12 1898

103*Corpee, Evence, 71, Boulevard d'Anderlecht, Brussels, Belgium
Feb. 9, 1907

164 Corbett, Vincent. Blackett Colliery, Haltwhistle, Northumberland
A. June 11, 1898

165 Corbett, Vincent Charles Stuart Wortley, Chilton Moor, Fence Houses
Sept 3, 1870

166 Corlett, George Stephen, Wigan
Dec. 12, 1881

167 Coste, Eugene, 210, Poplar Plains Road, Toronto, Ontario, Canada
June 9, 1900

168 Coulson. Frank, Shamrock House, Durham
S. Aug. 1, 1868

169 Couves, Harry Augustus, 64, Osborne Road, Newcastle-upon-Tyne
Feb. 10, 1906

170 Cowell, Edward, Horden Colliery, Horden, Sunderland
A. Oct. 8, 1904

171 Cowell, Joseph Stanley, Vane House, Seaham Harbour, County Durham
M. June 20, 1908

172 Coxon, William Bilton, Seaton Hill, Boosbeck, Yorkshire
S. Feb. 12, 1908

173 Chaster, Walter Spencer, P.O. Box 216, Kopje, Salisbury, Rhodesia, South Africa
Dec. 8, 1900

174 Craven, Robert Henry, The Libiola Copper-mining Company, Limited, Sestri Levante, Italy
Feb. 11, 1905

175 Crawford, James Mill, Denehurst, Ferry Hill
Feb. 14, 1903

176 Crofton, Charles Arthur, 3, Hardy Terrace, Crook, S. Dec. 10, 1898 County Durham
A. Aug. 1, 1893

177 Crookston, Andrew White, 188, St. Vincent Street, Glasgow
Dec. 14, 1895

178 Crosby, Arthur, Douglas Colliery, Limited, Balmoral, Transvaal
A.M. Aug. 7, 1897

179 Cross, William Haslam, 77, King Street, Manchester
March 12, 1902

180 Croudace, Francis Henry Lambton, The Lodge, Lambton, Newcastle, New South Wales, Australia
June 8, 1907

181 Croudace, Sydney, New Lambton, Newcastle, New South Wales, Australia
June 8, 1907

182 Cruz y Diaz, Emiliano de la, Director-General de l'Empresa Minas et Minerales, Limited, Ribas, Provincia de Gerona, Spain
June 14, 1902

183 Cullen, Daniel, 14, Neville Street, Newcastle-upon-Tyne
Dec. 11, 1909

184 Cullen, Matthew, The Clydesdale (Transvaal) Collieries, Limited, Springs, Transvaal
Feb. 12, 1910

185 Cummings, John, Hamsterley Colliery, Ebchester, County Durham
A. Aug. 2, 1902

186 Cunningham, John Allan, P.O. Box 59, Dundee, Natal, South Africa
Dec. 8, 1906

187 Currie, Walter, P.O. Box 220, Bulawayo, Rhodesia, South Africa
April 25, 1896

188 Curry, George Alexander, Thornley House, Thornley, County Durham
Oct. 12, 1907

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<td>Mtsui Mining Company, 1, Suruga-cho, Nihonbashi-ku, Tokyo, Japan</td>
<td>April 14, 1894</td>
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<td>Greymouth, New Zealand</td>
<td>April 8, 1893</td>
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<td>Christopher Cunnion, Hardheads, Egremont, Cumberland</td>
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[xxvi]
233 Dunkerton, Ernest Charles, 53, Grosvenor Place, Newcastle-upon-Tyne  M. Dec. 12, 1903
234 Dunn, George Victor Septimus, 7, St. James' Buildings, William Street, Melbourne, Victoria, Australia  June 20 1908
235 Eastlake, Arthur William, Grosmont, Palace Road, Streatham Hill, London, S.W.  June 11,1892
236 Ede, Henry Edward, 10, Violet Bank Road, Nether Edge, Sheffield  July 14, 1896
237 Eden, Charles Hamilton, Glyn-Dderwen, Blackpill, Glamorgan  June 14, 1890
238 Edwards, Edward, Ocean Collieries, Nantymoel, Bridgend  Feb. 9, 1895
239 Edwards, Herbert Francis, 104, Stanwell Road, Penarth  Oct. 12, 1901
240 Edwards, Owain Tudor, Fedwhir, Aberdare  Aug. 4, 1906
241 Eliet, Francis Constant Andre, Benoni Elie du, Compagnie Lyonnaise de Madagascar, a Ambositra, Madagascar  Aug. 3, 1901
242*Elsdon, Robert William Barrow  April 13, 1901
243 Eltingham, George, Eltringham Colliery, Prudhoe, Ovingham, Northumberland  A. Dec. 8, 1894
244 Elwen, Thomas Lee, Brandon Colliery, County Durham  Oct. 13, 1888
245 Embleton, Henry Cawood, Central Bank Chambers, Leeds  April 14, 1894
246 Englesqueville, Rene d', 7, rue Henri Martin, Paris, France  Feb. 8, 1908
247 English, John, Broomfield, Chopwell, Ebchester, County Durham  Dec. 9, 1899
248 English, William, North Walbottle Colliery, Newburn, Northumberland  Dec. 14, 1907
249 Epton, William Martin, M Syndicate, Golden Valley, Rhodesia, South Africa  Oct. 12,1895
250 Esmarch, Cecil August, 19, Wentworth Place, Newcastle-upon-Tyne  April 9, 1904.
251 Etherington, John, 39a, King William Street, London Bridge, London, E.C  Dec 9,1893
252 Evans, Lewis, P.O. Box 84, Gwelo, Rhodesia, South Africa  Oct. 14, 1893
253 Everard, John Breedon, 6, Millstone Lane, Leicester  March 6, 1869
254 Faibley, James, Craighead and Holmside Collieries, Chester-le-Street  A.M. Aug. 7, 1880
256 Fawcett, Edward Stoker, Battle Hill House, Walker, Newcastle-upon-Tyne  A. June 11, 1892
257*Fenwick, Barnabas, 66, Manor House Road, Newcastle-upon-Tyne  M. Aug. 6,1904
258 Fergie, Charles, The Linton, Sherbrook Street, Montreal, Canada  A. June 2, 1866
259 Fergie, George, Copiapo, Chile, South America  A.M. Dec. 8, 1883
260 Ferguson. David, 140, Hyndland Road, Glasgow, W.  M. Aug. 3, 1889
261 Ferguson, James, The Cedars, High Wycombe  Dec. 12, 1896
262 Fevre, Lucien Francis, 1, place Possoz (XVIe), Paris, France  Feb. 8, 1908
263 Figari, Alberto, Apartado 516, Belgrano, Buenos Aires, Argentina  April 25, 1896
264 Fishback, Martin, Guaranty Trust Building, El Paso, Texas, U.S.A.  April 12, 1902
266 Fisher, Henry Herbert, Calle Sucre, 1841, Belgrano, near Buenos Aires, Argentina Republic, South America  M. Aug. 3, 1889
267 Fleming, Henry Stuart, 1, Broadway, New York City, U.S.A  Oct. 8, 1904
268 Fletcher, James, State Colliery, Seddonville, New Zealand  June 10, 1905
270*Fletcher, Walter, The Hollins, Bolton  A.M. April 14, 1888
271 Flint, John, Radcliffe House, Acklington, Northumberland  M. June 8,1889
273 Ford, Mark, Washington Colliery, Washington Station, County Durham (Member of Council)  Jan. 19, 1895
274 Ford, Stanley Horace, 42, Dacre Park, Blackheath, London, S.E.  Feb. 8, 1908
275 Forster, Alfred Llewellyn, Newcastle and Gateshead Water Company, Engineer's Office, Pilgrim Street, Newcastle-upon-Tyne  Aug. 3, 1895
276 Forster, Henry, Herbert, Calle Sucre, 1841, Belgrano, near Buenos Aires, Argentina Republic, South America  June 10, 1893
277 Forster, John, Radcliffe House, Acklington, Northumberland  June 8, 1901
278 Forster, John, Radcliffe House, Acklington, Northumberland  March 6, 1869
279 Forster, Lewis, P.O. Box 84, Gwelo, Rhodesia, South Africa  April 12, 1902
280 Forster, Robert, Wansbeck, Ammanford, Carmarthenshire  A.M. Aug. 2, 1884
276 Forster, John Henry Bacon, Whitworth House, Spennymoor

277 Forster, Joseph William, P.O. Box 56, East Rand, Transvaal

278 Forster, Thomas Emerson, 3 Eldon Square, Newcastle-upon-Tyne (Past-President, Member of Council)

279 Forster, Joseph William, P.O. Box 56, East Rand, Transvaal

280 Fryar, John William, Eastwood Collieries, near Nottingham

281 Fryar, Mark. Denby Colliery, Derby

282 Fryar, George Kellett, Bleak House, Broughton Moor, Maryport

283 Futers, Thomas Campbell, 17, Balmoral Gardens, Monkseaton, Whitley Bay, Northumberland

284 Galloway, Thomas Lindsay, 175, West George Street, Glasgow

285 Galloway, William, Cardiff

286 Gibson, James, c/o W. E. Robarts. Acutts Arcade, Durban, Natal, South Africa

287 Gifford, Henry J., The Champion Reef Gold-mining Company of India, Limited, Champion Reefs P.O., Mysore State, South India

288 Gillman, Gustave, Aguilas, Provincia de Murcia, Spain

289 Gipps, F. G. De Visme, Irvinebank, North Queensland, Australia

290 Glass, Robert William, Axwell Park Colliery, Swalwell, County Durham

291 Goninon, Richard

292 Goodwin, Robert Harvey, Karabournou Mercury-mine, c/o C. Whittall and Company, Smyrna, Turkey

293 Goodwin, William Lawton, School of Mining, Kingston, Ontario, Canada

294 Gough, George Henry, Singareni Collieries, Yellandu (Deccan), India

295 Gouldie, Joseph, 48, Standard Bank Chambers, Johannesburg, Transvaal

296 Gowland, Joseph Edwin, Crook House, Crook, County Durham

297 Graham, Edward, Jun., Bedlington Colliery, Bedlington, Northumberland

298 Grave, Percy, La Leonesa Mines, Matagalpa, Nicaragua, Central America

299 Greaves, J. O., Westgate, Wakefield

300 Green, Edwin Henry, P.O. Box 1978, Johannesburg, Transvaal

301 Green, Joseph, Crag House, Ferry Hill

302 Green, John Dampier, P.O. Box 340, Johannesburg, Transvaal

303 Green, Leonard Clifford, Wienholt Street, Torwood, Brisbane, Queensland, Australia

304 Greenwell, Allan, 30 and 31, Furnival Street, Holborn, London, E.C

305 Greenwell, Alan Leonard Stapylton, Eldon Colliery, Bishop Auckland

307 Greenwell, George Clementson. Poynton, Stockport

308 Greenwell, Maes Gwyn, Cymmer, Forth, Pontypridd

311 Griffith, William, Waterloo House, Aberystwyth

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313 Grundy, James, 8, Grosvenor Gardens, Cricklewood, London, N.W             June 13, 1890
314 Grunson, Robert, Minas Errazuriz, Lebu, Chile, South America              June 12, 1909
315 Gullachsen, Berent Conrad, Beatestrasse 19, Kattowitz, O.S., Germany       S. April 8, 1905
                                                        M. Aug. 3,1907
316 Gummerson, James M., 35, Birkbeck Road, Acton, London, W                A.M. June 10, 1899
                                                        M. Dec. 12, 1903
317 Haddock, William Thomas, South Rand Exploration Company, Limited, P.O. Pox 1, A.M. Aug. 1, 1880
                                                    S. Oct. 7, 1876
Balfour, District Heidelberg, Transvaal                                                    M. June 8, 1889
                                                        Dec. 11, 1909
318 Haggie, John Douglass, Walbottle Colliery, Newcastle-upon-Tyne              A. Dec. 14, 1889
                                                        M. Aug. 3, 1895
319 Halbaum, Henry Wallace Gregory, Horden, Sunderland                        Dec. 10, 1904
                                                        S. Oct. 9, 1897
320 Hall, Frederick, Fernleigh, Highfield, Workington                           A. Aug. 2, 1902
                                                        M. Oct. 9, 1909
321 Hall, Joseph John, Ashington Colliery, Morpeth                              Date of Election and
                                                        of Transfer
                                                        Feb. 14, 1874
322 Hall, Joseph Percival, Talbot House, Birtley, County Durham               A. Dec. 13, 1902
                                                        M. June 8, 1907
                                                        June 8,1889
                                                        S. Oct. 7, 1876
                                                        A.M. Aug. 4, 1883
                                                        M. June 8, 1889
                                                        Dec. 14, 1889
323 Hall, Matthias Stokoe, Springwell Villa, Bishop Auckland                   A.M. June 13, 1885
324 Ball, Robert William, Fairlawn, Leeholme, Bishop Auckland                 M. Aug. 3, 1889
                                                        S. Nov. 1, 1873
325 Ball, Tom, Ryhope Colliery, Sunderland                                      A.M. Aug. 2, 1879
                                                        M. June 8, 1889
326 Ballas, George Henry, Claremont, Huyton, Liverpool                        Dec. 14, 1895
                                                        Oct. 10, 1908
327 Ballimond, William Tasker, c/o Hose Deep, Limited, P.O. Box 6, Germiston, A.M. Aug. 4, 1894
                                                    Oct. 12, 1907
                                                        M. Nov. 24, 1894
328 Halse, Edward, 15, Clarendon Road, Notting Hill, London, W. All             A. Feb. 12, 1898
communications                                           M. Dec. 14, 1907
                                                        M. Aug. 1, 1891
communications                                                   M. Aug. 7, 1880
                                                        Oct. 10, 1908
                                                        Oct. 12, 1907
                                                        M. Nov. 24, 1894
                                                        Oct. 14, 1895
331 Hamilton, James, Horden, Sunderland                                        M. Oct. 12, 1901
                                                        Oct. 14, 1895
332 Hancock, Henry Lipson, Wallaroo and Moonta Mining and Smelting Company, A. Feb. 12, 1898
                                                    Oct. 10, 1908
Limited, Moonta Mines, South Australia                                     M. Dec. 14, 1907
                                                        Oct. 12, 1907
333 Hare, George, Seghill Colliery, Seghill, Dudley, Northumberland            A.M. June 12, 1897
                                                        M. Aug. 7, 1880
                                                        M. Dec. 14, 1907
                                                        M. Dec. 14, 1907
334 Hancock, Henry Richard, Holwell, Whitchurch, Tavistock                     Date of Election and
                                                        Aug. 7, 1897
335 Harris, H. Richard, Brownie Colliery, Durham                              of Transfer
                                                        April 7, 1877
336 Harris, Howard, P.O. Box 1112, Johannesburg, Transvaal                   A. Apr. 14, 1894
                                                        Oct. 12, 1901
                                                        Dec. 12, 1908
337 Harris, William Scorer, Kibblesworth, Gateshead-upon-Tyne                  A.M. June 12, 1897
                                                        M. April 13, 1901
                                                        Aug. 7, 1897
                                                        S. Feb. 14, 1874
338 Harris, William, Bowburn Colliery, Coxhoe, County Durham                   A.M. Aug. 7, 1880
                                                        M. Jan. 8, 1889
                                                        June 21, 1894
339 Harrington, Charles Augustus, North Eastern Railway, Newcastle-upon-Tyne A.M. June 12, 1897
                                                        M. April 13, 1901
                                                        June 21, 1894
340 Harrington, William B., Brownhills Collieries, near Walsall                   March 6, 1867
<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Address</th>
<th>Date of Election</th>
<th>Date of Transfer</th>
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<tbody>
<tr>
<td>348</td>
<td>Haselden, Arthur, Linares</td>
<td>Provincia de Jaen, Spain</td>
<td>A.M. Dec. 11, 1897</td>
<td>M. Dec. 11, 1897</td>
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<td>349</td>
<td>Hawker, Edward William</td>
<td>Adelaide Club, Adelaide, South Australia</td>
<td>Oct. 12, 1895</td>
<td>Apr. 2, 1898</td>
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<td>350</td>
<td>Hawkins, Thomas Spear</td>
<td>The St. John del Rey Mining Company, Limited, Villa</td>
<td>Aug. 6, 1901</td>
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<td>351</td>
<td>Hawker, Edward William</td>
<td>Adelaide Club, Adelaide, South Australia</td>
<td>Oct. 12, 1895</td>
<td>Apr. 2, 1898</td>
</tr>
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<td>352</td>
<td>Beads, Robert William</td>
<td>85, Raffles Chambers, Singapore</td>
<td>June 14, 1902</td>
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<td>353</td>
<td>Bedley, Arthur Morton</td>
<td>Blaydon Burn, Blaydon-upon-Tyne, County Durham (Member of Council)</td>
<td>A. Nov. 24, 1894</td>
<td>M. Dec. 12,1903</td>
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<tr>
<td>354</td>
<td>Hedley, Septimus H.</td>
<td>Langholme, Roker, Sunderland</td>
<td>Aug. 6, 1904</td>
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<td>355</td>
<td>Heise, Fritz</td>
<td>45, Bochum, Germany</td>
<td>Aug. 5, 1905</td>
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<td>356</td>
<td>Henderson, Charles</td>
<td>Cowpen Colliery Office, Blyth</td>
<td>Dec. 9, 1899</td>
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<td>357</td>
<td>Henderson, William</td>
<td>Alston House, Durham</td>
<td>Aug. 7, 1909</td>
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<td>358</td>
<td>Hendy, John</td>
<td>Etherley, via Darlington</td>
<td>Oct. 14, 1893</td>
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<td>359</td>
<td>Henriksen, Gudbrand</td>
<td>Inspector of Mines, Fosanger, near Bergen, Norway</td>
<td>Aug. 6,1904</td>
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<td>360</td>
<td>Herdman, William</td>
<td>St. John's Chapel, County Durham</td>
<td>Apr. 11 1908</td>
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<tr>
<td>361</td>
<td>Herrmann, Henry J. A.</td>
<td>Mine de Mesloula, par Clairfontaine, Algeria</td>
<td>Dec. 10, 1888</td>
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<td>362</td>
<td>Heslop, Christopher</td>
<td>Woodside, Marske Mill Lane, Saltburn-by-the-Sea</td>
<td>M. Aug. 2, 1873</td>
<td>S. Feb. 1 1868</td>
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<td>363</td>
<td>Heslop, Grainger</td>
<td>North Moor House, Sunderland</td>
<td>Feb. 5, 1872</td>
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<td>364</td>
<td>Heslop, Michael</td>
<td>Rough Lea Colliery, Willington, County Durham</td>
<td>A. Feb. 10 1894</td>
<td>M. June 21, 1894</td>
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<td>365</td>
<td>Heslop, Septimus</td>
<td>New Beerbhoom Coal Company, Limited, Asansol, Bengal, India</td>
<td>Oct. 12, 1895</td>
<td>S. Oct. 2, 1880</td>
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<td>367</td>
<td>Heslop, William Taylor</td>
<td>St. George's Colliery, Hatting Spruit, Natal, South Africa</td>
<td>Aug. 3, 1895</td>
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<td>368</td>
<td>Hewitt, George Colthurst</td>
<td>Serridge House, Coalpit Heath, Bristol</td>
<td>June 3, 1871</td>
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<td>369</td>
<td>Hewlett, Alfred</td>
<td>Haseley Manor, Warwick</td>
<td>Mar. 7, 1861</td>
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<td>370</td>
<td>Hewlett, Alfred</td>
<td>The Cossall Colliery Company, Limited, Cossall, near Nottingham</td>
<td>June 2, 1908</td>
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<td>371</td>
<td>Hewlett, Erne</td>
<td>Ammanford Colliery Company, Limited, Ammanford, Carmarthenshire</td>
<td>Oct. 9, 1908</td>
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<td>372</td>
<td>Hewlett, Howe</td>
<td>Clock Face Colliery, Sutton Oak, St. Helens</td>
<td>Feb. 13, 1904</td>
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<td>373</td>
<td>Higson, Jacob</td>
<td>Crown Buildings, 18. Booth Street, Manchester</td>
<td>Aug. 7, 1862</td>
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<tr>
<td>374</td>
<td>Hill, William</td>
<td>Hill Crest, Dordon, Tamworth</td>
<td>A.M. June 9, 1883</td>
<td>M. Aug. 3, 1889</td>
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<tr>
<td>376</td>
<td>Hindmarsh, Joseph Parker</td>
<td>Corrimal, South Coast, New South Wales, Australia</td>
<td>June 20, 1908</td>
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<td>377</td>
<td>Hindson, Thomas</td>
<td>Framwellgate Colliery, near Durham</td>
<td>Dec. 9, 1905</td>
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<td>378</td>
<td>Hodgkin, Jonathan Edward</td>
<td>Shelleys, Darlington</td>
<td>Dec. 13, 1902</td>
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<td>379</td>
<td>Hodgson, Jacob</td>
<td>Comsay Colliery, Durham</td>
<td>June 8, 1895</td>
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<td>381</td>
<td>Hogg, John</td>
<td>Thornley Colliery Office, Thornton, County Durham</td>
<td>Dec. 12, 1903</td>
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<td>382</td>
<td>Holberton, Walter Twining</td>
<td>Compania Estanifera de Llallagua, Llallagua, Bolivia</td>
<td>June 9, 1900</td>
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<td>383</td>
<td>Holland, Charles Henry</td>
<td>Auckland, New Zealand</td>
<td>Apr. 9, 1910</td>
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<td>384</td>
<td>Holliday, Martin Forster</td>
<td>Park House, Durham</td>
<td>May 1, 1875</td>
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<td>385</td>
<td>Holliday, Norman Stanley</td>
<td>Boyne Villa, Langley Moor, Durham</td>
<td>S. Apr. 10, 1897</td>
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<td>386</td>
<td>Holman, Nicholas</td>
<td>The Gibraltar Consolidated Gold-mines, Limited, Sheppardstown, New South Wales, Australia</td>
<td>Dec. 11, 1909</td>
<td></td>
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<tr>
<td>387</td>
<td>Homersham, Edwin Collett</td>
<td>The Randfontein Estates Gold-mining Company, Limited, P.O., Randfontein, Transvaal</td>
<td>Feb. 9, 1901</td>
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<td>388</td>
<td>Homersham, Thomas Henry</td>
<td>Vulcan Iron Works, Thornton Road, Bradford</td>
<td>Aug. 6,1898</td>
<td></td>
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<td>389</td>
<td>Hood, George</td>
<td>Agents Terrace, Boldon Colliery, County Durham</td>
<td>Dec. 14, 1907</td>
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<td>390</td>
<td>Hood, William Walker</td>
<td>Tredean, near Chepstow</td>
<td>Apr. 9, 1904</td>
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392 Hooper, James Auoitstus, Cannop, Coleford
393 Hopwood, Howell Arthur, Mynydd Isa, near Mold
394 Hopwood, Kingsley, c/o Effuenta and Wassau Mines, Limited, Effuenta, Gold Coast Colony, West Africa
395 Hopwood, William, Vron Haul, Buckley, Chester

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396 Horswill, Frederick Alva, Stone Canon, Monterey County, California, U.S.A. Feb. 13, 1909
397 Horswill, Frederick J., 1070, Sixteenth Street, Oakland, California, U.S.A Oct. 14, 1899
398 Hoskold, Carlos A. Synn, Monterey County, California, U.S.A. June 8, 1895
399 Horswill, Frederick J., 1070, Sixteenth Street, Oakland, California, U.S.A Oct. 14, 1899
400 Howe, Richard Algeo, Sunnybrow, Willimton, County Durham April 9, 1910
401 Howe, Frank T., Chipping Sodbury, Gloucestershire A. Dec. 10, 1892
402 Howson, Charles, Harraton Colliery, Chester-le-Street M. Dec. 12, 1903
403 Howson, William, Lawson Street, Hamilton, Newcastle, New South Wales, Australia June 14, 1902
404 Humble, Ernest, Killingworth Colliery, West Wallsend, New South Wales, Australia S. Feb. 14, 1903
405 Humble, John, West Pelton House, Beamish, County Durham M. June 8, 1907
407 Humphris, Henry, Blaenau Ffestiniog A. Aug. 4, 1906
408 Hunter, Christopher, Cowpen Colliery Office, Blyth M. Oct. 14, 1893
409 Hunter, Robert, Gympie, Queensland, Australia S. Dec. 14, 1901
410 Hurst, George, Lauder Grange, Corbridge, Northumberland M. Aug. 1, 1891
411 Hutchinson, George Weymouth, Greensburg, Westmoreland County, Pennsylvania, U.S.A. Aug. 7, 1909
412 Hutchinson, John William, Llwynceloyd House, Porth, near Pontypridd Oct. 14, 1899
413 Hutton, John George, Barfield, Fast Maitland, New South Wales, Australia Dec. 10, 1904
414 Hylton, Frederick William, Ryhope Colliery, Sunderland Aug. 3, 1907
415 Inskipp, Dudley James, The Bulawayo Club, Bulawayo, Rhodesia, South Africa June 8, 1907
416 Ivey, Joseph Henry, c/o Aramayo, Francke and Company, Limited, Quechisla, Bolivia, South America, via Buenos Aires Aug. 7, 1909
417 Jackson, Walter Geoffrey, Bramham Hall, Boston Spa, Yorkshire June 7, 1873
418 Jacobs, Lionel Asher, Giridih, E.I.R., Bengal, India S. Aug. 4, 1900
419 Jacobs, Montagu, IS, Greville Road, London, N.W. M. April 13, 1907
420 James, William Henry Trewartha, Finsbury House, Blomfield Street, London, E.C Oct. 9, 1909
421 Jamieson, John William, Medomsley, County Durham Dec. 12, 1896
422 Jarvie, James, Kembla Heights, near Wollongong, New South Wales, Australia Feb. 8, 1908
423 Jefferson, Frederick, Whitburn Colliery, South Shields Dec. 11, 1897
425 Jenkins, Philip Thomas, Owlyf, Liansamlet, Glamorgan Dec. 10, 1904
426 Jenkins, William, Ocean Collieries, Treorchy, Pontypridd Dec. 6, 1862
427 Jennings, Albert, 12, Grainger Street, Darlington June 20, 1908
428 Jennings, Thomas Bryant, P.O. Box 1565, Johannesburg, Transvaal Dec. 10, 1904

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429 Jepson, Henry, 39, North Bailey, Durham

Date of Election and of Transfer
S. July 2 1872
A.M. Aug. 2, 1879
430*Jobling, Thomas Edgar, Bebside, Northumberland (Member of Council)  
M. June 8, 1889  
S. Oct 7, 1876  
A.M. Aug. 4, 1883  
M. June 8, 1889

431 Johns, Bennet, Station Road, Keswick  
Dec. 9, 100

432*Johns, John Harry (Henry), c/o H. Trembath, 26, North Parade, Penzance  
June 21 1891

433 Johnson, Edward, River View, Morpeth  
Dec. 9, 1905

434 Johnson, Henry Howard, Bushtick Mine, Essexvale, Rhodesia, South Africa  
Feb. 13 1904

435 Johnson, James, Boldon Lodge, East Boldon, County Durham  
A. Aug. 6, 1898  
M. Dec. 12, 1903

436 Johnston, J. Howard, c/o Backus and Johnston, Lima, Peru, South America  
Feb. 10 1894

437 Joicey, William James, Sunningdale Park, Berkshire  
March 6. 1869

438 Jones, Clement, Neath Colliery, Cessnock, New South Wales, Australia  
Dec. 8 1906

439 Jones, Evan, Plas Cwmorthin, Blaenau Festiniog  
April 13, 1907

440 Jones, Jacob Carlos, Wollongong, New South Wales, Australia  
Aug. 6, 1892

441 Jones, John Elias, 20, Lawrence Lane, Gresham Street, London, E.C  
June 14, 1902

442 Jones, Percy Howard, Ty Ceirios, Pontnewynydd, Pontypool  
Oct. 11,1902

443 Jones, Roiveht, 11, The Square, Blaenau Festiniog  
April 3, 1909

June 12, 1897

445 Jordan, Edmond William, Arlington House, Croydon, Surrey  
Dec. 14, 1907

446 Joyner, John James, Ferndale, Lydbrook, Gloucestershire  
Aug. 6, 1904

447 Kayll, Alfred Charles, Gosforth, Newcastle-upon-Tyne  
S. Oct. 7, 1876  
M. Aug. 3, 1889

448 Kearney, Joseph Musgrave, Lismore, Whitehaven  
Aug. 1, 1903

449 Keightley, Frederick Charles, Unitontown, Fayette County, Pennsylvania, U.S.A  
Aug. 4,1900

450 Kellett, Matthew Henry, Eldon, Bishop Auckland  
S. April 11, 1881  
M. Aug. 3, 1895

451 Kerr, Andrew, New Brancepeth Colliery, Durham  
Dec. 14, 1907

452 Kerr, David Gillespie, Room 129-130, Confederation Life Building, Toronto, Canada  
Aug. 4,1900

453 Kidd, Thomas, Jun., Linares, Provincia de Jaen, Spain  
S. June 9, 1900  
A. Aug. 1, 1903  
M. Oct. 12, 1907

454 Kirby, Matthew Robson, c/o Addison Langhorne Steaven, Holywell Hall, Durham  
S. April 9, 1892  
A.M. April 25, 1896  
M. Feb. 14, 1903

455 Kirkby, William, c/o Aire and Calder Navigation, Leeds  
A.M. April 2, 1898  
M. Aug. 6, 1904

456 Kirkup, Austin, Mining Office, Bunker Hill, Fence Houses (Member of Council)  
S. April 9, 1892  
M. June 12, 1897

457 Kirkup, Frederic Octavius, Garesfield Colliery, Rowlands Gill, Newcastle-upon-Tyne  
S. April 9, 1892  
A.M. April 25, 1896  
M. Feb. 14, 1903

458 Kirkup, John Philip, Burnhope, Durham (Member of Council)  
April 11, 1891

459 Kirkup, Philip, Leafield House, Birtley, County Durham (Member of Council)  
S. March 2, 1878  
A.M. Aug. 7, 1886  
M. Aug. 3, 1889

460 Kirsopp, John, Jun., Lamesley, Gateshead-upon-Tyne  
June 9, 1900

461 Kirton, Hugh, Kimblesworth Colliery, Chester-le-Street  
S. April 7, 1877  
A.M. Aug. 1, 1885  
M. June 8, 1889

462 Kitchin, James Bateman, Woodend House, Bigrigg, Cumberland  
Aug. 5, 1905

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Date of Election and of Transfer

463 Klepetko, Frank, 307, Battery Park Building, 21-24, State Street, New York City, U.S.A  
Oct. 13,1900

464*Knowles, Robert, Ednaston Lodge, near Derby  
April 10, 1886

465 Kondo, R., c/o Furukawa Mining Office, 1, Icchome Taesuchio, Kojimachi, Tokyo, Japan  
June 21, 1894

466 Korte, Christian, Standard Buildings, 38, Park Row, Leeds  
Feb. 13, 1909

467*Kwantg, Kwong Yung, Mines de Lincheng, Lin Tcheng Sien, Lu-Han Railway, via Peking, North China  
June 8, 1895

468 Kyle, George Robert, 6, Ravensworth Road, Dunston, Gateshead-upon-Tyne  
Dec. 14, 1907
469 Lamb, Robert Ormston, Hayton, How Mill, Carlisle  Aug. 2, 1866
470 Lancaster, John, Dunchurch Lodge, Rugby  March 2, 1865
471 Lancaster, John, Auchenheath, Lanarkshire  Sept. 7, 1878
472* Landero, Carlos F. de  Feb. 15, 1896
474* Laporte, Henry. 35, rue de Turin, Brussels, Belgium  May 5, 1877
475 Lathbury, Graham Campbell, Giridih, F.I.R., Bengal, India  Feb. 14, 1903
476 Latimer, Hugh, St. Helen’s Colliery, Bishop Auckland  S. Feb. 15, 1896
477* Lawn, James Gunson, University College, Johannesburg, Transvaal  A. Aug. 1, 1903
478* Leach, Charles Catterall, Seghill Colliery, Seghill, Dudley, Northumberland (Vice-President, Member of Council)  M. Feb. 11, 1905
479 Lebour, George Alexander Louis, Armstrong College, Newcastle-upon-Tyne  Feb. 1, 1873
480 Leck, William, H.M. Inspector of Mines, Cleator Moor, Cumberland  Nov. 24, 1894
482 Lee, Richard Henry Lovelock, 1, Burghley Road, Highgate Road, London, N.W.  Aug. 5, 1905
483 Leech, Arthur Henry, 11, King Street, Wigan  Feb. 9, 1901
485 Liddell, Hugh, 21, Framlington Place, Newcastle-upon-Tyne  Feb. 11, 1905
486 Liddell, John Matthews, Tofton Hall, Acklington, 5 Northumberland  S. March 6, 1872
487 Lidster, Ralph, Langley Park Colliery, Durham  S. Nov. 24, 1894
488 Lisboa, Miguel Arrojado Ribeiro, 426, Praia de Botafogo, Rio de Janeiro, Brazil, South America  A. Aug. 7, 1897
489 Lisle, James, Kroonstad Coal Estate Company, Limited, P.O. Box 118, Klerksdorp, Transvaal  M. April 13, 1901
490 Lishman, Robert Richardson. Brethi Colliery, Burton-upon-Trent  S. June 9, 1883
492 Lishman, William Ernest, 4, Field House Terrace, Durham  S. Nov. 5, 1870
493 Lisle, James, Kroonstad Coal Estate Company, Limited, P.O. Box 118, Klerksdorp, Transvaal  M. Aug. 3, 1872
494 Liveing, Edward H., Brookfield House, Long Stanton, Cambridge  S. Nov. 24, 1894
495 Lloyd, George Christopher, 28, Victoria Street, London, S.W  A. Aug. 7, 1897
496 Lockwood, Alfred Andrew, 46, Marmora Road, Honor Oak, London, S.E  M. April 13, 1901
497 Long, Ernest, c/o — Cunliffe, Holt Farm, Shevington, Wigan  June 10, 1893
498 Longbotham, George Augustus, Ings Foundry, Wakefield  S. July 2, 1872
499 Longworth, William, Ocean House, Moore Street, Sydney, New South Wales, Australia  A.M. Aug. 3, 1878
500 Lonsdale, Talbot Richard, Malton Colliery, near Durham  M. June 8, 1889
502 Louis, Henry, 4, Osborne Terrace, Newcastle-upon-Tyne  M. Aug. 3, 1889
503 Lowdon, Thomas, Hamsteels, near Durham  S. Sept. 1, 1877
505 Lyall, Edward, Barton, Yorkshire  M. June 8, 1889
506 Lyall, William, 4, Vane Terrace, Darlington  A.M. Aug. 2, 1884
507 Macarthur, James Duncan, Bangkok, Siam  M. Aug. 3, 1889
508 MacArthur, John Stewart. 74. York Street, Glasgow  June 12, 1899

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Date of Election and Transfer
497 Long, Ernest, c/o — Cunliffe, Holt Farm, Shevington, Wigan  Aug. 4, 1906
498 Longbotham, George Augustus, Ings Foundry, Wakefield  Oct. 12, 1907
499 Longworth, William, Ocean House, Moore Street, Sydney, New South Wales, Australia  June 11 1910
500 Lonsdale, Talbot Richard, Malton Colliery, near Durham  June 14 1902
501* Louis, David Alexander, 123, Pall Mall, London, S.W.  April 8, 1893
502 Louis, Henry, 4, Osborne Terrace, Newcastle-upon-Tyne  Feb. 15 1896
503 Lowdon, Thomas, Hamsteels, near Durham  Dec. 14, 1889
504 Lupton, Arnold, 7, Victoria Street, Westminster, London, S.W  Nov. 6, 1869
505 Lyall, Edward, Barton, Yorkshire  Oct. 14 1905
506 Lyall, William, 4, Vane Terrace, Darlington  Feb. 13 1909
507 Macarthur, James Duncan, Bangkok, Siam  Oct. 13, 1906
508 MacArthur, John Stewart. 74. York Street, Glasgow  April 8, 1893
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<td>509</td>
<td>McCann, James</td>
<td>Hunter, American Exchange, 60, Haymarket, London, S.W.</td>
<td>Dec. 12, 1908</td>
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<td>510</td>
<td>McCarthy, Edward</td>
<td>Thomas, 125, Victoria Street, London, S.W.</td>
<td>A.M. Oct. 8, 1887</td>
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<td>511</td>
<td>McCowan, Robert</td>
<td>David, Barnhill, Distington, Cumberland</td>
<td>Dec. 11, 1909</td>
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<td>512</td>
<td>McCreath, James</td>
<td>208, St. Vincent Street, Glasgow</td>
<td>March 5, 1870</td>
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<td>513</td>
<td>Macfarlane, Rienzi</td>
<td>Walton, c/o Parral Foreign Club, Parral, Estado Chihuahua, Mexico.</td>
<td>April 9, 1904</td>
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<td>514</td>
<td>McGechie, Duncan</td>
<td>West Wallsend, New South Wales, Australia</td>
<td>Nov. 24, 1894</td>
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<td>516</td>
<td>McInerny, James</td>
<td>26, Sandringham Terrace, Benton, Newcastle-upon-Tyne</td>
<td>Feb. 12, 1910</td>
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<td>517</td>
<td>McInto, Stewart</td>
<td>sutherland, 26, Sandringham Terrace, Benton, Newcastle-upon-Tyne</td>
<td>Oct. 12, 1895</td>
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<td>518</td>
<td>Mackintosh, James</td>
<td>Burrea Coal Company, Salarpur Colliery, Sitarampur, E.I.R., Bengal, India</td>
<td>Oct. 12, 1895</td>
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<td>519</td>
<td>McLellan, Neil</td>
<td>Idsley House, Spennymoor</td>
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<td>520</td>
<td>McCreath, George</td>
<td>Edwin James, Radstock, Bath</td>
<td>S. Aug. 2, 1884</td>
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<td>521</td>
<td>McMurtrie, James</td>
<td>5, Belvedere Road, Durhain Park, Bristol</td>
<td>M. Dec. 12, 1891</td>
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<td>523</td>
<td>Maddison, W. H. F.</td>
<td>The Lindens, Darlington</td>
<td>Dec. 11, 1897</td>
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<td>524</td>
<td>Maitland, Lionel</td>
<td>Clinton, Highfield, Pemberton, Wigan</td>
<td>June 14, 1890</td>
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<td>525</td>
<td>Mammatt, John</td>
<td>Ernest, 1, Albion Place, Leeds</td>
<td>April 9, 1910</td>
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<td>526</td>
<td>Manning, Arthur</td>
<td>Hope, P.O. Box 88, Heidelberg, Transvaal</td>
<td>Aug. 3, 1865</td>
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<td>527</td>
<td>Markham, Gervase</td>
<td>Edward, Gloucester Villa, Darlington</td>
<td>Dec. 11, 1897</td>
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<td>528</td>
<td>Marks, Arthur</td>
<td>Tristman, c/o The Nile Valley Gold-mining Company, Limited, 15,</td>
<td>S. Dec. 4, 1875</td>
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<td>529</td>
<td>Marks, Herbert</td>
<td>T., c/o Royal Colonial Institute, Northumberland Avenue, London, W.C.</td>
<td>M. Aug. 7, 1880</td>
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<td>530</td>
<td>Marley, Frederic</td>
<td>Thomas, Post Office, Gainford, Darling</td>
<td>A.M. April 7, 1880</td>
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<td>531</td>
<td>Marr, James</td>
<td>Heppell, Castlecomer, County Kilkenny</td>
<td>M. June 8, 1889</td>
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<td>532*</td>
<td>Marriott, Hugh</td>
<td>Frederick, c/o Wernher, Beit and Company, 1, London Wall Buildings,</td>
<td>Dec. 12, 1896</td>
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<td>533</td>
<td>Marsh, Thomas</td>
<td>Aspinall, Leaders Buildings, Wigan</td>
<td>Oct. 10, 1908</td>
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<td>534</td>
<td>Martin, Henry</td>
<td>Stuart, c/o H. Eckstein and Company, Johannesburg, Transvaal</td>
<td>April 13, 1907</td>
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<td>535</td>
<td>Martin, Henry</td>
<td>William, Sherwood, Newport Road, Cardiff</td>
<td>Oct. 9, 1897</td>
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<td>536</td>
<td>Martin, Tom</td>
<td>Pattinson, 22, Station Road, Workington</td>
<td>April 4, 1903</td>
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<td>537</td>
<td>Mathieson, Alexander</td>
<td>Hetton Colliery, Carrington, near Newcastle, New South Wales, Australia</td>
<td>Nov. 5, 1892</td>
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<td>538</td>
<td>Matthews, Frederick</td>
<td>Berkley, Lartington Hall, Darlington</td>
<td>A.M. Dec. 9, 1882</td>
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<td>539</td>
<td>Matthews, John</td>
<td>R. and W. Hawthorn, Newcastle- upon-Tyne</td>
<td>M. June 8, 1889</td>
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<td>540</td>
<td>Maurice, William</td>
<td>The Elms, Hucknall Torkard, Nottingham</td>
<td>A.M. Aprl 11, 1885</td>
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<td>541</td>
<td>Mawson, Robert</td>
<td>Bryham, Elm Rank, Wigan</td>
<td>M. Aug. 3, 1889</td>
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<td>542</td>
<td>May, George</td>
<td>Clervaux Castle, Croft, Darlington (Past-President, Member of Council)</td>
<td>June 11, 1892</td>
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<td>543</td>
<td>Mein, Henry</td>
<td>Johnson, Cartherhorne Colliery, Toft Hill, Bishop Auckland</td>
<td>March 6, 1862</td>
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<td>544</td>
<td>Mellon, Henry</td>
<td>Brook Lea, Askam, Lancashire</td>
<td>Dec. 9, 1899</td>
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<td>545</td>
<td>Menzies, Joseph</td>
<td>Frederick, Roslyn, Washington, U.S.A.</td>
<td>April 25, 1896</td>
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<td>546</td>
<td>Merivale, Charles</td>
<td>Herman, Middleton Estate and Colliery Company, Middleton, Leeds</td>
<td>June 10, 1905</td>
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<td>547</td>
<td>Merivale, John</td>
<td>Herman, Togston Hall, Acklington, Northumberland (Honorary Secretary, Past-President, Member of Council)</td>
<td>S. June 9, 1900</td>
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[xxxv]
548 Merz, Charles Hesterman, Collingwood Buildings, Collingwood Street, Newcastle-Upon-Tyne  June 10, 1903
549 Metcalf, Alfred T., United Reefs (Sheba), Limited, Eureka City, De Kaap, South  Africa  June 21, 1894
550 Michell, Thomas Henry, Pool Mining Company, Bettws-y-coed, Carnarvonshire  April 3, 1909
551 Middleton, Robert, Sheep Scar Foundry, Leeds  Aug. 1, 1891
552 Miller, John Henry, South Hetton, County Durham  A. Dec. 8, 1894
M. April 4, 1903
554 Millett, Cornish, Pentire, Carbis Bay, Cornwall  Dec. 11, 1909
555 Milne, Norman Boarer, Inspector of Mines Office, Boksburg, Johannesburg, Transvaal  Dec. 11, 1909
556 Minns, Thomas Tate, Binchester Blocks, Bishop Auckland  S. April 10, 1897
557 Mitchinson, Robert, Catchgate House, Annfield Plain, County Durham  A. Aug. 1, 1903
M. Feb. 12, 1910
558 Molengraaff, Gustaaf Adolf Frederik, 43, van Stolberglaan, The Hague  Oct. 14, 1899
559 Montgomery, Alexander, State Mining Engineer, Department of Mines, Perth, Western Australia  Dec. 9, 1899
561 Moore, Robert Thomas, 142, St. Vincent Street, Glasgow  Oct. 8, 1892
562 Moore, Richard Walker, Somerset House, Whitehaven  S. Nov. 5, 1870
M. Aug. 4, 1877
563 Moore, William, Westfield, Loftus, Yorkshire  A.M. Nov. 19, 1881
564 Moreing, Charles Algernon, 20, Copthall Avenue, London, E.C  Nov. 7, 1874
565 Morgan, John, Stanley Villa, Crook, County Durham  Dec. 9, 1905
566 Morison, John, 14, Saville Row, Newcastle-upon-Tyne. A.M. Dec. 4, 1880 (Member of Council)  M. Aug. 3, 1889
567 Morland-Johnson, Edward Thomas, Bank of England Chambers, Tib Lane, Cross Street, Manchester  April 10, 1897
568 Morris, John, Lydbrook Colliery, Lydbrook, Gloucestershire  A. April 4, 1903
M. Aug. 6, 1904
569 Morris, William, Waldridge Colliery, Chester-le-Street  Oct. 8, 1892
570 Morrison, Edward, 51, Pica Cottages, Distington, Cumberland  June 20, 1908

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Date of Election and Date of Transfer
571 Morse, Willard S., Seaford, Delaware, U.S.A  June 13, 1896
572* Mort, Arthur, Khost, N. W. R., Baluchistan, India  Dec. 9, 1899
573 Morton, Reginald Charles, 548, Eccleshall Road, Sheffield  Aug. 3, 1907
574 Morton, William Rostern, 57, Sanderson Road, Newcastle-upon-Tyne  Aug. 7, 1909
575 Mountain, William Charles, 8, Sydenham Terrace, Newcastle-upon-Tyne (Member of Council)  April 9, 1892
576 Mundle, Arthur, Murton Chambers, 8, Grainger Street, Newcastle-upon-Tyne  S. June 5, 1875
M. Aug. 4, 1877
577 Murdoch, Arthur Stanley, Largiemore, Camborne  Aug. 7, 1909
578 Murray, William Cuthbert, Littleton, Durham  June 10, 1903
579 Nagazumi, Junjiro, Kannonsaki, Shimonoseki, Japan  Dec. 12, 1908
580 Nesbit, John Straker, Marley Hill Colliery, Swalwell, County Durham  S. Oct. 9, 1897
A. Aug. 5, 1905
M. Oct. 12, 1907
M. Dec. 11, 1897
582 Nettle, Henry, Tremayne House, Basset Terrace, Camborne  Dec. 12, 1908
583 Nevin, John, Littlemoor House, Mirfield, Yorkshire  S. May 2, 1808
M. Aug. 5, 1871
584 Newbery, Frederick, 230, Camden Road, London, N.W.  A.M. April 2, 1898
M. Feb. 13, 1904
585 Newbigin, Henry Thornton, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne  Oct. 13, 1894
586 Nicholson, Arthur Darling, H.M. Inspector of Mines, Red Hill, Durham (Member of Council)  S. June 13, 1885
Date of Election and
of Transfer

603*Oshima, Rokuro, No. 121, Yoyogi, Toyotainaga-gun, Tokyo, Japan  April 10, 1897
604 Oughtov, William, Milburn House, Newcastle-upon-Tyne  Feb. 8, 1908
605 Owens, William David, Lehigh Valley Coal Company, 239, Philadelphia Avenue, Pottston, Pennsylvania, U.S.A.  Feb. 11, 1905
606 Padbury, John, 54, Westbourne Avenue, Gateshead-upon-Tyne  Feb. 13, 1909
607 Pace, Arthur Herbert Sheepshanks, Escomb, Bishop Auckland  Aug. 3, 1907
608 Pally, George, Glebe House, Whitburn, Sunderland  Oct. 12, 1901
609 Palmer, Claude Bowes, Wardley Hall, Pelaw, Newcastle-upon-Tyne  A.M. Nov. 5, 1892
610 Palmer, Henry, Monks Holme, Corbridge, Northumberland (Vice-President, Member of Council)  A.M. Aug. 4, 1883
611 Pamely, Caleb, 64, Cromwell Road, Bristol  M. Aug. 3, 1889
612 Pamplin, Eliah George, Cherry Hinton, Cambridge  S. Sept. 5, 1868
614 Parrington, Henry Mason, Dene House, Castletown, Sunderland  Aug. 1, 1903
615 Parrington, Matthew William, Wearmouth Colliery, Sunderland (President, Member of Council)  A.M. June 12, 1886
616 Parrington, Thomas Elliot, Carley Hill, Monkwearmouth, Sunderland  M. Aug. 3, 1889
617 Parsons, Hon. Charles Algernon, Heaton Works, Newcastle-upon-Tyne  A.M. April 10, 1897
618 Pascoe, Thomas, 509, Salisbury House, London, E.C.  M. June 12, 1897
619 Peake, R. Cecil. Cumberland House, Redbourn, St. Albans  S. Feb. 7, 1880

601 Ormsby, Robert Embleton, Seaton Delaval Colliery, Northumberland  June 11, 1898
602 Osborne, Francis Douglas, Gopeng, Perak, Federated Malay States  Feb. 14, 1903
603*Oshima, Rokuro, No. 121, Yoyogi, Toyotainaga-gun, Tokyo, Japan  April 10, 1897
604 Oughtov, William, Milburn House, Newcastle-upon-Tyne  Feb. 8, 1908
605 Owens, William David, Lehigh Valley Coal Company, 239, Philadelphia Avenue, Pottston, Pennsylvania, U.S.A.  Feb. 11, 1905
606 Padbury, John, 54, Westbourne Avenue, Gateshead-upon-Tyne  Feb. 13, 1909
607 Pace, Arthur Herbert Sheepshanks, Escomb, Bishop Auckland  Aug. 3, 1907
608 Pally, George, Glebe House, Whitburn, Sunderland  Oct. 12, 1901
609 Palmer, Claude Bowes, Wardley Hall, Pelaw, Newcastle-upon-Tyne  A.M. Nov. 5, 1892
610 Palmer, Henry, Monks Holme, Corbridge, Northumberland (Vice-President, Member of Council)  A.M. Aug. 4, 1883
611 Pamely, Caleb, 64, Cromwell Road, Bristol  M. Aug. 3, 1889
612 Pamplin, Eliah George, Cherry Hinton, Cambridge  S. Sept. 5, 1868
614 Parrington, Henry Mason, Dene House, Castletown, Sunderland  Aug. 1, 1903
615 Parrington, Matthew William, Wearmouth Colliery, Sunderland (President, Member of Council)  A.M. June 12, 1886
616 Parrington, Thomas Elliot, Carley Hill, Monkwearmouth, Sunderland  M. Aug. 3, 1889
617 Parsons, Hon. Charles Algernon, Heaton Works, Newcastle-upon-Tyne  A.M. April 10, 1897
618 Pascoe, Thomas, 509, Salisbury House, London, E.C.  M. June 12, 1897
619 Peake, R. Cecil. Cumberland House, Redbourn, St. Albans  S. Feb. 7, 1880
A.M. Aug. 7, 1866
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<td>M. Aug. 3, 1889</td>
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<td>M. Aug. 3, 1889</td>
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<td>620 Pearse, John Walter, aux Quatre Vents, Arlon, Belgium</td>
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<td>621 Pearson, Clement Alfred Ritson, South End Avenue, Darlington</td>
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<td>622 Pearson, Reginald George, Planet Mine, Box 123, Salisbury, Rhodesia, South Africa</td>
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<td>623 Pedelty, Simon, Broomhill Colliery, Aeklington, Northumberland</td>
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<td>A. Dec. 10, 1892</td>
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<td>624 Peel, Robert, New Brancepeth Colliery, Durham</td>
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<td>M. Dec. 14, 1907</td>
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<td>625 Percy, Frank, Mining College, Wigan. Transactions sent to The Librarian, Wigan</td>
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<td>626 Percy, Robert McLeod, Karagandy Colliery, Spassky Copper-mines, Limited, Spassky Zabod, Akмолинск, Siberia</td>
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<td>627 Phillips, Percy Clement Campbell, Bettisfield Colliery, Bagillt, Flintshire</td>
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<td>628 Pingstone, George Arthur, P.O. Box 445, Bulawayo, Rhodesia, South Africa</td>
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<td>M.A. June 11, 1898</td>
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<td>629 Plummer, John, Bishop Auckland</td>
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<td>630 Pollitzer, Samuel Joseph, Terry's Chambers, 14, Castlereagh Street, Sydney, New South Wales, Australia</td>
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<td>April 12, 1902</td>
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<td>631 Poole, William, School of Mines, Charters Towers, Queensland, Australia</td>
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<td>632 Poore, George Bentley, 1730, Cupouse Avenue, Scranton, Pennsylvania, U.S.A</td>
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<td>633 Porter, John Bonsall, McGill University, Montreal, Quebec, Canada</td>
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<td>634 Powell, Charles Henry, International Mines, Limited, Biggenden, via Maryborough, Queensland, Australia</td>
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<td>635 Prest, John Joseph, Hardwick Hall, Castle Eden, County Durham</td>
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<td>Feb. 9, 1901</td>
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<td>636 Price, Francis Holborrow Glynn, Longlands Place, Swansea</td>
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<td>June 10, 1899</td>
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<td>637 Price, Stephen Richard, Dilston House, Corbridge, Northumberland</td>
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<td>S. Nov. 3, 1877</td>
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<td>639 Price, William Frederick, A Floor, Milburn House, Dean Street, Newcastle-upon-Tyne</td>
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<td>M. Aug. 3, 1889</td>
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<td>640 Pringle, John Archibald, c/o J. C. Reddie, 4, Earl's Court Square, London, S.W.</td>
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<td>641 Pringle, Robert William, 25, Ellerker Gardens, Richmond, Surrey</td>
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<td>643 Pullon, Joseph Thomas, Rowangarth, North Park Road, Roundhay, Leeds</td>
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<td>644 Purdy, Richard, Katrasgarh P.O., E.I.R., Bengal, India</td>
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<td>Feb. 11, 1905</td>
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<td>645 Rae, John Livingston Campbell, 40, Church Street, Newcastle, New South Wales, Australia</td>
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<td>Aug. 1, 1908</td>
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<td>646 Raine, Frederick James, Etherley Grange Colliery, Bishop Auckland</td>
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<td>Oct. 14, 1899</td>
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<td>647 Ramsay, John, Tursdale Colliery, Ferry Hill</td>
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<td>S. Feb. 15, 1896</td>
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<td>648 Ramsay, William, Bentinck House, Pegswood, Morpeth</td>
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<td>649 Ramsay, William Henry, South Tanfield Colliery, Stanley, County Durham</td>
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<td>A. Aug. 6, 1904</td>
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<td>650 Randolph, Beverley S., Barkeley Springs, West Virginia, U.S.A</td>
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<td>M. Feb. 9, 1907</td>
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<td>651 Rankin, Thomas Thomson, Mining and Technical College, Wigan</td>
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<td>652 Rateau, Auguste, 7, rue Bayard, Paris, France</td>
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<td>656 Redwood, Sir Boyerton, Wadhams Lodge, Wadhams Gardens, London, N.W</td>
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<td>20, Park Row, Leeds</td>
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700 Rutherford, Robert, Mainsforth, Ferry Hill
Oct. 11, 1902
701 Rutherford, William, West Stanley Colliery, Stanley, County Durham
Feb. 9, 1901

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702 Ryan, William Arthur, Lonely Gold-mining Company, Lonely Mine, Private Bag,
P.O., Bulawayo, Rhodesia, South Africa
Dec. 12, 1908
703 Saise, Walter, Stapleton, Bristol
A.M. Nov. 1877
704 Sam, Thomas Birch Freeman, Domkodu, Cape Coast Castle, West Africa
Aug. 5, 1893
705 Samborne, John Stukely Palmer, Timsbury House, Bath
Aug 1 1891
706 Sample, James Bertram, 17, Tynedale Terrace, Hexham
S. Jan. 19, 1895
707 Sampson, William, 33, Queen Street, Singapore
Oct. 9 1909
708 Samwell, Nicholas, c/o Alexander Forbes, P.O. Box 331, Rangoon, Burma, India
April 13 1901
709 Sandow, William John Josiah, 1a, Telferscot Road, Streatham Hill, London, S.W.
Feb. 8 1908
710 Saunders, David William Alban, Worcester Chambers, Swansea
A.M. Feb. 12, 1898
711 Saunders, William Thomas, 9 and 10, Pancras Lane, Queen Victoria Street,
London, E.C.
M. June 11, 1898
S. Dec. 6, 1873.
713 Schmidt, Henry Morton, United Coal Company, 804, Bank for Savings Building,
Pittsburgh, Pennsylvania, U.S.A
Aug. 1, 1908
714 Schnabel, Leberecht Ferdinand Richard, Sun Buildings, Corner of Bourke and
Queen Streets, Melbourne, Victoria, Australia
April 13, 1907
715 Schwarz, Paul, Dortmund, Crook, County Durham
April 9, 1904
716 Scott, Anthony, Netherton Colliery, Nedderton, Newcastle-upon-Tyne
April 8, 1905
717 Scott, Charles F., Newbell, Consett, County Durham
S. April 11, 1874
718 Scott, Ernest, Sun Buildings, Newcastle-upon-Tyne
M. April 4, 1877
719 Scott, Edward Charlton, Woodside Cottage, Totley Rise, Sheffield
A. Oct. 8, 1892
720 Scott, George Henry Hall, c/o Thomas Emerson Forster, 3, Eldon Square,
Newcastle-upon-Tyne
S. April 12, 1902
721 Scott, Herbert Kilburn, 46, Queen Victoria Street, London, E.C
M. Dec. 8, 1906
722 Scoolar, George, St. Bees, Cumberland
Oct. 11,1902
723 Selby, John Baseley, Leigh
July 2, 1872
724 Severs, Joseph, North Walbottle, Newburn, Northumberland
April 25, 1896
725 Skiers, William, Beamish, County Durham
June 8, 1901
726 Shanks, John, Coal Creek, Fernie, British Columbia
A. Nov. 5, 1892
727 Sharp, Jacob, Lambton House, Fence Houses
M. Dec. 8, 1900
728 Sharp, Robert Rich, Union Mine du Haut Katanga, Star of the Congo Mine, via
Ndola, North Western Rhodesia, South Africa
Aug. 5, 1905
729 Shaw, James, 41, Wicksteed Street, Wanganui, New Zealand
Dec. 12, 1896
730 Shealer, Arthur Whitcomb, Pottsville, Pennsylvania, U.S.A
Aug. 4, 1894
731 Shiel, John, South Garesfield Colliery, Rowlands Gill, Newcastle-upon-Tyne
May 6, 1871
732 Simon, Frank, Hand Club, Johannesburg, Transvaal
Dec. 14, 1895
733 Simpson, Charles Liddell, 13, Montagu Place, Montagu Square, London, W
April 8, 1893
734 Simpson, Francis L. G., Mohapi Coal-mines, Gadawarra, C.P., India
A.M. Dec. 13, 1881
735 Simpson, Frank Robert, Hedgefield House, Blaydon-upon-Tyne, County Durham
M. Aug. 3, 1889
(Vice-President, Member of Council)

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735 Simpson, Frank Robert, Hedgefield House, Blaydon-upon-Tyne, County Durham
S. Aug. 4, 1883
M. Aug. 1,1891
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<td>S. Dec. 6, 1866, M. Aug. 1, 1868</td>
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<td>Simpson, John Bell, Bradley Hall, Wylam, Northumberland (Past-President, Member of Council)</td>
<td>S. Aug. 3, 1895, A. Aug. 2, 1902, M. Oct. 11, 1902</td>
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<td>Skertchley, Sydney A. R., Apartado Postal Num. 3023, Sucursals V., Paseo de la Reforma, Mexico, D.F.</td>
<td>July 2, 1872, A. Oct. 11, 1902, M. Oct. 12, 1907</td>
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<td>Smallwood, Percy Edmund, Mining Offices, Medomsley, County Durham</td>
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<td>743</td>
<td>Smart, Alexander, c/o Frazer and Chalmers, Limited, Erith, Kent</td>
<td>Apr. 12, 1902, A. Aug. 2, 1891, M. Aug. 3, 1895</td>
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<td>Aug. 6, 1891, A. Aug. 2, 1891, M. Aug. 3, 1895</td>
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<td>Apr. 12, 1902, A. Aug. 2, 1891, M. Aug. 3, 1895</td>
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<td>Steavenson, Addison Langhorne, Durham (Past-President, Member of Council)</td>
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<td>Stephenson, Ralph, Fern Cottage, Poolstock Lane, Wigan</td>
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<td>A.M. Aug. 4, 1888, M. Aug. 3, 1889</td>
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<td>Oct. 3, 1874</td>
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<td>Aug. 6, 1904</td>
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<td>Aug. 5, 1905</td>
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<td>A. June 10, 1893</td>
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<td>April 7, 1877</td>
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<td>Dec. 12, 1903</td>
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<td>Via dei Cattaneo, Novara, Italy ; and Ceppomorelli per Macugnaya, Valf Anzasca, Prov. di Novara, Italy</td>
<td>Apr. 12, 1902</td>
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883 Wilkinson, Maurice Hewson, Avenue Rise, Bushey, Herts  A. Dec. 12, 1903
M. Oct. 10, 1908


885 Willey, Joseph Leonard, East Rand Proprietary Mines, P.O. Box 123, East Rand, Transvaal  Aug. 1, 1908

886 Williams, Arthur Hamilton, c/o Burrakur Coal Company, Panuria P.O., via Sitarampur, Bengal, India  Oct. 10, 1908

887 Williams, Foster, Miniera di Libiola, Sestri Levante, Italy  A. April 13, 1907
M. June 20, 1908

888 Williams, Griffith John, H.M. Inspector of Mines, Bangor  Aug. 2, 1902

889 Williams, James, c/o James Pollock, Sons and Company, Limited, 3, Lloyd's Avenue, London, E.C.  April 11, 1908

890 Williams, John, Dolavon, Llanrwst, Denbighshire  Oct. 8, 1904

891 Williams, Luke, Claremont, Moonah, Tasmania  April 10, 1897

892 Williams, Robert, 30, Clements Lane, Lombard Street, London, E.C.  June 13, 1896

893 Williams, Arthur Hamilton, c/o Burrakur Coal Company, Panuria P.O., via Sitarampur, Bengal, India  Oct. 10, 1908

894 Williams, Foster, Miniera di Libiola, Sestri Levante, Italy  A. April 13, 1907
M. June 20, 1908

895 Wilson, Anthony, Thornthwaite, Keswick  A.M. Feb. 10, 1900
M. Dec. 13, 1902

896 Wilson, Archibald Laurence, The New Ravenswood, Limited, Ravenswood, Queensland, Australia  A.M. June 12, 1897
M. April 2, 1888

897 Wilson, Frederick, Hebburn Colliery, Hebburn, County Durham  Dec. 12, 1908

898 Wilson, James, Wellington House, Edmondsley, Durham  April 13, 1901

899 Wilson, Lloyd, Flimby Colliery, Maryport  Jan. 19, 1895

900 Wilson, Nathaniel, 2, East India Avenue, Leadenhall Street, London, E.C.  Dec. 9, 1899

901 Wilson, Peregrine Oliver, c/o F. F. Wilson, 7, Devonshire Square, Bishopsgate Street, London, E.C.  Dec. 9, 1893

902 Wilson, Robert Gott, Battle Green, Pelton Fell, County Durham  A. Aug. 6, 1892
M. Dec. 12, 1903

903 Wilson, William, Chilton Colliery, via Ferry Hill  June 8, 1907

904 Wilson, William Brumwell, Horden Dene, Easington, Castle Eden, County Durham  S. Feb. 6, 1869
M. Aug. 2, 1873

905* Wilson, William Brumwell, Jun., Langley-on-Tyne, Northumberland  Feb. 9, 1901

906 Winchell, Horace V., 505, Palace Building, Minneapolis, Minnesota, U.S.A  Nov. 24, 1894

895 Wilson, Anthony, Thornthwaite, Keswick  A.M. Feb. 10, 1900
M. Dec. 13, 1902

896 Wilson, Archibald Laurence, The New Ravenswood, Limited, Ravenswood, Queensland, Australia  A.M. June 12, 1897
M. April 2, 1888

897 Wilson, Frederick, Hebburn Colliery, Hebburn, County Durham  Dec. 12, 1908

898 Wilson, James, Wellington House, Edmondsley, Durham  April 13, 1901

899 Wilson, Lloyd, Flimby Colliery, Maryport  Jan. 19, 1895

900 Wilson, Nathaniel, 2, East India Avenue, Leadenhall Street, London, E.C.  Dec. 9, 1899

901 Wilson, Peregrine Oliver, c/o F. F. Wilson, 7, Devonshire Square, Bishopsgate Street, London, E.C.  Dec. 9, 1893

902 Wilson, Robert Gott, Battle Green, Pelton Fell, County Durham  A. Aug. 6, 1892
M. Dec. 12, 1903

903 Wilson, William, Chilton Colliery, via Ferry Hill  June 8, 1907

904 Wilson, William Brumwell, Horden Dene, Easington, Castle Eden, County Durham  S. Feb. 6, 1869
M. Aug. 2, 1873

905* Wilson, William Brumwell, Jun., Langley-on-Tyne, Northumberland  Feb. 9, 1901

906 Winchell, Horace V., 505, Palace Building, Minneapolis, Minnesota, U.S.A  Nov. 24, 1894

[xlvi]
ASSOCIATE MEMBERS (Assoc. M.I.M.E.).
Marked * have paid life composition.

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<td>Aug. 1, 1885</td>
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<td>Nov. 5, 1892</td>
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<td>Middlesbrough</td>
<td>Dec. 9, 1887</td>
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<td>Bishop, Clarence Adrian</td>
<td>Engineering and Building Works, Mooi River, Natal, South Africa</td>
<td>Oct. 10, 1903</td>
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<td>Farm Sabonabon, near Motor Mine, Gatooma, Rhodesia, South Africa</td>
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<td>Oct. 11, 1890</td>
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<td>Findon Cottage, near Durham</td>
<td>Oct. 9, 1897</td>
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<td>36</td>
<td>Graham, James Parmsley</td>
<td>26, Cloth Market, Newcastle-upon-Tyne</td>
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<td>37</td>
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<td>4, Park Terrace, North Shields</td>
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<td>38</td>
<td>Guthrie, Reginald</td>
<td>Neville Hall, Newcastle-upon-Tyne (Treasurer, Member of Council)</td>
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<td>39</td>
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<td>The Manor House, Long Benton, Newcastle-upon-Tyne</td>
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<td>The Limes, Whitburn, Sunderland</td>
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<td>Harris-Edge, H. P.</td>
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<td>42</td>
<td>Haswell, William Spence</td>
<td>Beverley Gardens, Cullercoats, Whitley Bay, Northumberland</td>
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<td>Hedley, John Hunt</td>
<td>1 Elms West, Sunderland</td>
<td>June 13, 1891</td>
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<td>44</td>
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<td>45</td>
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<td>c/o John George Weeks, Bedlington, Northumberland</td>
<td>Dec. 9, 1882</td>
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<td>46</td>
<td>Henzell, Robert</td>
<td>Northern Oil Works, Newcastle-upon-Tyne</td>
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<td>Hodgetts, Arthur</td>
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<td>49</td>
<td>Hopper, George William Nugent</td>
<td>The Ropery, Thornaby-on-Tees, Stockton-on-Tees</td>
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<td>50</td>
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<td>164, Rye Hill, Newcastle-upon-Tyne</td>
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<td>51</td>
<td>Humphreys-Davies</td>
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<td>52</td>
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<td>Prudential Buildings, Mosley Street, Newcastle-upon-Tyne</td>
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<td>James, Henry M.</td>
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<td>Jeans, James Stephen</td>
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<td>70</td>
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<td>71</td>
<td>Palmer, Sir Alfred Molyneux</td>
<td>Bart., John Bowes and Partners, Limited, Milburn House, Newcastle-upon-Tyne</td>
<td>Nov. 24, 1894</td>
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<td>72</td>
<td>Patterson, Robert Oliver</td>
<td>Thomeyholme, Wylam, Northumberland</td>
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<td>73</td>
<td>Pickup, Peter Wright Dixon</td>
<td>Rishton Colliery, Rishton, Blackburn</td>
<td>Feb. 12, 1898</td>
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Date of Election and of Transfer

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<td>Postlethwaite, John</td>
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<td>75</td>
<td>Prior-Wandesforde, Richard Henry</td>
<td>Castlecomer House, Castlecomer, County Kilkenny</td>
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<td>76</td>
<td>Proctor, John Henry</td>
<td>29, Side, Newcastle-upon-Tyne</td>
<td>June 8, 1889</td>
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### ASSOCIATES (Assoc. I.M.E.)

Marked * have paid life composition.

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<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Allan, Herbert Durham</td>
<td>Rewah State Collieries, Umaria, Central India, Bengal Nagpur Railway</td>
<td>Feb. 10 1906</td>
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<tr>
<td>Almond, Charles Percy</td>
<td>15, Maureen Terrace, Seaham Harbour, County Durham</td>
<td>Oct. 9 1900</td>
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<td>Annett, Hugh Clarkston</td>
<td>Office Row, East Cramlington, Cramlington, Northumberland</td>
<td>S. Feb. 15, 1906</td>
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<td>Archer, Matthew William</td>
<td>Grosvenor House, Manchester Road, Stocksbridge, Sheffield</td>
<td>S. June 8, 1895</td>
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<td>Armstrong, Henry</td>
<td>29, William Street, New Seaham, Seaham Harbour, County Durham</td>
<td>A. Aug. 4, 1901</td>
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<td>Askew, Alfred Hill</td>
<td>16, Telford Street, Gateshead-upon-Tyne</td>
<td>A. Aug. 6, 1904</td>
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<td>Bamborough, Jacob</td>
<td>Preston Colliery, North Shields</td>
<td>Oct. 8, 1904</td>
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<td>Barkes, Percy</td>
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<td>June 12, 1909</td>
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<td>Barrett, Rollo Samuel</td>
<td>Whitehill Hall, Pelton Fell, County Durham</td>
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<td>Bates, Johnson</td>
<td>5, Grange Villa, County Durham</td>
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<td>Bates, Thomas</td>
<td>West Wylam Terrace, Prudhoe, Ovingham, Northumberland</td>
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<td>14, Kotchkar, via Miass, Government of Orenburg, Russia</td>
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16 Bewick, George, Johnson Terrace, West Auckland, Bishop Auckland
   A Aug. 5, 1905
   Bewick, George, Johnson Terrace, West Auckland, Bishop Auckland
   April 10, 1897
17 Bewley, Thomas, Stoatswood Colliery, Acklington, Northumberland
   Aug. 5, 1905
18 Blair, Robert Richmond, 6, Hamilton Terrace, Whitehaven
   Aug. 2, 1902
19 Blunden, Philip Sidney, The Villas, Dean Bank, Ferry Hill Village, Ferry Hill
   June 8, 1907
20 Booth, Frederic Lancelot, Ashington Colliery, Morpeth
   S. Feb. 10, 1894
21 Booth, James Frederick, 8, Uxbridge Terrace, Felling, County Durham
   A. Aug. 4, 1900
22 Bowes, Thomas, Overdale, Catchgate, Anntield Plain, County Durham
   Dec. 13, 1902
23 Brandon, Geoffry, 9, Beech Grove, Benton, Newcastle-upon-Tyne
   S. Dec. 13, 1894
24 Brown, John, Central Pench Coal Company, Limited, Pench Valley P.O., District
   Chindwara, C.P., India
   A. Aug. 7, 1909
25 Burt, Thomas, Hill House, Washington, Washington Station, County Durham
   April 9, 1904
26 Carroll, John, Spring Bank House, Newfield, Willington, Durham
   Feb. 12, 1898
27 Chapman, John, Tyzack Street, Edmondsley, Durham
   Dec. 14, 1907
28 Cheesman, Matthew Forster, Throckley Colliery, Newburn, Northumberland
   S. Dec. 13, 1902
29 Clark, Nathaniel J., Belle Vue, Chester de-Street
   A. Aug. 5, 1905
30 Clark, Thomas, Dighton Colliery, Lintz Green Station, County Durham
   Oct. 11, 1909
31 Clifford, Edward Herbert, Binchester Hall, Bishop Auckland
   S. Aug. 2, 1902
32 Clough, Edward Stokoe, Bomarsund House, Bomarsund, Bedlington, Northumberland
   Feb. 14, 1903
33 Coade, Samuel, Steel Green, Millom, Cumberland
   Dec. 10, 1904
34 Cockbain, Tom Stewartson, Usworth Colliery, Washington Station, County Durham
   Dec. 8, 1906
35 Cockburn, John, Fafffield Road, Washington, County Durham
   April 9, 1904
36 Cook, George, Binchester Hall, Bishop Auckland
   S. Aug. 2, 1902
37 Cowx, H. F., The Villa, Thornley, County Durham
   A. Aug. 5, 1905
38 Cowx, H. F., The Villa, Thornley, County Durham
   April 14, 1894
39 Coxon, Samuel George, Hamsteels Colliery, Durham
   Feb. 9, 1901
40 Crawford, Thomas, Eighton Banks, Gateshead-upon-Tyne
   Dec. 8, 1906
41 Crowle, Percy, Mysore Mine, Markkuppam, Mysore State, India
   Feb. 11, 1905
42 Cummings, William, Beamish View, Stanley, County Durham
   Dec. 14, 1907
43 Daglish, Frank, 1, Wilson Terrace, Broughton Moor, Maryport
   Dec. 14, 1907
44 Daniell, Henry Edmund Blackburne, Grange Road, Ryton, County Durham
   S. Aug. 3, 1907
45 Danskin, Thomas, Springwell Colliery, Gateshead-upon-Tyne
   A. Aug. 6, 1910
46 Davies, Daniel John, Cymru, Corrimal, Illawarra Line, New South Wales, Australia
   Dec. 10, 1898
47 Davis, James E., South Medomsley Colliery, Dighton, County Durham
   Feb. 12, 1898
48 Davison, Francis, Ash Grove House, Hedley Hill Colliery, near Waterhouses, Durham
   Oct. 9, 1909
49 Dawson, Charles, Bettisfield Colliery, Bagillt, Flintshire
   Dec. 8, 1906
50 Dick-Cleland, Archibald Felce, c/o Bank of Montreal, Mexico City, Mexico.
   Transactions sent to Ria Ora, Trelawny Road, Camborne
   S. Dec. 13, 1902
51 Dixon, Edwin Carr, Hallgarth, Lanchester, Durham
   A. Aug. 1, 1908
52 Dixon, George, High Park Colliery, Newthorpe, Nottingham
   S. Feb. 9, 1901
53 Dunnett, Samuel, West View House, Coomassie Road, Waterloo, Blyth
   A. Aug. 3, 1907
54 Eadie, John Allan, Jun., Eller Bank, Harrington, Cumberland
   June 8, 1895
55 Elliott, Arthur, Springfield, Cressington Park, Liverpool
   S. Oct. 10, 1903
56 Elliott, George, South View, Mickley Colliery, Stocksfield, Northumberland
   A. Aug. 5, 1905
57 Emmerson, Thomas, The British India Coal Company, Limited, Nowpara Colliery, Aaansol P.O., E. I. Railway, India
   Oct. 12, 1907
58 English, Thomas Weddle, Halton Colliery, Whittington, Corbridge, Northumberland
   Feb. 11, 1905

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33 Clough, Edward Stokoe, Bomarsund House, Bomarsund, Bedlington, Northumberland
   Feb. 14, 1903
34 Coade, Samuel, Steel Green, Millom, Cumberland
   Dec. 10, 1904
35 Cockbain, Tom Stewartson, Usworth Colliery, Washington Station, County Durham
   Dec. 8, 1906
36 Cockburn, John, Fafffield Road, Washington, County Durham
   April 9, 1904
37 Cook, George, Binchester Hall, Bishop Auckland
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38 Cowx, H. F., The Villa, Thornley, County Durham
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42 Cummings, William, Beamish View, Stanley, County Durham
   Dec. 14, 1907
43 Daglish, Frank, 1, Wilson Terrace, Broughton Moor, Maryport
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44 Daniell, Henry Edmund Blackburne, Grange Road, Ryton, County Durham
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45 Danskin, Thomas, Springwell Colliery, Gateshead-upon-Tyne
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46 Davies, Daniel John, Cymru, Corrimal, Illawarra Line, New South Wales, Australia
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47 Davis, James E., South Medomsley Colliery, Dighton, County Durham
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57 Emmerson, Thomas, The British India Coal Company, Limited, Nowpara Colliery, Aaansol P.O., E. I. Railway, India
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<td>Llanarth Villas, Cross Keys, Newport, Monmouthshire</td>
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<td>Herriotts, Joseph</td>
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<td>A. Aug. 6, 1910</td>
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<td>Apr. 28, 1900</td>
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<td>91</td>
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<td>St. George's Colliery, Hatting Spruit, Natal, South Africa</td>
<td>Dec. 15, 1896</td>
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140 Paddon, Neyille Blackmore, Mote Park, Ballymurray, County Roscommon, Ireland  Dec. 14, 1907
141 Palmer, Harry, The Manor House, Medomsley, County Durham  S. June 14, 1902
A. Aug. 7, 1909
142 Palmer, Meyrick, Jobs Hill, near Crook, County Durham  S. June 8, 1901
A. Aug. 1, 1908
143 Pattison, Charles Werner, Milburn House, Darlington Road, Ferry Hill  June 12, 1909
144 Pattison, Andrew, Greenside, Ryton, County Durham  Dec. 8, 1906
145 Pattison, Charles Arthur, High Grange, Howden-le-Wear, County Durham  S. April 13, 1901
A. Aug. 5, 1905
146 Pattison, William, Witbank Colliery, Witbank, Transvaal  Dec. 13, 1902
147 Pearson, John Charlton, Hotchpudding Farm, Denton, Scotswood, Northumberland  Feb. 14, 1903
148 Peel, George, Jun., 27, Langley Street, Langley Park, Durham           April 4, 1903
149 Phelps, Charles, c/o Wragg and Company, Gatooma, Southern Rhodesia, South Africa  Aug. 3, 1901
150 Potts, Launrice Wylam, 77, Mowbray Road, South Shields  April 4, 1903
151 Pratt, George Ross, Springwell Colliery, Gateshead-upon-Tyne  June 8, 1895
152 Proctor, Thomas, Woodhorn Colliery, Morpeth  Oct. 13, 1894
153 Pumphrey, Charles Ernest, Greenside House, Ryton, County Durham  S. Dec. 10, 1904
A. Aug. 4, 1906
154 Ramsay, John Gladstone, 2, Steavenson Street, Bowburn, Coxhoe, County Durham  Dec. 10, 1892
155 Richardson, Frank, Ravensworth, Ashton-under-Lyne  S. Oct. 12, 1901
A. Aug. 1, 1908
156 Richardson, Henry, Claravale Colliery, Ryton, County Durham  Dec. 8, 1906
157 Ridley, George Dinning, 14, First Row, Ashington, Morpeth  Feb. 8, 1890
158 Ridley, Henry Anderson, Burnbrae, Blaydon Burn, Blaydon-upon-Tyne, County Durham  Dec. 14, 1897
159 Ridley, William, Jun., School House, Burnside, Blaydon-upon-Tyne, County Durham  Dec. 8, 1906
160 Rivers, John, Bow Street, Thornley Colliery, Durham  Feb. 9, 1895
161 Robinson, John William, 3, The Terrace, Boldon Colliery, County Durham  S. April 12, 1902
A. Aug. 5, 1905
162 Robinson, Stanley, Chesterholm, North Biddick, Washington Station, County Durham  S. Oct. 12, 1901
A. Aug. 1, 1908
163 Rochester, William, 1, Office Row, Netherton Colliery, Nedderton, Newcastle-upon-Tyne  Dec. 9, 1905

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164 Rogers, John, Widdrington Colliery, Acklington, Northumberland  S. April 8, 1899
A. Aug. 4, 1906
165 Roose, Hubert F. G., Royal School of Mines, South Kensington, London, S.W.  S. Dec. 9, 1899
A. Aug. 3, 1907
166 Rutherford, Robert Archibald, Wellington Terrace, Edmondsley, Durham  Dec. 14, 1907
167 Rutherford, Thomas Easton, West Shield Row Colliery, Stanley, County Durham  S. June 10, 1899
A. Aug. 4, 1906
168 Saner, Charles B., Turf Mines, Limited, P.O. Box 5887, Johannesburg, Transvaal  April 10, 1897
169 Schollick, Thomas, 13, Model Street, New Seaham, Sunderland  Dec. 12, 1903
170 Scobie, Isaac, Woonona, near Sydney, New South Wales, Australia  Oct. 13, 1906
171 Scott, Thomas Amour, 5, Swarland Terrace, Acklington, Northumberland  Oct. 9, 1909
172 Seed, Alexander, 1, College Terrace, Brandon Colliery, County Durham  April 4, 1903
173 Severs, Jonathan, 1, Quality Row, Ryhope, County Durham  S. June 8, 1895
A. Aug. 4, 1900
A. Aug. 6, 1910
175 Sharp, Thomas, Wilson Terrace, Broughton Moor, Maryport  Dec. 14, 1907
176 Simpson, Richard Charlton, Wellington Terrace, Edmondsley, Durham  Feb. 13, 1904
177 Smith, James, View Lane, Stanley, County Durham  Dec. 11, 1899
178 Smith, Joseph, South Pontop Colliery, Annield Plain, County Durham  Oct. 12, 1907
179 Snowdon, Thomas, Jun., Oakwood, Cockfield, County Durham  S. June 12, 1897
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180 Southern, Charles, Radstock, Bath  S. June 10, 1903
A. Aug. 7, 1909
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9 Coxon, Samuel Bailey, Washington Colliery, Washington Station, County Durham Oct. 12, 1907
10 Dakers, Edgar Walton, Tudhoe Colliery, Spennymoor Dec. 14, 1907

[ [lvii] Date of Election
11 Douglas, Albert Edward, Beethoven House, Horden, Castle Eden, County Durham Aug. 1, 1903
12 Farnshaw, Oscar, Kiln Bank House, Amble, Acklington, Northumberland Feb. 8, 1908
13 English, Henry Edward, Lumley Manor House, Fence Houses Aug. 7, 1909
14 Ford, Eric Loufwin, Whittonstall House, Chopwell, Ebchester, County Durham April 11, 1908
15 Fowler, Albert Ernest, Us worth Villa, Washington Station, County Durham Oct. 12, 1907
16 Gallon, Joseph, 71, Seventh Row, Ashington, Morpeth Sept. 9, 1909
17 Grace, William Grace, Hall Garth Hall, Winlaton, Blaydon-upon-Tyne, County Durham Feb. 9, 1907
19 Hepburn, Henry, Greenhead Terrace, Chopwell, Ebchester, County Durham Oct. 12, 1907
20 Kuggup, Ralph, 33, Wingrove Road, Newcastle-upon-Tyne Feb. 10, 1906
21 Hull, Tom Edward, 11, Clarence Terrace, Regent's Park, London, N.W Dec. 12, 1908
22 Hunter, Herbert Stanley, Blakelaw, Kenton, Newcastle-upon-Tyne Feb. 9, 1907
23 Hunter, John, West View, Front Street, Sacriston, Durham Dec. 11, 1909
24 Hutton, Allan Robinson Bowes, Nine Mile Point Colliery, Cross Keys, Newport, Monmouthshire April 8, 1905
26 Jacobs, George, 6, St. George's Square, Sunderland Dec. 11, 1909
27 Kirkup, Ernest Hodgson, Eighton Lodge, Low Fell, Gateshead-upon-Tyne April 13, 1907
28 Lawson, Richard Forster, Holmside Villa, Holmside, Edmondsley, Durham March 13, 1904
29 Magee, Charlie Sharpe, Colliery Offices, Lumley Thicks, Fence Houses Aug. 7, 1909
30 Maughan, Thomas, Ferry Hill Engine Works, West Cramlington, County Durham April 13, 1907
31 Nicholson, George Thompson, Dene House, Scotswood, Northumberland Jan. 10, 1904
32 Prest, Norman Leslie, East Cramlington, Cramlington, Northumberland Oct. 9, 1909
33 Rayner, Sydney, The Marshes, Atherton Road, Hindley Green, Wigan Feb. 13, 1909
34 Ridley, William, 10, Railway Street, Tow Law, County Durham Aug. 1, 1908
35 Ritson, John Anthony Sydney, Burnhope Colliery, Lanchester, Durham Aug. 4, 1906
36 Rutherford, Hooper, Mainsforth, Ferry Hill Dec. 11, 1909
37 Varvill, Wilfred Walter, Colombian Mining and Exploration Company, co Tracey Brothers, Medellin, Republic of Colombia, South America Dec. 12, 1908
38 Wrightson, Philip B. H., 6, Leazes Crescent, Hexham June 10, 1905
39 Woodhouse, James, Waterside House, Coatham, Middlesbrough April 13, 1907
40 Wraith, Charles Osborn, Thornley Colliery Office, Thornley, County Durham June 10, 1905

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41 Slater, Thomas Edward, Blaydon Burn Colliery, Blaydon-upon-Tyne, County Durham April 13, 1907
42 Strong, Johns William, 7, Earl's Drive, Low Fell, Gateshead-upon-Tyne Oct. 9, 1909
43 Thompson, George Heron Dinsdale, Dinsdale Vale, Windsor Avenue, Waterloo, Blyth Febr. 14, 1903
44 Turnbull, John James, Jun., 34, Victoria Terrace, Seaton Hirst, Ashington, Morpeth Feb. 8, 1908
45 Varvill, Wilfred Walter, Colombian Mining and Exploration Company, co Tracey Brothers, Medellin, Republic of Colombia, South America Dec. 12, 1908
46 Walton-Brown, Stanley, Seghill Colliery, Seghill, Dudley, Northumberland June 20, 1908
47 Watson, Thomas, Jun., Rosebank, Darlington June 8, 1907
48 Watts, Hubert, Blytheswood North, Osborne Road, Newcastle-upon-Tyne June 8, 1907
49 Weeks, Francis Mathwin, Eastwood Collieries, near Nottingham Feb. 10, 1906
50 Welch, William Hall, 32, Beaconsfield Avenue, Low Fell, Gateshead-upon-Tyne Feb. 10, 1906
51 Wilkinson, Ralph Percy, 51, Railway Terrace, New Herrington, Fence Houses Dec. 9, 1905
52 Williamson, George Armstrong, 59, Coatsworth Road, Gateshead-upon-Tyne Feb. 13, 1909
53 Wrightson, Philip B. H., 6, Leazes Crescent, Hexham June 10, 1905
54 Wrightson, Philip B. H., 6, Leazes Crescent, Hexham April 11, 1908

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Members are desired to communicate all changes of address, or any corrections or omissions in the list of names, to the Secretary.

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