CONTENTS OF VOL. XVIII.

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report of Council</td>
<td>v</td>
</tr>
<tr>
<td>Finance Report</td>
<td>vi</td>
</tr>
<tr>
<td>Technical Education Report</td>
<td>ix</td>
</tr>
<tr>
<td>Treasurer's Account</td>
<td>xii</td>
</tr>
<tr>
<td>General Account</td>
<td>xiv</td>
</tr>
<tr>
<td>Patrons</td>
<td>xv</td>
</tr>
<tr>
<td>Officers 1869/70</td>
<td>xvii</td>
</tr>
<tr>
<td>Members</td>
<td>xvii</td>
</tr>
<tr>
<td>Graduates</td>
<td>xxxviii</td>
</tr>
<tr>
<td>Subscribing Collieries</td>
<td>xli</td>
</tr>
<tr>
<td>Rules (as altered to August 7, 1869)</td>
<td>xliii</td>
</tr>
</tbody>
</table>
GENERAL MEETINGS.

1868.

Sept. 5. — Model of a new Safety-Cage exhibited by Mr. James Barkus;
Mr. J. A. R. Morison's Invention for preventing Tampering with Safety-Lamps explained 2

Oct. 3. — Technical Education Committee's Report read ........ 7
"Remarks on Rivetting," by Mr. W. Boyd............. 9
   Discussed................. 4
Hann's Safety-Lamp exhibited and explained .... ... 5

Nov. 7. — Mr. George Elliot's Inaugural Address ...... 19
   Report of the Smoke Committee .................... 37

Dec. 5. — Books Presented to Mr. E. Bainbridge .......... 41
Paper "On the Mechanical Stoking of Steam Boilers," by Mr. James Nelson..................... 51
   Discussed ..................... 141

1869.

Feb. 6. — Tail-Rope Committee's Report discussed .......... 61
Paper by Mr. A. L. Steavenson " On some Experiments with the Lemielle Ventilator at Page Bank Colliery " ......... 63
   Discussed .................. 57

Mar. 6. — Further Discussion on Tail-Rope Committee's Report ...... 71
Mr. Boyd's Paper "On Mechanical Rivetting " discussed...... 82

April 10. — Mr. I. L. Bell elected a Vice-President in place of Mr. J. F. Spencer (resigned) ... ...... 85
   Further discussion on Mr. Nelson's Paper "On the Mechanical Firing of Steam Boilers 86
Further discussion on Mr. Steavenson's Paper "On Fan Ventilation" ......................... 99
Experiments on board the "Weardale" .......... 105

May 8. — Notice of Proposed Alteration of Rules by Mr. Marley ...... 107
Paper by Mr. W. Waller "On Steam Boilers" .......... 121
Mr. Nelson's Paper "On Mechanical Stoking" discussed...... 107

( IV )

June 5. — Mr. Marley's Proposed Alteration of Rules .... ... 127
Mr. A. L. Steavenson's Paper on the Lemielle Ventilator discussed. 130
Supplementary Papers on the subject by Mr. Steavenson and Mr. Cochrane ........133, 139

Aug. 7 — Council, Finance, and Technical Education Committees' Reports read; Paper by
Mr. T. J. Bewick "On the Mountain or Carboniferous Limestone District of the North of
England; " Paper by Mr. George Fowler " On a Method of Abstracting Explosive Gas from
the Goaves of Coal Mines" ; Discussion on Mr. A. L. Steavenson's Paper adjourned;
Mr. E. F. Boyd elected President 149

Index at end of volume.

(V)

Report
The Council have much satisfaction in having so favourable a Report to present to the Members of
the Institute.

The continued increase in the number of members has been most gratifying, and the deduction to
be made for death and other causes is unusually small. The increase of members during the last
three years has been nearly 40 per cent.

Adverting to the Transactions and Papers, the Council think them well calculated to sustain the
prestige of the published proceedings.
The address of our late President gives a most interesting summary of the work done by the Institute, and a valuable exposition of the labour of the Mining Engineer, and several theoretical and practical questions connected with ventilation have been placed before the Institute in such a way as to invite much valuable discussion.

The contributions on mechanical subjects are also full of interest. The all-important question of Mechanical Stoking and the Consumption of Smoke has been most ably treated, and your Council consider that the Institute may justly take some credit to itself for having induced the Government to permit the use of Hartley Coal on board Her Majesty’s ships.

The paper on Rivetting is a valuable and comprehensive treatise on a subject that has not before received much close attention.

The work done by the Committees has been very important, more especially that effected by the one on Technical Education, whose report the Council refer to with satisfaction; and this opportunity is taken of thanking the Coal Trade Association for the most valuable assistance they have rendered to the undertaking, by supplying the necessary funds for starting the movement. The Council hope another year will render pecuniary support unnecessary, and the undertaking, under the joint direction of the Institute and Coal Trade, from its own resources will prove a most valuable boon to the district.

The Committee on the Prevention of Smoke have given a Report, which very properly, as far as regards hand-firing, considers the question to have been exhausted, and recommends future enquiry to be confined exclusively to mechanically fired furnaces. A new Committee has been formed, who propose to issue suggestions as to the mode of conducting these experiments, so as to ensure uniformity in the manner of recording them.

The Building Committee have also made progress, as the members will have perceived; Neville Hall has been removed, and in a few months the new building will rise in its place, and the members will soon have the satisfaction of meeting in a handsome and appropriate Hall suited to their wants.

The Council refer with pleasure to the visit of the Members of the South Staffordshire Mining Institute to this district, in May, and to the more recent meeting of the Institute of Mechanical Engineers in this town, and they suggest to their successors the advisability of holding the next annual meeting of this Institute at some town other than Newcastle.

Finance Report
Your Committee have much pleasure in reporting that the Finances of the Institute continue in a very satisfactory state. During the past year there have been 65 new members elected, making a total number, after deducting the number whose memberships have ceased, 465 members and 41 graduates.

The receipts of the Society are about £100 more than for the year 1868, and amount to £1,278 10s. 4d. The expenditure has also been greater owing to the extra cost of printing the proceedings, which are more voluminous than last year, in consequence of the Report from the Tail-rope Committee. The sales have, however, increased from £65 to £124.

The Capital Fund has been reduced from £3,174 18s. 11d. to £2,366 12s. 10d., mainly owing to a payment of £1,056. 5s. being made for the balance of the purchase of the site of the Wood Memorial Hall.

(Signed)

LINDSAY WOOD. JOHN DAGLISH.

( viii )

ADVERTISEMENT.

The Institution is not, as a body, responsible for the facts and opinions advanced in the papers read, and in the Abstracts of the Conversations which occurred at the Meetings during the Session.

( ix )

Technical Education

REPORT OF THE COMMITTEE.

Since the last annual meeting of this Institute the subject of Technical Education in the coal district of Northumberland and Durham has assumed a more tangible form. In October last this Committee in sending their report to the annual meeting of the Coal Trade Association, recommended the services of Mr. Rowden, who had offered to come north to carry out a scheme of Education in connection with the Government Department of Science and Art. This suggestion was favourably received, and that gentleman at once came into the district.
It was first necessary to consider what subjects fostered by the Science Department would be most useful and most likely to succeed. Mathematics in its application to mining and mechanical operations was considered very essential: but here was a difficulty; to work on in pure mathematics till the pupils acquired sufficient knowledge to benefit them practically, would, considering the present state of primary education, undoubtedly have proved a failure. The subject of Practical, Plane, and Solid Geometry was considered the most deserving of attention, as giving that practical knowledge of the application of geometry which could only be obtained by a protracted study of pure mathematics. Next in importance for this neighbourhood were classed Mechanics, Machine Construction and Drawing, Building Construction and Drawing, and Chemistry.

The object of this Committee being to disseminate a technical knowledge among working men, it was, of course, necessary to confine the time of instruction to the evenings after the men had finished work. The question next arose, how is the instruction to be given? Occasional popular lectures were at once considered totally inadequate to impart any sound knowledge, and it was determined that classes at which the pupils could attend at least twice per week was the proper method. But difficulties again presented themselves; the district was large, the session far advanced, and only one master recognised by the department. It was therefore determined to start classes one by one in the most central and most accessible districts, extending the number as circumstances permitted.

Following out this scheme a public meeting was held at Hetton on Wednesday, 11th November, 1868, at which Mr. Rowden explained the nature and object of the classes about to be formed. The attendance was very good, and so much interest was aroused that a class of about sixty commenced on the following Wednesday. On Friday, the 20th of the same month, a similar meeting was held at Blyth with a like result. Early in the year 1869 meetings were held at Seaton Delaval, Seaham, and Murton, and classes afterwards formed. Other classes had previously been established, without public meetings, at Elswick and Monkwearmouth.

With work going on in so many centres it was absolutely necessary that Mr. Rowden should have assistance. By the kindness of Mr. Daglish a young man from London, holding some of the science qualifications to teach, was employed at Earl Vane's works at Seaham, and in addition to his ordinary duties he took charge of the classes at Seaham and Murton. Two others were found in Newcastle, one of whom had come from Bristol, and these assisted at Hetton, Monkwearmouth, and Elswick. At Blyth and Seaton Delaval valuable assistance was rendered by resident schoolmasters who have since taken science certificates enabling them to teach under the department.

Altogether about 500 names were entered on the class rolls, but as the sessions commenced so late scarcely 300 attended the requisite number of evenings to admit them to the science examinations in April and May, but these sent up nearly 600 worked papers for examination by the Science Department.
The subjects having been quite new in the district, the sessions so short [no class worked more than two-thirds the usual time and some less than one half], and staff assistance so scanty, but little could be expected of the pupils at the examination. The results have, however, proved very satisfactory. They are as follows:—

[ Table of examination results ]

( xi )

Besides these, who are ordinary pupils, eight have worked the advanced papers, thus qualifying them to act as teachers under the science department.

During the coming session, which will commence as early as practicable, classes will be started in new localities, and those already in operation rendered more efficient.

In all cases the instruction afforded seems to have been highly appreciated by the great majority of pupils, and the work of the past winter shows that there is a great desire in the district for this class of education. It is, of course, impossible to start classes simultaneously in every town and village, but it is hoped that, in a year or two, the scheme may spread from the classes which will be established, till technical instruction is accessible to every one in the district.

The Committee will thank any gentleman who may be desirous of extending the scheme into his own immediate neighbourhood, if he will kindly communicate with Mr. Rowden on the subject.

In concluding this report the Committee beg to thank those gentlemen who have been members of local committees for the time and attention which they have given in superintending the Government Science Examinations.

WILLIAM COCHRANE., EDW. F. BOYD., G. B. FORSTER.

( xii )

[ Accounts for the Year ending July, 1869. ]

( xiii )

[ Accounts for the year ending July, 1869, continued ]

( xiv )

[ General Financial Statement, July , 1869 ]
Patrons.

His Grace the DUKE OF NORTHUMBERLAND.
His Grace the DUKE OF CLEVELAND.
The Right Honourable the EARL OF LONSDALE.
The Right Honourable the EARL GREY.
The Right Honourable the EARL OF DURHAM.
The Right Honourable the EARL VANE.
The Right Honourable LORD WHARNCLIFFE.
The Right Honourable LORD RAVENSWORTH.
The Right Reverend the LORD BISHOP OF DURHAM.
The Very Reverend the DEAN AND CHAPTER OF DURHAM.
WENTWORTH B. BEAUMONT, Esq., M.P.

elected.

WILLIAM ALEXANDER, Esq., Inspector of Mines, Glasgow ... 1863
JOHN J. ATKINSON, Esq., Inspector of Mines, Chilton Moor, Fence Houses......................... 1853
  1856
LIONEL BROUGH, Esq., Inspector of Mines, Clifton, Bristol ... 1855
JOSEPH DICKINSON, Esq., Inspector of Mines, Manchester ... 1853
THOMAS EVANS, Esq., Inspector of Mines, Field Head House, Belper ......................... 1855
PETER HIGSON, Esq., Inspector of Mines, 94, Cross Street, Manchester ................. 1854
1856
THOMAS WYNNE, Esq., Inspector of Mines, Stone ...... 1853
* T. RUTHERFORD, Esq., Inspector of Mines, Halifax, Nova Scotia 1866
* JAMES P. BAKER, Esq., Inspector of Mines, Wolverhampton ... 1853
1866
* THOMAS E. WALES, Esq., Inspector of Mines, Swansea ... 1855
1866
* RALPH MOORE, Esq., Inspector of Mines, Glasgow ...... 1866
* G. W. SOUTHERN, Esq., Inspector of Mines, 89, Park Road, Newcastle-on-Tyne ................. 1854
1866
* FRANK N. WARDELL, Esq., Inspector of Mines, Pontefract, Yorkshire.................. 1864
1868
MATTHIAS DUNN, Esq., Ex-Inspector of Mines, Highland Villa, Central Road, Upper Norwood, London ... 1853
JOHN HEDLEY, Esq., Ex-Inspector of Mines, Derby ...... 1853 1858
CHARLES MORTON, Esq., Ex-Inspector of Mines ...... 1853
GOLDSWORTHY GURNEY, Esq., Bude Castle, Cornwall ... 1853
M. DE BOUREUILLE, Commandeur de la Legion d'Honneur, Conseiller d'etat, Inspecteur General des Mines, Paris ... 1853
Dr. H. von DECHEN, Berghauptmann, Ritter, etc., Bonn am Rhine, Prussia............ 1853
HERR R. von CARNALL, Berghauptmann, Ritter, etc., Breslau, Silesia, Prussia........... 1853
WARRINGTON W. SMYTH, Esq., Jermyn Street, London

Life Member.

H. J. MORTON, Esq., Garforth House, Leeds, Yorkshire....... 1856
1861

* Honorary members during term of office only; elected under Rule 5 as altered.
OFFICERS, 1869-70.

PRESIDENT
E. F. BOYD, Esq., Moor House, near Durham.

VICE-PRESIDENTS
FOUR MINING ENGINEERS.
W ARMSTRONG, Esq., Wingate Grange, Ferry Hill.
J DAGLISH, Esq., F.G.S., Dene House, Seaham Harbour.
G. B. FORSTER, Esq., M.A., Backworth House, near Newcastle-on-Tyne.
L. WOOD, Esq., Hetton Hall, Fence Houses.

TWO MECHANICAL ENGINEERS.
T. E. HARRISON, Esq., Central Station, Newcastle-on-Tyne.

COUNCIL
TWELVE MINING ENGINEERS.
C. BERKLEY, Esq., Marley Hill Colliery, Gateshead.
W. COCHRANE, Esq., Seghill House, Dudley, Northumberland.
S. C. CRONE, Esq., Killingworth Colliery, near Newcastle-on-Tyne.
T. DOUGLAS, Esq., Peases' West Collieries, Darlington.
R. HECKELS, Esq., Wearmouth Colliery, Sunderland.
T. G. HURST, Esq., F.G.S., Lovaine House, North Shields.
R. F. MATTHEWS, Esq., South Hetton Colliery, Fence Houses.

J. MARLEY, Esq., Mining Offices, Darlington.

J. B. SIMPSON, Esq., Hedgefield House, Blaydon-on-Tyne.

A. L. STEAVENSON, Esq., 13, Old Elvet, Durham.

H. S. STOBART, Esq., Witton-le-Wear, Darlington.

SIX MECHANICAL ENGINEERS.

W. BOYD, Esq., Spring Gardens Engine Works, Newcastle-on-Tyne.

J. MORRISON, Esq., 34, Grey Street, Newcastle-on-Tyne.

J. NELSON, Esq., Bonner’s Field, Sunderland.

R. S. NEWALL, Esq., Ferndene, Gateshead.

P. G. B. WESTMACOTT, Esq., Elswick Iron Works, Newcastle-on-Tyne.

E. WILLIAMS Esq. (Bolckow, Vaughan, and Co.), Middlesbro'-on-Tees.

Ex-officio


T. E. FORSTER, Esq., 7, Ellison Place, Newcastle-on-Tyne.

J. TAYLOR, Esq., Earsdon, Northumberland.

Secretary and Treasurer

THEO. WOOD BUNNING, Neville Hall, Newcastle-on-Tyne.

(List of Members)

AUGUST, 1869.
1 Ackroyd, Thomas, Berkenshaw, Leeds ....... March 7, 1867.
2 Adams, W., Severn House, Roath Road, Cardiff 1854.
3 Ainslie, Aymer, Iron Ore Master, Ulverstone ... Aug. 7, 1869.
4 Aitken, Henry, Falkirk, North Britain ... ... March 2, 1865.
5 Allinson, T., Belmont Mines, Guisbro' ...... Feb. 1, 1868.
6 Anderson, C. W., St. Hilda's Colliery, South Shields Aug 21, 1852.
8 Anderson, William, Rainton Colliery, Fence Houses Aug. 21, 1852.
9 Appleby, Charles Edward, Reinshaw Colliery, near Chesterfield .......... Aug 1, 1861.
10 Archbold, James, Murton Colliery, Sunderland ... Sept. 5, 1868.
11 Arkless, John, Tantoby, Burnopfield ...... Nov. 7, 1868.
13 Armstrong, Wm., Wingate Grange, Ferry Hill, Durham (Vice President) Aug. 21, 1852.
15 Ashwell, Hatfield, Anchor Colliery, Longton, North Staffordshire............ March 6, 1862.

18 Baeck, —, Mons., Belgium ......... June 5, 1869.
19 Bagnall, Thomas, jun., Whitby, Yorkshire ... March 6, 1862.
20 Bailes, John, Kelloe Colliery, Ferryhill...... Sept. 5, 1868.

(xix) elected.
22 Bailey, George, Colliery Proprietor, Wakefield June 5, 1869.
23 Bailey, Samuel The Pleck, Wallsall, Staffordshire June 2, 1859.
24 Bailey, W. W., Kilburn, near Derby ...... May 13, 1858.
26 Barclay A. Caledonia Foundry, Kilmarnock, North Britain ............... Dec 6, 1866
27 Barkus, Wm., jun., Tynemouth........ Aug. 21, 1852.
28 Bartholomew, C, Doncaster, Yorkshire...... Aug. 5, 1853.
31 Batey, John, Newbury Collieries, Coleford, Bath... Dec. 5, 1868.
32 Beacher, E., Thorncliffe and Chapeltown Collieries, Sheffield ... 1854.
33 Beanlands, Arthur, University College, Durham... March 7, 1867.
34 Beck, Alexander, Mons, Belgium ...... Dec. 7, 1867.
36 Bell, John, Normanby Mines, Middlesbro'-on-Tees Oct. 1, 1857.
37 Bell, T., Monkwood Colliery, near Chesterfield ... 1854.
38 Bell, Thomas, jun., Coatham, Redcar ...... March 7, 1867.
40 Berkley, C., Marley Hill Colliery, Gateshead (Member of Council) Aug. 21, 1852.
41 Bewick, Thomas, J., Neville Chambers, Newcastle-upon-Tyne ............ April 5, 1860.
42 Bidder, B. P., Powell, Duffryn Collieries, Aberdare May 2, 1867.
43 Bigland, J., Bedford Lodge, Bishop Auckland ... June 4, 1857.
44 Binns, C., Claycross, Derbyshire....... July 6, 1854.
45 Biram, Benjamin, Peasely Cross Collieries, St. Helen's, Lancashire......... 1856.
47 Bolckow, H. W. F., Middlesbro'-on-Tees April 5, 1855.
49 Bourne, Peter, 39, Rodney Street, Liverpool ... 1854.
50 Bourne, S., West Cumberland Hematite Iron Works, Workington........... Aug. 21, 1852.

( xx ) elected.

52 Boyd, E.F., Moor House, near Durham (President) Aug. 21, 1852.

53 Boyd, Nelson, Carrickfergus, Ireland ... March 3, 1864.

54 Boyd, William, Spring Gardens Engine Works, Newcastle-upon-Tyne (Member of Council) Feb. 2, 1867.

55 Breckon, J. R., Park Place, Sunderland ... Sep. 3, 1864.


57 Broadbent, Jubal C, Drake Street, Rochdale, Lancashire ...... March 7, 1867.

58 Brogden, James, Tondu Iron and Coal Works, Bridgend, Glamorganshire ... ... ... 1861.

59 Brown, John N., 56, Union Passage, New Street, Birmingham ... ... ... ... 1861.

60 Brown, Thos. Forster, Guildhall Chambers, Cardiff 1861.

61 Brown, Ralph, Ryhope Colliery, Sunderland ... Oct. 1, 1863.

62 Bruton, William, M.E., Whitwood Collieries, near Normanton.............. Feb. 6, 1869.


64 Bryham, William, Rose Bridge, &c, Collieries, Wigan, Lancashire.......... Aug. 1, 1861.

65 Bryham, Wm., jun., Ince Hall, Wigan...... Aug. 3, 1865.

66 Bunning, Theo. Wood, Corbridge, Northumberland ......(Secretary and Treasurer) 1864.

67 Burn, James, Rainton Colliery, Fence Houses ... Aug. 2, 1866.

68 Burrows, James, Douglas Bank, Wigan, Lancashire May 2, 1867.

69 Buxton, Wm., New Street, New Whittington, Chesterfield............. Aug. 1, 1861.

70 Caldwell, George, Moss Hall Colliery, near Wigan March 6, 1869.

71 Campbell, James, Staveley Works, Chesterfield ... Aug. 3, 1865.

72 Carr, Charles, Cramlington, Newcastle-upon-Tyne Aug. 21, 1852.


74 Carrington, Thomas, jun., Kiveton Park Coal Company, near Sheffield ... ... Aug. 1, 1861.

76 Chadborn, Beckit T., Pinxton Collieries, Alfreton, Derbyshire.............. 1864.

77 Chambers, A. M., Thorncliffe Iron Works, near Sheffield ............... March 6, 1869.

( xxi ) elected

78 Chapman, Matthew, Plashetts Colliery, Falstone, Northumberland Aug. 1, 1868

79 Charlton, Edward, Evenwood Colliery, Bishop Auckland ................. Sept. 5, 1868

80 Checkley, Thomas, Mining Engineer, Walsall ... Aug. 7, 1869.

81 Childe, Rowland, Wakefield, Yorkshire May 15, 1862

82 Clark, Christopher Fisher, Garswood, Newton-le-Willows ........... Aug. 2, 1866

83 Clark, George, Ravenhead Colliery, St. Helens, Lancashire.......... Dec. 7, 1867

84 Clark, R. P., 9, St. Mary's Terrace, Newcastle-upon-Tyne .......... Nov. 7, 1868

85 Clark, William, Mining Engineer, Doe Hill House, near Alfreton........ April 7, 1866.


87 Cochrane, W., Seghill House, Dudley, Northumberland......(Member of Council) 1859.

88 Cochrane, B., Alden Grange, Durham ...... Dec. 6, 1866.


90 Cockburn, Geo., 8, Summerhill Grove, Newcastle-upon-Tyne ........ Dec. 6, 1866.


92 Coke, Richard George, Tapton Grove, Chesterfield, Derbyshire ........ May 5, 1859.


94 Collis, William Blow, Heigh House, Stourbridge, Worcestershire ........ June 6, 1861.

95 Cook, Joseph, jun., Washington Iron Works, Gateshead ... May 8, 1869.

96 Cook, Richard, East Holywell Colliery, Earsdon, Newcastle-upon-Tyne ......... 1860.

97 Cooke, John, 4, Mulberry Street, Darlington ... Nov. 1, 1860.'

98 Cooksey, Joseph, West Bromwich, Staffordshire... Aug. 3, 1865.

99 Cooksey, J. H., West Bromwich, Staffordshire ... Aug. 3, 1865.
<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Location</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Cooper, Philip</td>
<td>Rotherham Colliery, Rotherham, Yorkshire</td>
<td>Dec. 3, 1857</td>
</tr>
<tr>
<td>101</td>
<td>Cooper, Thomas</td>
<td>Park Gate Colliery, Rotherham, Yorkshire</td>
<td>April 2, 1863</td>
</tr>
<tr>
<td>102</td>
<td>Cope, J.</td>
<td>Pensnett, Dudley, Worcestershire</td>
<td>Aug. 5, 1853</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>103</td>
<td>Cope, W. S.</td>
<td>Port Vale, Longport, North Staffordshire</td>
<td>May 2, 1867</td>
</tr>
<tr>
<td>104</td>
<td>Cossham, H.</td>
<td>Hill House, Bristol, Somersetshire</td>
<td>Sept. 6, 1855</td>
</tr>
<tr>
<td>105</td>
<td>Coulson, W.</td>
<td>Shamrock House, Durham</td>
<td>Oct. 1, 1852</td>
</tr>
<tr>
<td>106</td>
<td>Cowen, Joseph</td>
<td>Blaydon Burn, Newcastle-upon-Tyne</td>
<td>Oct. 5, 1854</td>
</tr>
<tr>
<td>107</td>
<td>Coxon, S. B.</td>
<td>Usworth Colliery, Washington Station, Durham</td>
<td>June 5, 1856</td>
</tr>
<tr>
<td>108</td>
<td>Craig, W. Y.</td>
<td>Harncastle Colliery, Stoke-upon-Trent</td>
<td>Nov. 3, 1866</td>
</tr>
<tr>
<td>109</td>
<td>Crawford, T.</td>
<td>Littleton Colliery, Durham</td>
<td>Aug. 21, 1852</td>
</tr>
<tr>
<td>110</td>
<td>Crawford, Thomas</td>
<td>Howlish Offices, Bishop Auckland</td>
<td>Sept. 3, 1864</td>
</tr>
<tr>
<td>111</td>
<td>Crawford, T., jun.</td>
<td>Littleton Colliery, near Durham</td>
<td>Aug. 7, 1869</td>
</tr>
<tr>
<td>112</td>
<td>Croften, J. G.</td>
<td>Thornley Colliery Office, Ferryhill</td>
<td>Feb. 7, 1861</td>
</tr>
<tr>
<td>113</td>
<td>Crone, S. C.</td>
<td>Killingworth Colliery, Newcastle-upon-Tyne</td>
<td>1853</td>
</tr>
<tr>
<td>114</td>
<td>Crone, Joseph Robert</td>
<td>Killingworth Colliery, Newcastle-upon-Tyne</td>
<td>Feb. 1, 1868</td>
</tr>
<tr>
<td>115</td>
<td>Cross, John</td>
<td>78, Cross Street, Manchester</td>
<td>June 5, 1869</td>
</tr>
<tr>
<td>116</td>
<td>Croudace, T. Dacre</td>
<td>Willington, Durham</td>
<td>March 7, 1867</td>
</tr>
<tr>
<td>117</td>
<td>Crow, Geo.</td>
<td>2, Park Road, Newcastle-upon-Tyne</td>
<td>Feb. 2, 1867</td>
</tr>
<tr>
<td>118</td>
<td>Crudace, Thomas</td>
<td>Waratah, Australia</td>
<td>.. 1862</td>
</tr>
<tr>
<td>119</td>
<td>Curry, James</td>
<td>Turston, Pontefract</td>
<td>1864</td>
</tr>
<tr>
<td>120</td>
<td>Daglish, John</td>
<td>F.G.S., Dene House, Seaham Harbour</td>
<td>Aug. 21, 1852</td>
</tr>
<tr>
<td>121</td>
<td>Dakers, W.</td>
<td>Seaham Collieries, Sunderland</td>
<td>April 7, 1866</td>
</tr>
<tr>
<td>122</td>
<td>Darlington, James</td>
<td>Springfield House, near Chorley, Lancashire</td>
<td>Aug. 1, 1861</td>
</tr>
</tbody>
</table>
124 Davidson, James, Blyth Place, St. Bees, near Whitehaven.............       Feb. 1, 1868.
125 Davidson, James, Newbattle Colliery, Dalkeith ...                        1854.
126 Davison, A., Hastings Cottage, Seaton Delaval, Dudley, Northumberland......       Feb. 4, 1858.
127 Dawson, Thomas J., Cleugh Road, Masbro’, Yorkshire ..................       April 6, 1867.
128 Day, W. H., Monk Bretton, Barnsley......                              March 6, 1869.

(xxiii) elected.

129 Dees, J., Whitehaven                                              Nov. 1, 1855
130 Dennis, Henry, Brynyr Owen, Ruabon, Denbighshire                    Aug. 1, 1861
132 Dixon, George, Lowther Street, Whitehaven ...                         Dec. 3, 1857.
133 Dobson, S., Halswell Cottage, Cardiff......                           May 3, 1855.
134 Dobson, Thomas, Haltenlengate, Haltwhistle ...                      March 7, 1808.
135 Dodd, Benjn., Seaton Delaval Colliery, Dudley, Northumberland .........       May 3, 1866.
136 Dorning, Elias, 41, John Dalton Street, Manchester                  Aug. 3, 1865.
137 Douglas, T., Peases' West Collieries, Darlington ...... (Member of Council)    Aug. 21, 1852.
138 Douglas, C. P., Consett Iron Works, Gateshead                         March 6, 1869.
139 Douthwaite, Thomas, Wallsend, near Newcastle-on-Tyne ..........        June 5, 1869.
140 Dunn, A. M., Architect, Newcastle-on-Tyne ...                        March 6, 1869.
141 Dunn, James, Drummond Colliery, Pictou, Nova Scotia...............       May 8, 1809.
142 Dunne, D. G., Greenfield Colliery, Hamilton, North Britain .............       April 6, 1867.
143 Dyson, George, Middlesborough..........                               June 2, 1866.
144 Easton, J., Nest House, Gateshead .........                           1853.
145 Elliot, G., M.P., Houghton Hall, Fence Houses (Past President, Member of Council)...... Aug. 21, 1852.
146 Elliott, W., Weardale Iron Works, Towlaw, Darlington ..................       1854.
149 Everard, I. B., Mining Engineer, Leicester ... March 6, 1869.
150 Feare, G., Camerton Coal Works, Bath ...... 1861.
151 Fearn, John Wilmot, Chesterfield ...... March 6, 1869.
152 Fenwick, Barnabas, Team Colliery, Gateshead... Aug. 2, 1866.
153 Fidler, Edward, Platt Lane Colliery, Wigan, Lancashire ............ Sept. 1, 1866.
154 Firth, S., 14, Springfield Mount, Leeds...... 1865.
155 Firth, William, Birley Wood, Leeds ...... Nov. 7, 1863.
156 Fletcher, Herbert, Ladyshire Colliery, Little Lever, Bolton, Lancashire ... Aug. 3, 1865

(xxiv) elected.

157 Fletcher, Isaac, Clifton Colliery, Workington ... Nov. 7, 1863.
158 Fletcher, Jos., C.E., 69, Lowther Street, Whitehaven ...... 1857.
159 Foord, J. B., Secretary, General Mining Association, 52, Old Broad Street, London ... Nov. 5, 1852.
160 Forster, Thomas E., 7, Ellison Place, Newcastle-upon-Tyne (Past President, Member of Council) Aug. 21, 1852.
161 Forster, G. B., M.A., Backworth House, near Newcastle-upon-Tyne ...(Vice-President) Nov. 5, 1852.
162 Forster, George E., Washington, Gateshead ... Aug. 1, 1868.
163 Forster, Richard, Trimdon Grange Colliery, Ferryhill ............ Sept. 5, 1868.
164 Fothergill, Joseph, Cowpen and North Seaton Office, King Street, Quay, Newcastle-upon-Tyne ............ Aug. 7, 1862.
165 Fowler, Geo., Hucknall Torkard Colliery, near Nottingham.......... July 4, 1861.
166 Frazer, Benjamin, 28, Broad Chare, Newcastle-upon-Tyne ............ Oct. 4, 1866.
168 France, W., Cliff Terrace, Marske, near Redcar                        April 6, 1867.
169 Fryar, Mark, C.E., Laura House, Hanham, near Bristol ........        Sept. 7, 1867.
170 Gainsford, Thomas R., Darnall Hall, near Sheffield               Nov. 5, 1864.
172 Gilchrist, T., South Medomsley Collieries, Dibton, by Burnopfield .... March 2, 1865.
175 Gilroy, Samuel Bertram, Mining Engineer, Moreton Hall and Preesgwyn Collieries, Chirk, North Wales......... Sept. 5, 1868.
177 Goddard, William, C.E., Golden Hill Colliery, Longton, North Staffordshire .... March 6, 1862.

( xxv )

179 Goodman, Alfred, Walker Iron Works, Newcastle-upon-Tyne          Sept. 5, 1868
180 Gott, Wm. L., Shincliffe Collieries, Durham                        Sept. 3, 1864.
181 Gray, Thomas, Underhill, Taibach                                    June 5, 1869
182 Green, Wm., jun., Garesfield Colliery, Blaydon-on-Tyne            Feb. 4 1853.
183 Greener, Thos., Etherley Colliery, Darlington                     Aug. 3 1865
184 Greenway, Edward, Brierly Hill, Dudley, Worcestershire           June 1 1867
185 Greenwell, G. C, F.G.S., Poynton and Worth Collieries, Stockport, Cheshire ...... Aug. 21, 1852.
186 Greeves, J.O., Roundwood Colliery, Horbury, Wakefield, Yorkshire ...... Aug. 7, 1862
188 Griffith, N. R., Coppa Colliery, Mold, Flintshire                  1866
189 Grimshaw, Edward J., Cowley Hill, St. Helen's, Lancashire .......... Sept. 5, 1868.
190 Haddock, James, Ravenhead Colliery, St. Helen's, Lancashire .......... Dec. 7, 1867
191 Haggie, P., Gateshead............ 1854.

192 Hales, Chas., Maes-y-dre, Mold, North Wales ... 1865.


194 Hall, Frederick, W., 23, St. Thomas' Street, Newcastle-on-Tyne .......... Aug. 7, 1869.

195 Hall, Henry, Whitworth, Ferry Hill ...... Aug. 2, 1866.

196 Hall, Matthew, Peases' West Collieries, Darlington ................. Sept. 5, 1868.

197 Hall, T. Y., Towneley Colliery Office, Quay, Newcastle-upon-Tyne .......... Aug. 21, 1852.

198 Hall, William F., Hamsteels Colliery, Esh, Durham May 13, 1858.

199 Hargreaves, William, Rothwell Haigh, Leeds ... Sept. 5, 1868.

200 Harkness, Andrew, Birtley Iron Works, Fence Houses .......... Dec. 5, 1868

201 Harper, J. P., 74, Osmaston Street, Derby ... Feb. 2, 1867.


203 Harrison, T. E., C.E., Central Station, Newcastle-upon-Tyne (Vice-President) May 6, 1853.

204 Harrison, Robert, Eastwood Collieries, Nottingham............... 1861

(xxvi)

elected.

205 Harrison, W. B., Norton Hall, Cannock, Staffordshire .......... April 6, 1867.

206 Hawthorn, W., C.E., Newcastle-upon-Tyne ... March 4, 1853.

207 Hawthorn, Thomas, 12, Elswick Villas, Newcastle-upon-Tyne .......... Dec. 6, 1866.

208 Heckels, R., Wearmouth Colliery, Sunderland (Member of Council) Nov. 5, 1852.
209 Hedley, Edward, Osmaston Street, Derby ... Dec. 2, 1858.

210 Hedley, W. H., Consett Collieries, Medomsley, Burnopfield, County of Durham ... 1864.

211 Heppell, Thomas, Pelaw Main Collieries, Birtley, Fence Houses ............... Aug. 6, 1863.

212 Hepplewhite, Thomas, Hetton Colliery, Fence Houses ............... Dec. 5, 1868.

213 Herdman, John, Park Crescent, Bridgend, Glamorganshire ... Oct. 4, 1860.

214 Heslop, James, Peases'West Collieries, Darlington Feb. 6, 1864.

215 Hetherington, David, Blue House, Nedderton, Northumberland ... 1859.


217 Higson, Jacob, 94, Cross Street, Manchester ... 1861.


221 Homer, Charles S., Chatterley Hall, Tunstall ... Aug. 3, 1865.

222 Hood, Archibald, Whitehill Colliery, Lasswade, Edinburgh ............... April 18, 1861.


224 Horsfall, J. J., Bradley Green Colliery, near Congleton ............... March 2, 1865.

225 Horsley, W., Whitehill Point, Percy Main ... March 5, 1857.

226 Horton, T. E., Prior's Lee Hall, Shifnal, Shropshire ....... 1861.

227 Howard, Wm. Frederick, Cavendish Street, Chesterfield, Derbyshire .......... Aug. 1, 1861.

228 Hoyt, Jessie, Acadia Coal Mines, Pictou, Nova Scotia ............... May 8, 1869.
( xxvii )

229 Hudson, James, Albion Mines, Pictou, Nova Scotia 1862

230 Humble, Jos., jun., Garesfield, Blaydon-on-Tyne June 2, 1866.

231 Humble, W. J., Forth Banks West Factory, Newcastle-upon-Tyne Sept. 1, 1866

232 Hunt, A. H., Pelaw Main Office, Quayside, Newcastle-upon-Tyne 1862

233 Hunter, Wm., Moor Lodge, Newcastle-upon-Tyne Aug. 21, 1852.


235 Hunter, Wm. Slingsby, Moor Lodge, Newcastle-upon-Tyne Feb. 1, 1868.

236 Hunting, Charles, Fence Houses Dec. 6, 1866.

237 Huntsman, Benjamin, West Retford Hall, Retford June 1, 1867.

238 Hurst, T. G., F.G.S., Lovaine House, North Shields Aug. 21, 1852.

239 Hutchings, W. M., Colliery Guardian Office, S, Bouverie Street, Fleet Street, London Sept. 5, 1868.

240 Jackson, Henry, Astley and Tyldesley Collieries, Tyldesley, Manchester Aug. 1, 1861.

241 Jarratt, John, Edmondsley Colliery, Chester-le-Street Nov. 2, 1867.

242 Jenkins, William, M.E., 2, Woodfield Place, Cardiff Dec, 6, 1862.


244 Johnson, John, Chilton Hall, Ferryhill .. Aug. 21, 1852.

245 Johnson, R. S., Sherburn Hall, Durham Aug. 21, 1852.
246 Johnson, Thomas, Wigan Coal and Iron Company, Wigan, Lancashire...........
Aug. 7, 1869.

247 Joicey, Jacob G., Forth Banks West Factory, Newcastle-on-Tyne............
April 10, 1869.

248 Joicey, John, Urpeth Hall, Fence Houses .
Sept. 3, 1852.

249 Joicey, Wm. James, Tanfield Lea Colliery, Burnopfield .
March 6, 1869.

250 Jones, E., Granville Lodge, Wellington, Salop .
Oct. 5, 1854.

251 Jones, John, F.G.S, Secretary, North of England Iron Trade, Middlesbro'-on-Tees .. Sept. 7, 1867.

252 Kendall, W., Blyth and Tyne Railway, Percy Main
Sept. 1, 1866

253 Kennedy, Myles, M.E., Ulverstone .
June 6, 1868.

( xxviii )
elected.

254 Kenrick, Wm. Wynn, Wynn Hall, near Ruabon, Denbighshire........
1862,

255 Kirkwood, William, Larkhall Colliery, Hamilton
Aug. 7, 1869.

256 Knowles, A., High Bank, Pendlebury, Manchester
Dec. 5, 1856.

257 Knowles, Andrew, jun., Bar Hill, Pendleton, Manchester...........
Dec. 3, 1863.

258 Knowles, John, Pendlebury Colliery, Manchester
Dec. 5, 1856.

259 Knowles, Kaye, Little Lever Colliery, near Bolton
Aug. 3, 1865.

260 Knowles, R. M., Turton, near Bolton ....
Aug. 3, 1865.

262 Lamb, Robert, Cleator Moor Colliery, near Whitehaven .......... Sept. 2, 1865.


265 Lancaster, John, jun., Hunwick and Newfield Collieries, Ferryhill .......... March 2, 1865.


269 Lawrence, Henry, Grange Iron Works, Durham .......... Aug. 1, 1868.

270 Laws, Hubert, 21, Collingwood Street, Newcastle-on-Tyne .......... Feb. 6, 1869.


272 Lees, Samuel, Barrowshaw Colliery, Greenacres Moor, near Oldham .......... Aug. 2, 1866.

273 Legrand, A., Mons, Belgium .......... June 5, 1869.

274 Leslie, Andrew, Hebburn, Newcastle-upon-Tyne .......... Sept. 7, 1867.

275 Lever, Ellis, West Gorton Works, Manchester .......... 1861.

276 Lewis, G., Coleorton Colliery, Ashby-de-la-Zouch .......... Aug. 6, 1863.

278 Lewis, Lewis Thomas, Gadlys Uchaf, Aberdare
Feb. 1, 1868.

279 Lewis, T. Win., Abercanaid House, Merthyr Tydvil ..........
Sept. 3, 1864.

280 Lewis, Wm. Thomas, Mardy, Aberdare......
1864.

281 Liddell, J. R., Nedderton, Northumberland ...
Aug. 21, 1852.

282 Liddell, M., Tynemouth.........
Oct. 1, 1852.

283 Lindop, James, Bloxwich, Walsall, Staffordshire
Aug. 1, 1861.

( xxix )
elected.

284 Lishman, John, Haswell Colliery, Fence Houses
June 2, 1866

285 Lishman, Wm., Etherley Colliery, Darlington
1857

286 Lishman, Wm., Bunker Hill, Fence Houses ...
March 7, 1861.

287 Livesey, Clegg, Bredbury Colliery, Bredbury, Stockport
Aug. 3, 1865

288 Livesey, Thomas, Chamber Hall, Hollinwood, Manchester
Aug. 1, 1861

289 Llewelin, David, Glanwern offices, Pontypool, Monmouthshire ......
Aug. 4, 1864

290 Lloyd, Thomas H., Chapel Street, Brierly Hill, Worcestershire ......
Jun. 1, 1867

291 Logan, William, Littletown, Durham ......
Sept. 7, 1867.

Aug. 21, 1852

293 Love, Joseph, Brancepeth Colliery, Durham ...
Sept. 5, 1856

294 Low, Wm., Vron Colliery, Wrexham, Denbighshire ...
Sept. 6, 1855

295 Maddison, W., Woolley Colliery, Darton, Barnsley
Dec. 6, 1862.

296 Maddison, W. P., Thornhill Collieries, near Dewsbury ..........
Oct. 6, 1859.

298 Mammatt, John E., C.E., Barnsley, Yorkshire ... 1864

299 Manners, G. T., Birtley Iron Works, Gateshead 1866.

300 Marley, John, Mining Offices, Darlington (Member of Council) Aug. 21, 1852.

301 Marshall, F. C, Jarrow, South Shields...... Aug. 2, 1866.


303 Marshall, Robert, 10, Three Indian Kings Court, Quayside, Newcastle-upon-Tyne ...... 1856.

304 Marston, William Beale, Mold, Flintshire ... Oct. 3, 1868.

305 Matthews, Richard F., South Hetton Colliery, Fence Houses (Member of Council) March 5, 1857.


307 May, George, North Hetton Colliery, Fence Houses March 6, 1862


( xxx )


310 McMurtrie, J., Radstock Colliery, Bath...... Nov. 7, 1863.

311 Middleton, J., Davison's Hartley Office, Quay, Newcastle-upon-Tyne ...... 1853.

312 Miller, Robert, Strafford Collieries, near Barnsley March 2, 1865.

313 Mitchinson, Robert, jun., Kibblesworth Colliery, Gateshead ............. Feb. 4, 1865.

314 Monkhouse, Jos., Gilcrux Colliery, Cockermouth June 4, 1863.

315 Moor, Thomas, North Seaton Colliery, Morpeth Oct. 3, 1868.


317 Morison, David P., Bulman's Village, Newcastle-on-Tyne .............. 1861.

318 Morison, J. A. R., Nursery Cottage, Elswick Lane, Newcastle-upon-Tyne ... Nov. 7, 1868.

319 Morris, William, Waldridge Colliery, Chester-le-Street, Fence Houses ....... 1858.

320 Morrison, James, 34, Grey Street, Newcastle-upon-Tyne (Member of Council) Aug. 5, 1853.
322 Morton, H., Lambton, Fence Houses .............. 1852.
323 Morton, H. T., Lambton, Fence Houses ... Aug. 21, 1852.
324 Muckle, John, Monk Bretton, Barnsley March 7, 1861.
325 Mulcaster, Joshua, Crosby Colliery, Maryport ... June 4 1863.
326 Mulvany, Wm. Thomas, 1335, Carls Thor, Dusseldorf on the Rhine, Prussia ... Dec. 3, 1857.
327 Murray, T. H., Chester-le-Street, Fence Houses April 18, 1861.
329 Nasymth, James, Cornbrook Colliery, near Ludlow, Shropshire ............ Feb. 1, 1868.
330 Naylor, Joshua T., 10, West Clayton Street, Newcastle-upon-Tyne ... Dec. 6, 1866.
331 Nelson, James, C.E., Bonner's Field, Sunderland (Member of Council) Oct. 4, 1866.
332 Newall, Robert Stirling, Ferndene, Gateshead (Member of Council) May 2, 1863.

( xxxi )
elected.

334 Nicholson, Marshall, Middleton Hall, Leeds ... Nov. 7, 1863.
336 Noble, Captain, Jesmond, Newcastle-upon-Tyne Feb. 3, 1866.
337 North, Frederick W., Rowley Hall Colliery, Dudley, Staffordshire ........ Oct. 6, 1864.
338 Ogden, John M., Solicitor, Sunderland...... March 5, 1857.
340 Oliver, John, Victoria Colliery, Coventry
April 1, 1865.

341 Oliver, Wm., Stanhope Burn Offices, Stanhope, Darlington ... 1862.

342 Pacey, Thomas, Hunwick and Newfield Collieries, near Bishop Auckland April 10, 1869.


344 Palmer, C. M., Quay, Newcastle-upon-Tyne ...
Nov. 5, 1852.

345 Pattinson, John, Bensham Lodge, Gateshead ...
May 2, 1868.

346 Peacock, David, Horseley, Tipton ...... Aug. 7, 1869.


348 Pease, J. W., M.P., Woodlands, Darlington ...
March 5, 1857.

349 Peel, John, Springwell Colliery, Gateshead ...
Nov. 1, 1860.

350 Perrot, Sam. W., Hibernia and Shamrock Collieries, Gelsenkirchen, Dusseldorf......
June 2, 1866.

351 Pickersgill, Thomas, Waterloo Main Colliery, near Leeds.......... June 5, 1869.


353 Pilkington, Wm., jun., St. Helen’s, Lancashire...
Sept. 6, 1855.

354 Potter, Addison, Heaton Hall, Newcastle-on-Tyne
March 6, 1869.


356 Powell, T., Coldea, Newport, Monmouthshire ...
Sept. 6, 1855.

357 Prosser, Thomas, Architect, Newcastle-on-Tyne
March 6, 1869.

( xxxii )
elected.

358 Rake, A. S., Consulting Engineer and Naval Architect, Newcastle-upon-Tyne ......
Sept. 7, 1867.

359 Ramsay, J. T., Walbottle Hall, near Blaydon-on-Tyne..............
Aug. 3, 1853
360 Ramsey, J. A., Widdrington, near Morpeth  ...  March 6, 1869.

361 Reed, Robert, Felling Colliery, Gateshead  ...  Dec. 3, 1863.

362 Rees, Daniel, Lletty Shenkin Colliery, Aberdare  ...  1862.

363 Richardson, Henry, Backworth Colliery, Newcastle-upon-Tyne  ...  March 2, 1865.

364 Ridley, George, Cowpen Colliery, Blyth, Northumberland  ...  Feb. 4, 1865.

365 Robinson, Robert, jun., Albion Cottage, Bishop Auckland  ...  Feb. 1, 1868.

366 Robinson, Robert Henry, Staveley Works, near Chesterfield  ...  Sept. 5, 1868.

367 Robson, J. B., Paradise, Newcastle-on-Tyne  ...  May 8, 1869.

368 Robson, J. S., Butterknowle Colliery, Staindrop, Darlington  ...  1853.

369 Robson, Thomas, Lumley Colliery, Fence Houses  ...  Oct. 4, 1860.

370 Rogerson, John, Weardale Iron and Coal Co., Newcastle-on-Tyne  ...  March 6, 1869.

371 Ronaldson, James, Clough Hall Coal and Iron Works, Stoke-upon-Trent  ...  Aug. 2, 1866.

372 Roscamp, J., Acomb Colliery, Hexham  ...  Feb. 2, 1867.

373 Rose, Thomas, Merridale Grove, Wolverhampton  ...  1862.

374 Ross, A., Shipcote Colliery, Gateshead  ...  Oct. 1, 1857.

375 Rosser, Wm., Mineral Surveyor, Llanelly, Carmarthenshire  ...  1856.

376 Routledge, William (J. B. Foord), 52, Old Broad Street, London, E.C.  ...  Aug. 6, 1857.


378 Sanderson, R. B., West Jesmond, Newcastle-upon-Tyne  ...  1853.

379 Sanderson, Thomas, Seaton Delaval, Dudley, Northumberland  ...  Aug. 7, 1862.

380 Scarth, W. T., Raby Castle, Darlington  ...  April 4, 1868.

381 Scott, Andrew, Coanwood Colliery, Haltwhistle  ...  Dec. 7, 1867.

( xxxiii )
elected.
382 Seddon, William, Lower Moor Collieries, Oldham, Lancashire ... ... Oct. 5, 1865.

383 Shield, Hugh, Lamb’s Cottage, Gilesgate Moor, Durham .............. March 6, 1862.

384 Shortreed, Thomas, Park House, Winstanley, Wigan .............. April 3, 1856.

385 Simpson, John Bell, Hedgefield House, Blaydon-on-Tyne ... (Member of Council) Oct. 4, 1860.

386 Simpson, J., Rhos Llantwit Colliery, Caerphilly, near Cardiff............ Dec. 6, 1866.

387 Simpson, L., South Garesfield Colliery, Burnopfield .............. 1855.

388 Simpson, R., Ryton Moor House, Blaydon-on-Tyne ... ...... ...... Aug. 21, 1852.


390 Smith, F., Bridgewater Offices, Manchester ... Aug. 5, 1853.


392 Smith, Thomas Taylor, Oxhill, Chester-le-Street Aug. 2, 1866.

393 Snowball, James, Stourbridge Fire Clay Works, Gateshead ... ... Aug. 1, 1866.

394 Snowdon, Thomas, Stockton-on-Tees ...... Aug. 1, 1868.


396 Sopwith, T., F.G.S., etc., 103, Victoria Street, Westminster, London, S.W. ...... May 6, 1853.

397 Southern, Robert, Old Silkstone Collieries, near Barnsley.............. Aug. 3, 1865.

398 Spark, H. K., Darlington ........... 1856.

399 Spencer, T., Ryton, Newcastle-upon-Tyne ... Dec. 6, 1866.
400 Spencer, W., Thornley Colliery Office, Ferry Hill  Aug. 21, 1852.

401 Steavenson, A. L., 13, Old Elvet, Durham (Member of Council) Dec. 6, 1855.

402 Steel, Charles R., Ellenborough Colliery, Maryport March 3, 1864.

403 Stenson, W. T., Whitwick Colliery, Coalville, near Leicester Aug. 5, 1853.

404 Stephenson, John, Seaton Delaval Colliery, Dudley, Northumberland Sept. 5, 1868.


( xxxiv )
elected.


407 Stobart, H. S., Witton-le-Wear, Darlington (Member of Council) Feb. 2, 1854.

408 Stott, James, Chatham Hill, Manchester 1855.

409 Straker, John, West House, Tynemouth May 2, 1867.

410 Stutchbury, E., Mining Engineer, Almondsbury, near Bristol March 6, 1869.

411 Swallow, John, Harton Colliery, South Shields Aug. 6, 1863.

412 Swallow, R. T., Pontop Colliery, Gateshead 1862.

413 Taylor, H., Tynemouth Sept. 5, 1856.

414 Taylor, J., Earsdon, Newcastle-upon-Tyne (Member of Council) Aug. 21, 1852.
415 Telford, W., Cramlington, Northumberland ... May 6, 1853.
416 Tennant, John, East Holwell Colliery, near Newcastle-upon-Tyne ............ April 4, 1868.
418 Thompson, Astley, Kedwelly, Carmarthenshire... 1864.
419 Thompson, James, Bishop Auckland ...... June 2, 1866.
420 Thompson, John, Marley Hill Colliery, Gateshead Oct. 4, 1860.
421 Thompson, John, Field House, Hoole, Chester ... Sept. 2, 1865.
422 Thompson, Joseph, Norley Colliery, Wigan, Lancashire ............. April 6, 1867.
423 Thompson, Robert, jun., North Brancepeth Colliery, near Durham........ ... Sept. 7, 1867.
424 Thompson, T. C, Milton Hall, Carlisle...... May 4, 1854.
425 Thorpe, Richard S, 17, Picton Place, Newcastle-on-Tyne ............ Sept. 5, 1868.
426 Tinn, Joseph, C.E., Royal Insurance Buildings, Corn Street, Bristol...... Sept. 7, 1867.
427 Tone, John F., C.E , Westgate Street, Newcastle-upon-Tyne ............ Feb. 7, 1856.
428 Trotter, J., Newnham, Gloucestershire...... Nov. 2, 1854.
429 Truran, Matthew, Dowlais Iron Works, Merthyr Tydvil, Glamorganshire ........ Dec. 1, 1859.
430 Turner, Wm. Barrow, C. and M.E., Barrow-in-Furness............ ... Dec. 7, 1867.
431 Tweddell, Ralph Hart, Sunderland ...... Oct. 5, 1867.

433 Ure, J. F., Engineer to the River Tyne Commissioners, Newcastle-on-Tyne,........ May 8, 1869.

434 Vaughan, Thomas, Middlesbro'-on-Tees...... 1857.


436 Walker, Geo. W., Bulwell, near Notts...... Sept. 7, 1867.

437 Wallau, Jacob (Black, Hawthorn, & Co.), Gateshead .......... Nov. 2, 1867.

438 Waller, William, 82, Northgate, Darlington ....... 1866.


441 Warrington, John, Kippax, near Leeds .......... Oct. 6, 1859.


443 Watson, Henry, High Bridge, Newcastle-upon-Tyne .......... March 7, 1868.

444 Webster, R. C, Ruabon Collieries, Ruabon, Denbighshire .......... Sept. 6, 1855.


446 Westmacott, Percy G. B., Elswick Iron Works, Newcastle-upon-Tyne (Member of Council) June 2, 1866.
447 Whalley, Thomas, Orrell Mount, Wigan ... Aug. 2, 1866.

448 White, Jos. T., 68, Westgate, Wakefield ... March 1, 1866.

449 Whitwell, Thomas, Thornaby Iron Works, Stockton-on-Tees ....... Sept. 5, 1868.

450 Widdas, Cornelius, North Bitchburn Colliery, Howden, Darlington......... Dec. 5, 1868.

451 Williams, E., (Bolckow, Vaughan, and Co.,) Middlesbro'-on-Tees (Member of Council) Sept. 2, 1865.

452 Willis, Edward, Clarence House, Willington, Durham ............ Sept. 5, 1868.

453 Willis, James, Washington Colliery, Washington Station, County of Durham....... March 5, 1857.

454 Wilmer, F. B., Duffryn Collieries, Aberdare ... June 6, 1856.

( xxxvi )
elected

455 Wilson, J. B., Haydock, near St. Helen's, Lancashire ............ Nov. 5, 1852


458 Wilson, Thomas Hay, 40, Dean Street, Newcastle-on-Tyne .......... March 6, 1869.

459 Wood, Lindsay, Hetton Hall, Fence Houses (Vice-President) Oct. 1, 1857.

460 Wood, C. L., Howlish Hall, Bishop Auckland ... 1853.

461 Wood, John, Flockton Collieries, Wakefield, Yorkshire ............ April 2, 1863.
462 Wood, W. H., West Hetton, Ferryhill......
1856.

463 Wood, William O., Brancepeth Colliery, Willington, Durham...............
Nov. 7, 1863.

464 Woodhouse, J. T., Midland Road, Derby       ...
13, 1852.

465 Yardley, John, Burntree, Tipton ......
Nov. 3, 1866.

Graduates

elected.

1 Armstrong, William, jun., Wingate, County of Durham ...............
April 7, 1867.

2 Atkinson, W., Rainton Colliery, Fence Houses ...
June 6, 1868.

3 Booth, R. L., Medomsley, Burnopneld ......
1864.

4 Clarke, Nathl., jun., Beamish Park, Fence Houses
June 6, 1868.

5 Coates, C. N., Skelton Mines, Guisbro'......
May 3, 1866.

6 Coulson, Francis, Shamrock House, Durham  ...
Aug. 1, 1868.

7 Cowlishaw, John, 74, Osmaston Street, Derby  ...
March 7, 1867.

8 Fletcher, Geo., Trimdon Colliery, Trimdon Grange
April 4, 1868.

9 Forster, J. T., Washington, Gateshead ......
Aug. 1, 1868.

11 Greenwell, G. C, jun., Towneley Colliery, Blaydon-on-Tyne ............. March 6, 1869.

12 Hann, Edmund, Hetton Colliery, Fence Houses .................. Sept. 5, 1868.


16 Home, George, Rainton Colliery, Fence Houses .................. June 6, 1868.

( xxxvii )

elected.

17 Hunter, James, Peases' West Collieries, Darlington March 6, 1869.

18 Jenkins, John Herbert, Cramlington Collieries, Northumberland ............. March 6, 1869.

19 Longbotham, Jon., Waldridge Colliery, Chester-le-street .................. May 2, 1868.


22 Nevin, John, Mirfield ............. May 2, 1868.

23 Pamely, Caleb, Towneley Colliery, Blaydon-on-Tyne ............. Sept. 5, 1868.
24 Panton, Frederick S., 24, St. George's Square, Sunderland............ Oct.  5, 1867.


28 Ramsay, Thomas Dunlop, South Durham Colliery, via Darlington .......... March 1, 1866.

29 Robson, James M., Rainton Colliery, near Leamside.............. Dec.  5, 1868.

30 Sheraton, Frederick, Hetton Colliery, Fence Houses June  6, 1868.

31 Seddon, J. Frederick, Wigan Goal and Iron Works, near Wigan........ June  1, 1867.

32 Sopwith, T., jun., Towneley Colliery, Blaydon-on-Tyne .............. Nov.  2, 1867.

33 Sparkes, Charles, Peases' West Collieries, Darlington.............. Sept.  5, 1868.


35 Wardell, Stuart C, Radstock Colliery, Bath .......... April  1, 1865.

36 Watson, Matthew, Thornley Colliery, Ferryhill .......... March 7, 1868.

37 White, H., Moorhouse, near Durham .......... 1866.


39 Wilson, Wm. Brumwell, Killingworth Colliery, Newcastle-on-Tyne........ Feb.  6, 1869.

40 Verner, Frederick, Cowpen Colliery, Blyth .......... March 7, 1867.
List of subscribing collieries.

Owners of Black Boy Colliery, Bishop Auckland,

" Haswell Colliery, Fence Houses.
" Hetton Collieries, Fence Houses.
" Kepier Grange Colliery, by Durham.
" Lambton Collieries, Fence Houses (Earl Durham),
" Leasingthorne Colliery, Ferry Hill.
" North Hetton Colliery, Fence Houses.
" Rainton Collieries (Earl Vane).
" Ryhope Colliery.
" Seghill Colliery.
" South Hetton and Murton Collieries, Fence Houses
" Stella Colliery, Ryton, Newcastle-upon-Tyne.
" Westerton Colliery, Ferry Hill.
" Whitworth Colliery, Ferry Hill.

Rules

1. —The objects of the North of England Institute of Mining Engineers are to enable its members, comprising Mining and Mechanical Engineers, and other persons connected with or interested in Mining, to meet together at fixed periods, and to discuss the means for the Ventilation of Coal and
other Mines, the Winning and Working of Collieries and Mines, the Prevention of Accidents, and the Advancement of the Sciences of Mining and Engineering generally.

2. —The Members of the North of England Institute of Mining Engineers shall consist of four classes of Members, viz. :—Ordinary Members, Life Members, Graduates, and Honorary Members.

3. —Ordinary and Life Members shall be persons practising as Mining and Mechanical Engineers, and other persons connected with or interested in Mining.

4. —Graduates shall be persons engaged in study to qualify themselves for the profession of Mining or Mechanical Engineers.

5. —Honorary Members shall be Mining Inspectors during the term of their office, and other persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6. —The Annual Subscription of each Ordinary Member shall be £2. 2s., payable in advance, and the same is to be considered due and payable on the first Saturday of August in each year, or immediately after his election.

7. —The Annual Subscription of each Graduate shall be £1. 1s., payable in advance, and the same is to be considered due and payable on the first Saturday of August in each year, or immediately after his election.

8. —All persons who shall at one time make a donation of £20 or upwards shall be Life Members.

9. —Each Subscriber of £2. 2s. annually (not being a member) shall be entitled to a ticket to admit one person to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2. 2s., subscribed annually, another person shall be admissible up to the number of five persons; and each such Subscriber shall also be entitled for each £2. 2s. subscription to have a copy of the Proceedings of the Institute sent to him.

10. —Persons desirous of being admitted into the Institute as Ordinary Members, Life Members, or Graduates, shall be proposed by three Ordinary or Life Members, or both, at a General Meeting. The nomination shall be in writing, and signed by the proposers, and shall state the name and residence of the individuals proposed, whose election shall be balloted for at the next following General Meeting, unless it be then decided to elect by show of hands, and during the interval notice of the nomination shall be exhibited in the Society’s room. Every person proposed as an Honorary Member shall be recommended by at least five Members of the Society, and elected by ballot at the following General Meeting, unless it be then decided to elect by show of hands. A majority of votes shall determine every election.
11. —That the Officers of the Institute shall consist of a President, six Vice-Presidents (four of whom only to be Mining Engineers), and eighteen Councillors (twelve of whom only to be Mining Engineers), who, with the Treasurer and Secretary (if Members of the Institute), shall constitute a Council for the direction and management of the affairs of the Institute; all of which Officers shall be elected at the Annual Meeting (except in case of Vacancies), and shall be eligible for re-election, with the exception of any President, or Vice-President, who may have held office for the three immediately preceding years, and such three Councillors of the Mining Engineers, and two other Councillors, who may have attended the fewest Council Meetings during the past year, but such Members shall be eligible for re-election after being one year out of office, and such elections to be in manner following:

A.—Ordinary and Life Members shall be at liberty to nominate in writing, and send to the Secretary, not less than thirty days prior to the Annual or Special Meeting, a signed list of such persons as are considered suitable to fill the various offices, and to specify in such nominations respectively who are intended to represent the Mining or Mechanical Engineers and other persons interested in Mining; which list, having been duly stamped with the Institute Stamp, together with the List of such Officers as may be eligible for re-election, and a copy of this Rule shall be posted, at least fourteen days previous to the Annual or Special Meeting to all Ordinary and Life Members of the Institute, who must strike out from or add to such list, so as to leave a record of their Votes for Officers, not exceeding the number to be elected; but nothing shall prevent any Ordinary or Life Member nominating in writing subsequently (specifying the classes as aforesaid), and up to, and on the day of, and prior to the election taking place, any other Member or Members to fill the various Offices, nor shall anything prevent the Ordinary or Life Members, whether present or absent, from having power to vote for any other Member or Members, although he or they may not be nominated as before provided for. The Voting Papers being so filled up, must be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman, in all cases so as to be received before the hour fixed for the election of Officers.

B.—The Chairman shall, in all cases of voting, appoint Scrutineers of the Lists, and the scrutiny shall commence on the conclusion of the other business of the meeting, or at such other time as the Chairman may appoint. On the conclusion of the scrutiny the Voting Papers shall be destroyed, and the List, prepared and verified by the Scrutineers, shall be kept until the expiration of time for holding the ensuing three General Meetings.

C. --In the event of any vacancies occurring in the number of Officers subsequent to the Annual or Special Meeting at which the election of Officers shall have taken place, such vacancy or vacancies, except as to President, occurring within the time for holding the three next General Meetings, after such Annual or Special Meeting as aforesaid, shall be filled up by appointing a successor from those standing next highest on the Scrutineers’ List, but in the case of a vacancy for President, a new election by nomination and voting shall in all cases be proceeded with. After the expiration of time
for holding such three General Meetings, in the event of any vacancy then occurring for Vice-
Presidents and Councillors, the Council shall have discretionary power either to appoint a successor
or successors, or instruct the Secretary to issue Nomination and Voting Papers in the usual way.

D.—At Meetings of the Council five shall be a quorum, and the minutes of the Council’s proceedings
shall be at all times open to the inspection of the Members of the Institute.

12. — That the Vice-Presidents who have become, or may become, ineligible, from having held office
for three years, shall be, ex-officio, Members of the Council for the following year; and all past
Presidents (they continuing Members of the Institute) also to be, ex-officio, Members of the Council
for the following three years after their Presidentship.

13. — A General Meeting of the Institute shall be held on the first

( xlii )

Saturday of every month (except in January and July), at two o’clock; and the General Meeting in the
month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract
of the accounts of the previous year, shall be presented by the Council. A Special Meeting of the
Institute may be called whenever the Council shall think fit, and also on a requisition to the Council,
signed by ten or more Members.

14. — Every question which shall come before any meeting of the Institute shall be decided by the
votes of the majority of the Ordinary and Life Members then present.

15. — The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be
disbursed by him according to the direction of the Council.

16. — All papers sent for the approval of the Council shall be accompanied by a short abstract of
their contents.

17. — The Council shall have power to decide on the propriety of communicating to the Institute any
papers which may be received, and they shall be at liberty, when they think it desirable, to direct
that any paper read before the Institute shall be printed and transmitted to the Members.
Intimation, when practicable, shall be given at the close of each General Meeting of the subject of
the paper or papers to be read, and of the questions for discussion, at the next meeting; and notice
thereof shall be affixed in the rooms of the Institute a reasonable time previously. The reading of
papers shall not be delayed beyond such hour as the President may think proper, and if the election
of Members or other business should not be despatched soon enough, the President may adjourn
such business until after the discussion of the subject for the day.

18. — Members elected at any meeting between the Annual Meetings shall be entitled to all papers
issued in that year.
19. —The Copyright of all papers communicated to and accepted by the Institute shall become vested in the Institute; and such communications shall not be published for sale, or otherwise, without the permission of the Council.

20. —All proofs of discussion forwarded to Members for correction must be returned to the Secretary not later than seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

21. —The Institute is not, as a body, responsible for the facts and opinions advanced in the papers which may be read, nor in the abstracts

(xliii)

of the conversations which may take place at the meetings of the Institute.

22. —The Author of each paper read before the Institute shall be allowed twelve copies of such paper (if ordered to be printed) for his own private use.

23. —The Transactions of the Institute shall not be forwarded to Members whose subscription is more than one year in arrear.

24. —No duplicate copies of any portion of the proceedings shall be issued to any of the Members unless by written order from the Council.

25. —All Members of the Institute shall have power to introduce a stranger to any of the General Meetings of the Institute, and shall sign, in a book kept for the purpose, his own name, as well as the name and address of the person introduced; but such stranger shall not take part in any discussion or other business, unless permitted by the meeting to do so.

26. —No alteration shall be made in any of the Laws, Rules, or Regulations of the Institute, except at the Annual General Meeting, or at a Special Meeting, and the particulars of every such alteration shall be announced at a previous General Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of, or addit to, the Rules.

(xliv)

ERRATA.

Page 66, line 21, for "capacities to", read "capacities in preference to"
INDEX TO VOL. XVIII.

( vi )

[ Page vi is blank ]

( vii )

Title page " Catalogue of Institute Library "

( viii )

CATALOGUE.

A

Accum, Fred., A Practical Treatise on Gas Light. 1815.
Address to Coal Owners, by T. J. Taylor.
Agricola, Georgii, Kempnicensis Medici Ac Philosophi Clariss, De Re Metallica, libri XII. 1657.
American Academy, Proceedings of. Vol. VI. and 2 parts Vol. VII.
Ansted, David T., an Elementary Course of Geology, Mineralogy, and Physical Geography. 1850.

(L'Art d'exploiter les Mines de Charbon de Terre.)

Atlas de la Richesse Minerale. Par M. le Baron Heron de Villefosse. Nouveau Tirage. 1838.

B


Bakewell, R., An Introduction to Mineralogy. 1819.

Bakewell, R., An Introduction to Geology. 1833.

Bell, I. L., On the Chemistry of the Blast Furnace. 1869.

Bell, John, Collections relating to the History of Coal and Mining. 21 vols. Presented by T. J. Taylor, Esq.


Brongniart, Alex., Traite Elementaire de Mineralogie. 2 vols. 1807.


( ix )

C


Chabannes, Marquis de, on Conducting Air by Forced Ventilation, &c. 1818.

Chalmers, James, C.E., The Channel Railway. 1861.

Civil Engineers, Proceedings of. 27 vols. 1842 to 1868.

Civil Engineers, General Index to vols. 1 to 20. 2 Copies.

Civil Engineers, Catalogue of Books in Library of.


Combes, M. Ch., Traite de l'Exploitation des Mines. 3 vols. 1844-5.


Compleat Collier, The, 1708.


D

Dalton, John, Meteorological Observations and Essays. 1834.


Davy, Sir H., on the Fire Damp of Coal Mines. 1816.

De la Beche, H. T., Report on the Geology of Cornwall, Devon, and West Somerset. 1839.


Doursther, H., Dictionnaire Universelle des Poids et Mesures. 1840.

Dudley and Midland Geological Society, Transactions of. (Some odd parts only.)


Dunn, M., A Treatise on the Winning and Working of Collieries. 1852.

Dunn, M., How to prevent Accidents in Collieries. 1862.

Explosion at Hetton Colliery, Account of. 1860.
Explosion of Fire Damp at Eaglesbush or Eskyn Colliery, South Wales, March 29, 1848.

Feier, die, des Zehnjahrigen Stiftungsfestes des Architeceten und Ingenieur-Vereins fur das Konigreich Hannover, 1841.
Fenwick, Thomas, Essays on Practical Mechanics. 1824.
Flotz-Karte des Oberschlesischen Steinkohlengebirges. 1860.
Forster, Westgarth, A Treatise on a Section of the Strata from Newcastle to Cross Fell in Cumberland. 1821.
Fossil Fuel and Collieries, History of. 1841.

Geological Society, Quarterly Journal of, Nos. 1 to 89 (except No. 7, which is out of print).
Geological Survey of Great Britain, &c. 1858, Part 1
Geological Survey of Great Britain, &c. 1858, Maps.
Girardin and Burel, Rapport sur l’Exposition Universelle de 1855.

Glossary of Terms used in the Coal Trade.

Glynn, Joseph, Memoir of. 1863-4.


H

Hainault Societe des anciens Eleves. 13 Parts and Rules.

Hales, Stephen, A Description of Ventilators, whereby great quantities of Fresh Air may be conveyed into Mines, &c. 1743.

Hall, T. Y., Treatises on various British and Foreign Coal and Iron Mines and Mining. 1854.

Henekel, J. F., Pyritologia; or a History of the Pyrites. 1757.

I J

Index to Patents applied for. 7 Parts.

Ireland, Proceedings of Civil Engineers of. 6 vols., and vol. 7, part I

( xi )

Jars, M. G., Voyages Metallurgiques. 3 vols. 1774, 1778, and 1780.


Johnstone, Alex. Keith, Physical Atlas of Natural Phenomena.

K

Keelman's Society's Act. 1795.
Keilhan, B. M., Gaed Norwogica von mehreren Verfassern herausgegeben. 1838.

Kirwan, Richard, Elements of Mineralogy, 2 vols. 1794.

L

Lectures delivered at the Bristol Mining School. 1857. 15 copies.


Literary and Philosophical Society of Newcastle, Transactions of, 6 vols. 1793 to 1845. Presented by E. F. Boyd, Esq.

Literary and Philosophical Society of Newcastle, Catalogue. 1829.

Literary and Philosophical Society of Newcastle, Supplementary Catalogue. 1829.

Literary and Philosophical Society of Newcastle, Catalogue. 1848.

Literary and Philosophical Society of Manchester, Memoirs of, 18 vols.


M

Machines a Vapeur, Reglement de Police et Instructions. 1854.

Mammatt, E., Geological Facts and Practical Observations intended to elucidate the Formation of the Ashby Coal Field. 1834.

Manchester Geological Society, Transactions of, 6 vols. Imperfect.

Meteorological Tables, from the Register of the Literary and Philosophical Society of Newcastle. 1849 to 1851. Presented by P. S. Reid, Esq.

Metropolitan School of Science, Prospectus of, 7th Session. 1857-8. 3 copies.
Miner’s Safety Rod, or Safety Fuze, for Blasting Rocks. 1832.


Mining and Smelting Magazine. Odd parts.

Miner’s Friend. 1702.

Moore, Ralph, On the Ventilation of Mines. 1859.

Moore, Ralph, On the Black Band Ironstones of the Edinburgh and East Lothian Coal Fields. 1861.

Natural History Society of Newcastle, Transactions of, 2 vols. 1831-38.

Newcastle-upon-Tyne Chemical Society, Transactions of, Part I.


North of England Institute of Mining Engineers, Transactions of, 18 vols.

Nuisances on the River Tyne. 1824.


Observations on the Duty on Sea-borne Coal. 1831.

Pambour, Comte de, Theory of the Steam Engine. 1839.

Pambour, Comte de, Practical Treatise on Locomotive Engines. 1840.
Pamphlets (various). Presented by W. Green, Esq.

Pamphlets, 2 vols.

Parachute a Friction pour Cages des Mines. 1862.

Peclet, E., Traite de la Chaleur consideree dans ses applications. 1844.

Peclet, E., Traite de la Chaleur consideree dans ses applications, (planches). 1843.

Peclet, E., Nouveaux Documents relatifs au Chauffage et a la Ventilation, &c. (Supplement). 1854.


Phillips, John, Figures and Descriptions of the Palaeozoic Fossils of Cornwall, Devon, and West Somerset. 1841. Playfair, Prof., A Comparative View of the Huttonian and Neptunian Systems of Geology. 1802.


Proceedings and Resolutions at a Meeting of Deputations from the Coal Mining Interests of the Kingdom. 1854.

R

Rapport sur l'Exposition Universelle. 1855.

Rankine's Applied Mechanics. 1861.

( xiii )

Receuil de Memoires et de Rapports des moyens de soustraire l'Exploitation des Mines de Houille, aux chances d'Explosion. 1840.


Revue Universelle des Mines, odd part.

Richardson and Fletcher's Report on Experiments at Wigan to Test the value of the Lancashire and Cheshire Steam Coals for Marine Boilers.

Rogers, Ebenezer, Description of a Ventilating Fan at Abercorn Collieries, &c. 1857.

Ronalds and Richardson, Chemical Technology, 2 vols. 1855.

Royal Dublin Society, Transactions of, parts 1 to 36.


Royal Institution of Great Britain, List of Members. 1862.

Royal Institution of Great Britain, List of Members, 1863.

Royal Scottish Society, Transactions of, 3 odd parts.


Royal Society of London, List of Members. 1862.

Rules for Formation of a Colliers' Society. 1825.

Rules for Formation of Friendly Societies. 1832.

Safety Fuze, The. 1832.

School of Mines, Records of. Parts 1, 3, and 4 of vol. I.

Scientific Instruction, Report on. 1868.

Scientific Instruction, pamphlets.

Scotland Institute of Engineers, Transactions of. Vols. VI. to XI.


Seaham, Description of Port of. 1854.
Sinking at Annesley Colliery. E. Hedley. 1866.

(xiv)

Smeaton, John, F.R.S., Reports on Civil Engineering, 2 vols, in 1. 1837.
Smithsonian Report. 1866.
Sopwith, T., An Account of the Mining Districts of Alston Moor, &c, 1833.
Sopwith, T., Award of the Dean Forest Commissioners. 1841.
South Wales Institute of Civil Engineers, Transactions of, 5 vols. 1857 to 1865.
Statistiques de la Belgique, Mines, Usines, Mineralurgiques, Machines a Vapeur, &c. 1842, 1846, 1852, and 2 copies of 1855.
Statistiques de l'Administration des Mines, Resume des Travaux. 1847 to 1852.
Steam Boiler Assurance Company, Engineer's Reports. 1863 to 1868.
Stephenson, George, Report on his Claims to the Invention of the Safety-lamp; 1817.

T
Taylor, R. C, Statistics of Coal. 1848.

U

W
Williams, John, Natural History of the Mineral Kingdom, 2 vols. 1789.
NORTH OF ENGLAND INSTITUTE
OF
MINING ENGINEERS.

GENERAL MEETING, SATURDAY, SEPT. 5, 1868, IN THE ROOMS OF THE INSTITUTE, NEVILLE HALL, NEWCASTLE-UPON-TYNE.

G. B. FORSTER, Esq., Vice-President of the Institute, in the Chair.

The Secretary read the minutes of the previous meeting and the minutes of the Council, after which the following gentlemen were elected:—

Members: -

Robert Henry Robinson, Staveley Works, near Chesterfield.
Richard S. Thorpe, 17, Picton Place, Newcastle-upon-Tyne.
Edward J. Grimshaw, Cowley Hill, St. Helen's, Lancashire.


John Bailes, Kelloe Colliery, Ferry Hill.

James Archbold, Murton Colliery, Sunderland.

Richard Forster, Trimdon Grange Colliery, Ferry Hill.

Edward Charlton, Evenwood Colliery, Bishop Auckland.

Edward Willis, East Howle Colliery, Ferry Hill.

Matthew Hall, Peases' West Collieries, Darlington.

S. B. Gilroy, Moreton Hall and Preesgwyn Colliery Company, near Chirk.

W. M. Hutchings, Colliery Guardian Office, 5, Bouverie Street, Fleet Street, London.

John Stephenson, Seaton Delaval Colliery, Dudley, Northumberland.

Thomas Whitwell, Thornaby Iron Works, Stockton-on-Tees.

Graduates:

Caleb Pamely, Towneley Colliery, Blaydon-on-Tyne,

Charles Sparkes, Peases' West Collieries, Darlington. Edward Hann, Hetton Colliery, Fence Houses.

The Secretary stated that he had a communication from Mr. W.

Boyd, apologizing for not being ready with the promised paper on Rivetting, and expressing a hope to be able to lay it before the next meeting.

Mr. James Barkus exhibited the model of a new safety-cage, provided with weights and springs, which formed a subject for conversation.
Mr. James A. Richmond Morison explained a contrivance which he had invented for preventing any tampering with safety-lamps. It applied to his brother's, as well as to the Stephenson-lamp, with the present lock, or to any lamps which possessed the elements of safety. These could not be opened when fitted with his arrangement, except when turned upside down, when the products of combustion immediately extinguished the light, no key being required except that now used for locking the lamps.

The Chairman said, he had recently seen a lamp worked with a small padlock.

Mr. Atkinson said, he thought there was one little difficulty - namely, the oil might get into the lock-hole and clog the apparatus so that it would not work. The consequence would be that the lamp would go in unlocked.

Mr. Morison said, the lock was above the level of the oil.

The Chairman said, this contrivance seemed better than that of drawing down the wick.

Mr. Morison said, if they thought the invention worthy of approval he would leave those lamps with the Institute.

Mr. Atkinson said, all these contrivances could be rendered nugatory by a miner taking with him a lucifer match. Still it was a very pretty idea which Mr. Morison had carried out, and as he had given it to the Institute without taking out a patent, they ought to give him a vote of thanks, and he begged to move one accordingly.

Mr. Greene seconded the motion, which was carried by show of hands.

The meeting then separated.

( 3 )

NORTH OF ENGLAND INSTITUTE
OF
MINING ENGINEERS.

GENERAL MEETING, SATURDAY, OCT. 3, 1868, IN THE ROOMS OF THE INSTITUTE, NEVILLE HALL, NEWCASTLE-UPON-TYNE.

G. B. FORSTER, Esq., Vice-President of the Institute, in the Chair,

The Secretary read the Report of the Committee on Technical Education. He said the subject had been carefully considered, and the draft copy of the Report laid before the Parliamentary and Finance Committees of the Coal Trade, who had most favourably received it.

The following new members were elected:—

Thomas Moor, North Seaton Colliery, Morpeth,
William Beale Marston, Mold, Flintshire.
Edward Hall, Houghton-le-Spring,

Mr. W. Boyd then read a paper on Rivetting, with a description of a new portable rivetting machine. The paper was illustrated by diagrams.

After reading the paper, Mr. Boyd, at the request of the meeting, explained the working of the machine, one of which was exhibited.

In answer to Mr. Southern, Mr. Boyd said, the portable hydraulic machine would fasten two or three rivets in two minutes - rather better than one per minute. When they were experimenting, they did it at a rapid pace, faster than they could heat the rivets. The fixed steam machine was very like the fixed hydraulic machine, although he preferred the latter. Where steam machines had been made portable, he thought that description of machine which was in fact a small portable steam hammer the best. The portable hydraulic machine before them was not at all on this principle, but closed the rivets by direct pressure in all respects in the same way as if fixed.
Mr. Southern said, he supposed the preference given to the hydraulic machine was, that water was almost incompressible, while steam was elastic. Did Mr. Boyd think that any injury would be sustained by the plate in punching the hole gradually by the hydraulic machine?

Mr. W. Boyd said, the machine did not punch the hole; it simply put in the rivets. The advantage of the hydraulic machine was this - in all boilers, however well the plates are put together, there is always a certain space left between the plates before the rivet is put in. If the force used to close the rivet was in the nature of a blow, this space would be suddenly shut and would have a tendency to open again before the rivets had time to cool and contract; but where the process was gradual, however much the space was open, the plates were squeezed close up, and were never allowed to come back.

Mr. Rake said, Garforth’s machine kept the pressure on till the rivet was cooled.

Mr. Steavenson thought the plan suggested for portable machines superior to that of employing steam hammers, since hammering the rivets would deteriorate them.

Mr. Nelson asked where the improvement was as compared with Fairbairn’s lever machine?

Mr. W. Boyd said, one great advantage was this: the lever machine was so set, as in each case to close a certain length of rivet; if by any chance the rivet was a quarter or one-eighth of an inch longer, or the plate changed in thickness, the pressure still came up, and something must break or the machine must spring back. This defect was so great that Fairbairn’s machine had been gradually superseded by Cooke’s and Garforth’s steam rivetting machine.

Mr. Rake said, he had had experience of Fairbairn’s machine, and he could quite corroborate Mr. Boyd’s observations. There must be great care used in such machines to obtain an exact thickness of plate, and a correct and uniform length of rivet, or serious fracture would result.

Mr. W. Boyd, in answer to Mr. Nelson, who asked which power was to be preferred, steam, water, or the use of a cam, certainly thought both the former modes superior to the latter, since they each
conformed themselves to any extra length of rivet without chance of fracture; and he had already stated why he preferred hydraulic to steam power.

Mr. Tweddell said, that both the steam and hydraulic machines would make good work even with a short rivet, when with Fairbairn’s,

(5)

under the same circumstances, the boiler would not be made tight at all; in fact, both the former class of machines would accommodate themselves either to a short or a long rivet.

Mr. W. Boyd said, he had to thank Mr. Tweddell for introducing the fixed hydraulic machine to the notice of his firm.

Mr. Steavenson asked what would be the effect of the steel bar breaking in the portable machine before them?

Mr. W. Boyd - You would have to insert another in its place.

Mr. Steavenson - But would there not be danger to persons standing near?

Mr. W. Boyd - None whatever; in the preliminary testing of the bars he had been close behind when several had broken.

The Chairman then moved that the thanks of the Institute be presented to Mr. Boyd for his paper.

Carried by show of hands.

Mr. Willis said, this being the first paper on mechanical engineering, he hoped it would not be the last.
The Secretary read a letter from Mr. Spencer, stating that he was hardly ready with his remarks, and promising to have them prepared by next meeting.

The Secretary also read a notice of Hann's safety-lamp, a specimen of which was produced, and its properties pointed out.

After some conversation it was referred to the Lamp Committee.

The meeting then broke up.

(6)

[Page 6 is blank]

(7)

TECHNICAL EDUCATION COMMITTEE'S REPORT.

The Coal Trade Association having requested the Mining Institute to consider in what way the Government Scheme for Technical Education could he rendered available to the district, the matter was referred, at the annual meeting of the Institute, held on the 1st August, to Messrs. Lindsay Wood, William Cochrane, J. B. Simpson, John Daglish, E. F. Boyd, A. L. Steavenson, and G. B. Forster.

The Committee, after due examination of the subject, think that the scheme, if properly carried out, might be made of great value to the working classes of the Northern Counties, and considering that the Coal Trade Association in requesting the Mining Institute to report on the subject, were desirous of practically carrying out its recommendation by supplying the necessary funds, if a reasonable prospect of success were offered, recommend that the offer of Mr. W. T. Rowden, to organize the Government scheme in this district, should be accepted.
This gentleman has had considerable experience at Bristol and Woolwich, in the mode of carrying out the details necessary for obtaining Government grants for Educational purposes, is a successful teacher, has had great experience with working men, and has so much confidence in the success of the undertaking, that he would resign a present situation at Clifton College of £300 a-year, if he were guaranteed £160 from an independent source for the first year, and £150 for the second year, besides the necessary railway expenses, relying entirely, during two years, on such aid as he will obtain from Government, upon the results of his work, for all further remuneration for himself and the necessary staff of assistants; at the end of this period, either the Coal Trade Association or himself to be at liberty to terminate the engagement, or to negotiate a continuance of his services, on such terms as may be mutually arranged.

(Signed)

WILLIAM COCHRANE, LINDSAY WOOD, JOHN DAGLISH, GEORGE BAKER FORSTER, A. L. STEAYENSON.

REMARKS ON RIVETTING.

By WILLIAM BOYD.

In these remarks on rivetting it is proposed to introduce the subject to your notice by briefly stating the strength of joint obtained by the two arrangements of rivets in most common use, viz., single and double rivetting, and the power required to close the plates and form the rivet heads of the size most usually employed.

According to statements published by Mr. Fairbairn in 1856 it would appear that the proportionate strength of single and double rivetting was as follows:—

Taking the original strength of the plates as \( \ldots 1000 \)
Double rivetting is represented by........ 977
Single .................. 761

or roughly as 10, 9, and 7.

There is also the system of countersinking rivets largely used in shipbuilding, about which Mr. Fairbairn remarks: - "They do not add to the strength of the joint but rather reduce it, and though this reduction is not observable from the experiments, the simple fact of sinking the head of the rivet into the plate and thus cutting out a greater portion of the metal must of necessity weaken its strength, while the consequent reduction of the heads of the rivets renders them less able to bear an oblique or transverse strain."

Some of the experiments by Mr. Fairbairn were repeated in order to show the increase obtained by the use of Fairbairn's Rivetting Machine over the ordinary hand rivetting, but this does not appear to have been done throughout the entire series. When such trials were made the proportionate strength of machine to hand rivetting was as 5 to 4; in others nearly equal.

The question of how much the friction between the surfaces of two plates united by rivets assists in adding to the strength of the joint is also an interesting one; and from experiments made at the time of the construction of the Menai Bridge it seems as if this was of some value. Three plates 5/8 in. thick were rivetted together by 7/8 in. rivets, the hole in the centre plate being oval, and very much larger than the rivet. This arrangement bore a strain of 5.6 tons before the centre plate slipped and began to bear on the rivet. The addition of a plate or washer 1/2 in. thick under the rivet heads enabled them to bear a weight of 7.9 tons before they slipped. With 5/16 in. plates, 7/8 in. rivets and 5/16in. washers this weight was found to be 4.7 tons, and the whole result is of considerable importance, as showing that the strain upon rivets is not wholly a shearing, but, to a great extent, a tensile strain.

Your attention is now asked to a series of experiments made by Mr. Bunning at Messrs. Hawthorn's to obtain information as to the absolute amount of pressure required on the head of a rivet in an ordinary steam rivetting machine.
These experiments were made with an ordinary steam rivetting machine having a cylinder 36 inches diameter, the area of which is 1017 square inches, so that every pound pressure in this cylinder represents a pressure on the head of the rivet of 1017 lbs., or 0.4540 of a ton. The rivets were 3/4 in. diameter, and the plates 5/8 in. and 7/16 in. thick.

By reference to the diagrams (Plate I.) it will be observed that three different pressures of steam were employed, viz., 60 lbs., 40 lbs., and 30 lbs., and that at each pressure two different kinds of trials were made; in one the steam was admitted twice in each stroke, and each time suddenly, and in the others the steam was admitted gradually.

Take the 60 lbs. pressure. The average of the three experiments made with the steam admitted twice suddenly, shows a pressure on the rivet head of 27 tons. The average of the three experiments with the steam admitted gradually shows also 27 tons on the rivet.

At 40 lbs., the pressures are suddenly 18 tons.
At 40 lbs., the pressures are gradually 18 tons
At 30 lbs., the pressures are suddenly 13 tons
At 30 lbs., the pressures are gradually 13 tons

so that as far as the actual pressure on the rivet goes, the way in which the steam is admitted does not seem to make much difference.

But if the diagrams are carefully examined an important difference is exhibited in these modes of working, viz., that where the steam was admitted twice suddenly the line of pressure goes much further back in the direction of the original head of the rivet than in the cases where it was admitted gradually.

Where the steam was suddenly applied, the line of pressure goes as

(11)

far back as beyond the thickness of the nearest plate, or, in other words, nearly half an inch beyond the shoulder of the rivet head formed by the machine. When the steam was admitted gradually, the
line goes in some cases nearly as far back; but the rebound, which is seen in the former case, is not nearly so evident in this.

The cause of this position of the line of pressure is probably that the holder-up, not being perfectly rigid, yields to that extent to the pressure applied to it; and that this is so is confirmed by observations of the diagrams, it being readily understood that when the steam is admitted suddenly, the yielding of the holder-up would be greater than when it was admitted gradually, and it will also account for the rebound noticeable in all the diagrams, when the steam was suddenly admitted.

Your attention is particularly called to this point, as it will be referred to hereafter.

These diagrams were very carefully made with the intention of ascertaining the exact pressure necessary to produce a good rivet during the whole of the process. In diagram No. 2 a rivet is shown in its position, ready to be headed; and the heading cup, on the piston-rod of the machine, is shown in its position when at rest. It will at once be seen that the whole of the pressure shown during that part of the motion of the piston which precedes the contact of the cup with the rivet, is required to overcome friction; and, vis inertia, it will also be seen that in some cases this pressure is much increased when the rivet is being crushed, but that in very many the diagrams show really a very small increment of pressure as due to that process; in fact, it would appear that when the rivet is perfectly hot, the pressure necessary to crush it up to the head rarely exceeds 6 tons. Of course, when once the head is formed, the pressure may be augmented to any given height, compatible with the strength of the holder-up, since, when the plates touch, there is nothing left but the holder-up which can give way. This ultimate pressure is, of course, in the diagrams limited to the pressure of steam, being 27 tons with 60 lbs., 18 tons with 40 lbs., and 13 tons with 30 lbs. On a careful examination of the rivetting made under these diverse circumstances there was no appreciable difference between the work done at the higher and that executed at the lower pressure. The samples were planed through the centre, and were all equally good. If there were any preference to be given, it would be in favour of the rivetting executed at the lowest pressure, 30 lbs., probably owing to the plates, in that case, having been better punched.

Specimens of rivetting made under these various conditions are on

(12)

the table before you, and are numbered to correspond with the diagrams.
Rivetting by hydraulic power, which is more particularly the subject of this paper, has been for some time past in operation at Sir W. G. Armstrong's, and a machine which derives its power from this source, and which is at work in the writer's own factory, is now submitted to you.

It consists of two upright standards (see Plate II., Fig. 1), one of which contains a cylinder to which is fitted a ram or plunger, kept tight by a leather packing in the ordinary way. The other acts as the holder-up, and is connected to the first standard by a strong cast iron bed plate sunk into the ground, to which each standard is securely bolted.

The diameter of this cylinder is 6, 1/2 inches, its area 33 square inches, its maximum travel 5 inches, giving a content of 165 cubic inches. In ordinary working this travel is about 2, 1/2 inches, giving a content of 82.5 cubic inches.

The pressure employed is 13.5 cwts. per square inch, which gives an absolute pressure on the head of the rivet of 22 tons, and from this most excellent results have been obtained.

One rivet per minute can be put in in ordinary working, and boilers have been tested to 120 lbs. with cold water made by this machine without the slightest leak being visible.

A reserve of power is obtained by means of an accumulator (Plate III.). It derives its pressure from the difference in the diameter of the vertical standard at the point where it enters and leaves the chamber into which the water is pumped.

The larger diameter of the standard is 4, 5/8 inches, giving an area of 16.8 square inches; the smaller diameter of the standard is 3, 15/16 inches, giving an area of 12.1 square inches, giving an area for pressure of 4.7 square inches.

The total weight of the accumulator is 62 cwts., which gives a pressure on the above area of 1502 lbs. or 13.4 cwts.

A small pump, in connection with the engine, is constantly pumping into this accumulator - when it reaches the extent of its travel in an upward direction, a cord attached to it shuts the suction cock of the pump, and then until a further demand is made upon it no more water enters the accumulator.
When a rivet is being closed, the weight falls, the cord slackens, and the suction cock is opened by a balance weight, this enables the pump to commence its operations afresh, which are continued until the weight again reaches the top of its travel, when the cock is again shut, and the machine is in readiness for another rivet.

Specimens of the work done by this machine are before you, showing its effect on the rivets of 3/4 inch, 7/8 inch, and 1 inch diameter, with corresponding thickness of plates, and it will be observed how perfectly the rivets are made to fill the holes, though some are by no means “fair.” It was to make boilers with these larger sizes of rivets that this great pressure was arranged for, and a boiler with 7/8 in. rivets and 11/16in. plates is now under course of construction.

About two years ago, it occurred to your Secretary, Mr. Bunning, that a machine might be designed which should derive its power from hydraulic pressure, and be at the same time portable, having reference more particularly to employment on girders, keels of ships, and other work which could not be conveniently suspended over a fixed machine.

Before entering into a description of this machine, it may be stated that it depends for its efficacy on the strength of a steel bar which should be able in every case to pass through the holes to be subsequently occupied by the rivets.

Many will be acquainted with a valuable work by Mr. Kirkcaldy, giving an elaborate series of experiments on the strength of steel and iron bars. An examination of this work will show that steel bars of best cast chisel steel broke with a strain of 55.7 tons per square inch of their original section, and 60.5 tons per square inch of their stretched section. Best cast tool steel broke with 59.2 tons per square inch on original section; and with 62.3 tons per square inch on stretched section. These specimens were forged from rolled bars of the best cast steel, were re-heated after hammering and allowed to cool gradually and slowly.

If now the same quality of steel is taken and treated in various ways, the results are most interesting.

A bar of best cast chisel steel

Highly heated and cooled suddenly in oil breaks with 96.1 tons per square inch
Highly heated and cooled suddenly in water breaks with 40.2 tons per square inch

Highly heated and cooled slowly in ashes breaks with 54.3 tons per square inch

Heated to medium heat and cooled suddenly in oil breaks with 82.5 tons per square inch

Heated to medium heat and cooled suddenly in tallow breaks with 79.6 tons per square inch

Heated to medium heat and cooled slowly in ashes breaks with 53.2 tons per square inch

Heated to a low heat and cooled suddenly in oil breaks with 72.8 tons per square inch. Heated to a low heat and cooled suddenly in tallow breaks with 64.4 tons per square inch

Heated to a low heat and cooled slowly in ashes breaks with 56.2 tons per square inch

So that the breaking strain of a bar of cast steel highly heated and cooled suddenly in oil, may be estimated at 96 tons per square inch, or a

(14)

bar 3/4 inch diameter or 0.44 inch area will have a breaking strain of 42.24 tons per square inch, or taking a bar which should pass readily through a hole 3/4 inch diameter, say 11/16 inch diameter and 0.37 inch area, its breaking strain would be 32.6 tons per square inch.

Experiments were made on a few bars at Sir W. G. Armstrong's works, with a view of confirming or otherwise Mr. Kirkcaldy's results, and these gave the breaking strain on a bar of best cast steel allowed to cool gradually at 42 tons per square inch, and on one hardened in oil at 68.4 tons per square inch. Referring back to Mr. Kirkcaldy's experiments we find these to be somewhat less satisfactory results, but this is mainly attributable to the form of the bars employed, which all broke through the line A B where the strength was very considerably reduced by the corners being cut in sharp, and not rounded off with a proper curve. (See Plate I.) At the same time it will be observed that the relative increase of strength from hardening in oil is essentially preserved.

This then was the basis of operation in the portable machine, and it was in this form that it came before the writer two years ago.

By reference to Plate No. IV., it will be found to consist of a machine comprising three hydraulic cylinders, two horizontal and one vertical cylinder, a, b, c; the two horizontal cylinders being for the purpose, the one b, of forming the rivet head, and the other a, for compressing the plates previous
to the insertion of the rivet. The vertical cylinder, \( c \), is larger in diameter, and is for the purpose of securely holding one end of the steel bar, \( d \), which passes through the rivet hole, thereby obtaining a perfectly firm and secure connection between the machine on one side of the plate, and the holder-up, \( e \), on the other.

In the two horizontal, or what may be called the rivetting, cylinders, are fitted two rams - the one terminating in a cup, \( f \), of suitable form for making the head of the future rivet, the other in a pin or drift, \( g \), for steadying the machine, and with a shoulder for compressing the plate ready for the subsequent insertion of the rivet. These rams are kept tight by leather in the ordinary way, and the other ends of the cylinders are closed with screw plugs so as to be perfectly water tight.

The ram in the vertical cylinder is prolonged through a leather packing, and is attached to the top of a saddle, \( h \), which is one-half of what may be termed the nut in which the end of the steel bar, \( d \), is held; after the pressure has been admitted and the head of the rivet formed, the rams in the rivetting cylinders are drawn back by a handle, \( i \), and bar, to which are attached two levers acting directly on the said rams, and which are thus drawn back at the pleasure of the workman.

The vertical ram is lifted by means of a strong spring which comes into operation as soon as the hydraulic pressure is taken off, which is done by means of the lever, \( k \), acting on a small double valve under the machine.

The steel bar and its saddles or nuts were a problem, the solution of which offered the greatest obstacle to the success of the machine. The various forms which were tried unsuccessfully on this part of the machine need not now be detailed, since the present arrangement acts remarkably well; and entirely obviates all difficulty. At the end of the steel bar a square-threaded screw is cut deep at the furthest end, and running out to nothing towards the centre of the bar. The edges of the thread are rounded over to enable it freely to enter the saddles. At the deepest point of the thread it will be evident that the bar is considerably weakened, while at the other end it retains of course its original strength, so that the reduction in strength is represented by the mean depth of the thread, which is at a point somewhere in the middle of the saddle. There being a pressure of some 20 tons on this saddle, much of the strain on the bar is transferred to the saddle before it reaches the more weakened portion caused by the screwing, so that as the depth of the screw increases, so in like proportion does the strain at that part decrease, and this arrangement has been always found to leave a sufficient margin, keeping the strength of the bar at each part of its length equally in excess of the strain put upon it.
In the two halves of the saddle is also cut a square threaded screw, with the edges rounded off, corresponding in pitch to the thread cut on the steel bar, so that they fit down readily on to the bar when it is pushed by the holder-up into its place.

The holder-up, e, consists of a casting, the steel bar passes through its centre, and on one end is a cap to fit the head of the rivet when inserted into its place, and the other presses against the plate opposite to the drift spoken off above.

Underneath the machine is a double valve, worked by the workman, for admitting and cutting off the supply of hydraulic pressure.

The bar, as explained before, is of best cast steel, hardened in oil, as also are the saddles and dies; the rams, holder-up, and the machine itself, are all of malleable cast iron.

The action of the machine is as follows (see plate V.): - On the one side of the girder, or otherwise, to be rivetted, stands a man, having the holder-up with the steel bar attached to it, in readiness. On the other side is the machine, suspended over the place of operation from a light bar or other means above it, and with a workman in attendance. A rivet being heated, is inserted into the first rivet hole by the boy; the steel bar is passed through the second hole by the man behind; the machine is entered on to the bar and pushed up against the hot rivet point; the man then opens the valve admitting the pressure from the accumulator; the top half of the saddle is immediately forced down on the bar by the vertical cylinder; simultaneously, the rivet head is formed by the one horizontal or rivetting cylinder, while the other is forced up against the plate with a pressure equal to that employed against the head of the rivet.

When the workman considers that the head is properly formed, he shuts off the hydraulic pressure, at the same time drawing back the ram in the rivetting cylinder by the lever before-mentioned, and thereby forces out the water through the escape pipe; the spring, also described above, lifts the ram attached to the top half of the saddle, the bar is withdrawn, and the machine is in readiness for the next rivet.
Another rivet being ready, it is inserted this time in the second hole from the end; the bar goes through the third; the plate is compressed at the fourth; and this operation is continued till the whole line of rivets is complete.

The accumulator employed with this machine, and with which the specimens before you were rivetted, is of the same character exactly as the one already described, but with smaller contents, the area for pressure is 2.11 square inches, and the pressure per square inch is equal to 40 cwts.

The machine exhibited is arranged for working with rivets 2 inches apart, which is the common practice in marine boilers. The rivetting cylinders are each 2, 1/2 inches diameter, = area 4.9 square inches, which, with a pressure per square inch from the accumulator of 2 tons, gives a pressure in each cylinder of 9.8 tons, and a strain on the steel bar of 19.6 tons; the plates are, therefore, first of all squeezed together with a pressure of 19.6 tons, and the rivet closed in its place with 9.8 tons.

The diameter of the cylinder pressing upon the top half of the saddle is 3, 1/2 inches, = area 9.6, which, with a pressure of 2 tons from the accumulator, gives a total pressure on the saddle holding the steel bar of 19.2 tons.

Referring back to the strength of the steel bar, stated previously as able to bear a breaking strain of 32.6 tons, on a diameter of 11/16 inch, it will be seen that we are clearly within the limits of safety, and that if thought necessary the pressure per square inch might be increased to 2, 1/2 tons, giving a pressure on the rivet of 12.25 tons, and on the bar of 24.5 tons.

[ There following between pages 16 and 17 :

Plate I : Diagrams illustrating Machine Rivetting by the ordinary Steam Rivetter
Plate II : Diagram : Hydraulic Rivetting Machine at Messrs. Thompson, Boyd & Co.'s Boiler Yard
Plate III : Diagram : Accumulator for the Hydraulic Rivetting Machine
Plate IV : Diagram : Bunning's Portable Hydraulic Rivetter
Plate V : Diagram : Arrangement of and mode of working of Bunning's Portable Rivetting Machine
Plate VI : Diagrams from Fixed Hydraulic Rivetting Machine

( 17 )]
A larger machine has been made suitable for girder work, with 4, 1/2 inch centres. Rivetting cylinders 3, 1/2 inches diameter, = area 9.6 square inches, which, with a pressure of 30 cwts. per square inch, would give a pressure of 14.5 tons on the rivet, or 29 tons on the bar, while a bar 13/16inch diameter, to pass through a 7/8 inch hole, will bear a breaking strain of 48 tons.

In conclusion, I would draw your attention to what appears to me the advantage of hydraulic rivetting. From the experiments with the steam rivetting there appears a decidedly more uniform action on the head of the rivet where the steam is admitted gradually, and surely this must be still more the case where the rivet is squeezed gradually up by hydraulic pressure, which pressure is maintained in its entirety to the end of the stroke, and the rivet not forced into shape by an action par\(\text{t}\)aking more or less of the nature of a blow accompanied by its corresponding rebound.

Since writing the above, some diagrams (see Plate VI.) have been taken illustrating the pressures given out with hydraulic rivetting; they were obtained by means of an indicator specially constructed for the purpose, and will, in a great measure, explain themselves. The actual pressure exerted on the head of the rivet amounts in the case of the 3/4 inch rivet to 17 tons 13 cwts.; and in the case of the 7/8 inch rivets to 19 tons 3 cwts. The loss of pressure, as exhibited in these diagrams, when compared with the pressure due to the accumulator as stated above, is owing partly to its requiring a pressure of about 200 lbs. per square inch to overcome the friction of the indicator, which was only hurriedly constructed.

Comparing these diagrams with those obtained from the steam rivetting machine, they will be found to agree most nearly with these taken when the pressure of steam was at 40 lbs., though in excess throughout. And it is worthy of notice, in confirmation of the opinion expressed above as to the superiority of hydraulic rivetting, that while in the case of the steam rivetting the yielding of the holder-up amounted to about 1/2 an inch; in the hydraulic rivetting this yielding never exceeds 3/32 of an inch, a fact doubtless full of value in obtaining a perfectly secure union of the plates of the boiler.

These diagrams also seem to show that the pressure necessary to form the head previously to the compression of the plates is very small, in fact, is not shown on the diagram at all, so that in any case it cannot exceed 2 tons 18 cwts., which was the pressure found by experiment to be the amount required to overcome the friction of the indicator. This
compares very favourably with the amount found necessary to overcome the friction of the steam rivetting machine, which may be taken at about 6 tons. Thus, in the hydraulic machine the loss of friction in the machine itself is very small, and as the force necessary to form the rivet head must be a constant quantity in each case, the power thus saved is advantageously employed in compressing the plates.

(19)

NORTH OF ENGLAND INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING, SATURDAY, NOV. 7, 1868, IN THE ROOMS OF THE INSTITUTE, NEVILLE HALL, NEWCASTLE-UPON-TYNE.

GEORGE ELLIOT, Esq., President of the Institute, in the Chair.

The Secretary having read the minutes of the previous meeting, and reported the proceedings of the Council, The following gentlemen were elected

Members: -

R. P. Clark, 9, St. Mary's Terrace, Newcastle.

John Arkless, Tantoby, Burnopfield.

J. A. R. Morison, Nursery Cottage, Elswick Lane, Newcastle.

The Secretary then read the Report of the Committee appointed to investigate the Smoke Question.

After which, the President delivered the following

INAUGURAL ADDRESS.
Gentlemen, - During the sixteen years which have elapsed since our Institute commenced its corporate life, it has steadily advanced in position and importance until it has taken its place among the learned and scientific Associations of the country, and, as I venture to think, has become second to none of them either in its services to humanity in the past, or its capabilities of extended usefulness in the future. In addressing you for the first time as your President, I have the satisfaction of knowing that I shall meet with friendly sympathy and support, not merely in the brief sketch I purpose giving of the rise and progress of our Society, but in the proposals I have to make for what I believe to be the common good, - proposals which will be in strict accord with our original scheme, and which have for their aim augmented benefits and increased prosperity, not only to our profession, but to the community at large. The North of England Institute of Mining Engineers originated, as one or two of its older members will recollect, in consequence of a discussion which took place on 23rd June, 1852, between Mr. T. E. Forster, Mr. Matthias Dunn, Mr. T. C. Maynard, Mr. G. B. Forster, and some few other mining engineers, including myself, immediately after the inquest which followed upon the Seaton Colliery accident. The various viewers, and other authorities who had given evidence before the jury, were assembled together, and had, as was their habit, been debating as to the causes leading up to these terrible disasters, as well as the best means of preventing their recurrence, when it was proposed by your late President, Mr. Forster, and seconded by me, that the advantages we were deriving from professional argument and discussion should be extended to the rest of the coal-workers in the North of England; and that what had then the character of a friendly coterie should become a recognised body, working under fixed rules, and with aims which should be clearly defined. The title, the regulations, and the constitution of this Association were all settled that evening. Mr. Edward Sinclair, who was present, agreed to act as Honorary Secretary; and the present prosperous Society was established. It speedily found favour with all interested in the great mining operations of the country. It promised to supply a want which had not been felt the less strongly because it had not yet been publicly expressed; and in a few weeks from the inquest and decision I have adverted to, our Institute held a formal meeting, and its rules and principles were approved by the chief mining authorities of the day. We had the advantage of securing the services of our late friend, Mr. Nicholas Wood, as the first President, a position he occupied, until his death, to the great advantage of us all. His well-stored mind and habits of philosophic research were of infinite value to this Institute. It became as it were his favourite professional child. His studies were directed to its advancement, and much of his leisure was devoted to the same end. From the time of delivering his inaugural address in September, 1852, until he was succeeded by my immediate predecessor, Mr. Forster, in 1866, the Institution continued to expand under his fostering care, until, as your last President remarked on assuming the position I have now the honour to fill, it excelled all provincial associations both in the
number of its members and the extent of its range. Of my friend Mr. Forster's services I shall not in his presence presume to speak. You all know how cordially he has worked with you and for you; how he has given his best energies to the furtherance of the objects we meet here to promote; and how, on retiring from the chair, he hands over to his successor a Society which he has not only strengthened numerically, but which has gained in prestige and importance from the rule of one whose personal popularity is as well founded as his professional reputation is assured, and whose scientific skill is supplemented by practical experience of the most varied kind.

And now, Gentlemen, if we are asked what our Institution has done, and what it means to do, our best answer will, I think, be found in the published volumes of its Transactions, in the valuable theories launched under its auspices, in the scientific discoveries it has furthered, in the human happiness it has promoted, and in the human life it has preserved. It is impossible to over-estimate the value of the discussions which have taken place at its periodical meetings; and it would be difficult to praise too highly the exhaustive essays written by its members, and given to the world under the sanction of its name. I have often thought that the mining engineer is to the earth below what the astronomer is to the heavens above. He interprets signs and symbols which are "caviare to the general;" he has hopes and fears and interests which the multitude cannot share; and he prides himself upon the fact that scientific discovery lies only in the wake of honest, patient, and conscientious labour. It has been wisely said that there are only three kinds of men: the retrograde, the stationary, and the progressive; and I venture to claim for the profession of mining engineer that it is composed chiefly of the last-named class. Living, earnest, intelligent movement is necessary, not merely to our prosperity, but to our usefulness as professional guides. In all scientific pursuits men go back if they stand still; and in that which we are discussing now, it is our glory to make the goal of yesterday the starting-place of to-day. Working as we do in this spirit, Gentlemen, the value of our discoveries and inventions, and the scope of our Institution, are limited only by the extent of the civilised world. To take up a single volume of our Transactions is to find problems of momentous interest treated with judicial skill; to find the welfare and safety of the coal-worker occupying the anxious thoughts of men whose practical knowledge and long experience give their opinions authority and weight; and to become acquainted with subjects than which, as it seems to me, there are none more important to the future of England, none of greater value in the economy of the world. The young-professional man who makes these records his study learns how vast and numerous have been the strides taken in the art and practice of mining; and sees further how copious is the field of knowledge to be yet opened out. The present age has shown itself peculiarly favourable to discovery; and during the sessions before us, it is to be hoped that many of the subjects which have been explored, but not exhausted, will be treated again and again,
and that other topics of equal importance will be deliberated upon. Foremost among these is the preservation of the lives and health of those working underground. Nothing can be more important or more interesting to us than this. The ventilation of our mines, the advantages and drawbacks attending the old and yet common method of producing rarefaction by furnaces, as compared with the newer system of ventilation by the aid of machinery, is a subject claiming our earnest attention. The great depth at which many of our pits are worked, and the vast extent of their lateral ramifications, make it more than ever necessary that we should secure the best mode of rendering the supply of pure air certain, regular, and safe. It is maintained that ventilating by machinery insures these desiderata; that the nicety with which mechanical appliances may be regulated, the delicate adjustment of power of which they are capable, and the complete safety with which they may be worked, place them far before the system they are intended to supersede. The extent of our coal supply will be materially increased by the improvements of which this is a type. Public attention has been properly called to the duration of our coal-fields, and it is for us to consider how these may be beneficially worked so as to insure their material wealth being made fully available. The able and interesting inquiries of Professor Jevons, and the address delivered by Sir William Armstrong before the British Association in this town, are instances of the deep interest taken by scientific men, and by the public generally, in this grave question. The Royal Commission, of which I have the honour to be a member, has been most carefully constituted, and many of the most eminent scientific men of the day are serving on it. It has been busily engaged in investigating the entire subject, and I shall not presume to anticipate its report. Competent witnesses from all parts of the country have given, or will give, their evidence before that Commission; and I have satisfaction in believing that the extent of our coal-fields will be found to be much greater than was anticipated when the subject of their duration was broached. I have no hesitation in expressing my own opinion that the duration of our supply of coal depends in a great degree upon the scientific improvements we are able to make in our mode of ventilating the workings.

(23)

It is probable that the ordinary means of ventilation - whether by furnace or fan - may be aided by a change in the force or agency employed for the purposes of haulage and other underground work. As instance of my meaning, I may mention that the apparatus which I have introduced in South Wales, and which, by means of compressed air used as a motive power instead of steam, draws trams and pumps water with complete success, is found to generate ice in an atmosphere which is naturally hot and oppressive. The mechanical usefulness of these new air-engines seems capable of indefinite extension; while, as their cooling properties form a collateral advantage arising out of their use, it is at least possible that they may prove valuable auxiliaries to the more regular means of ventilation in extending the security and promoting the healthfulness of our mines. The difficulties of ventilation once surmounted, the extent of coal at our disposal is incalculably increased. The fields to be worked below the sea on our
east and west coasts, especially in the counties of Durham, Northumberland, and Cumberland, are in
themselves enormous, and will be for all practical purposes as entirely within the reach of the
mining engineer as the ordinary workings out of which coal is hewed. Geology indicates that in many
districts the coal-strata extend seaward ten or twelve miles beyond the shore; and it is my firm belief
that by sinking ventilating shafts in the German Ocean, the coal below it may be worked as safely
and certainly as it is beneath where I am now standing. Nor do I recognise any difficulty in the
transport of such coal. According to my estimates, it would neither be more costly nor more
laborious than it has been in days gone by to convey coal the same distance after it was brought to
the surface inland. You will readily see the enormous importance of this when I point out that, out of
the minerals obtainable in Durham alone, one-third may be held to lie under the sea; and, that all
coal fields having a similar inclination of strata and bordering on the ocean will be similarly enlarged.
This at once dispenses with some of the fears expressed as to the duration of the supply; and while I am
quite aware that these theories as to ocean-shafts and working under the sea may be challenged,
they are not put forward without due deliberation, and I am content to stake my professional
reputation on their practicability. Nor do I think that the views entertained as to the rapid
exhaustion of our inland coal fields should be hastily accepted as correct. No approximate estimate
can be formed as to the extent of coal yet unworked.

That lying under the Permian and New Red Sandstone has been comparatively untouched; and
according to my estimate but a very small per centage of our coal has been brought to the surface
during the hundreds of years we have been at work. In some districts, notably in South Wales,
scarcely more than one per cent, has been moved. If, therefore, we add the coal under the bed of
the ocean to that already at our disposal by known means, we find a supply which is more than
sufficient to allay the alarming fears which have been expressed. It is unnecessary to dwell upon the
national importance of this fact. The power, the wealth, the happiness of England are so intimately
connected with the proper working and adequate supply of a material to which so much of her
present prosperity and pre-eminence are due, that to pronounce upon the long continuance of the
supply is to open out new vistas of commerce, of enterprise, and of invention.

From coal itself it is natural to pass to the systems under which it is obtained; and here I have to
speak, not with censure, but with regret, of the modes still adopted by the majority of my fellow-
workers in the North of England. Few men have better right to think highly and to speak well of the
pitmen of this county. I know their wants, their trials, their temptations, and their sufferings - for the
best of reasons: I have tasted of them myself. Born in the midst of this great population of miners,
and associating and labouring with them from my earliest days, I am fully cognisant of the sterling
qualities by which they are distinguished; and that their industry, self-reliance, courage, and skill are
beyond praise. I would intrust to them duties the most difficult and the most arduous, confident that
what men could do they would do, and that in no other section of society should I meet more
thorough, more conscientious, and more resolute work. But in dealing with this branch of my
subject, I am compelled to judge and speak by results; and it is my experience - drawn not merely from Northumberland and Durham, but from the other coal counties of England and Wales - that the best means of working coal are not yet generally adopted in the North. The percentage of small coal is larger here than in almost any other district; the amount of large coal is not so great as might fairly be looked for from the quality of the material and the experience of our mining engineers. Furnishing, as we do, many of the leading men for all parts of the world in which coal is worked, it is to me a matter of grave regret that we have not yet accomplished the rudimentary art of adopting and holding fast by the most perfect method of working our own material. Elsewhere the long wall, the double stall, and several other systems have been tried with advantage; but here we have, with few exceptions, been content to run on in the old grooves, and the result is, that we have far greater waste than is at all necessary. I am the last man to advocate the running after things that are new simply for the sake of their novelty; but when statistics and analogy prove that other modes of working are attended with more practical advantages than our own, it behoves us to look closely into our daily practice, and to have the courage and energy to adopt improvements, lest our fame should be tarnished, and our laurels dimmed, merely because we have stood still while the world around us has advanced. But this is a subject which I trust will be discussed by the members of the Institution. No more valuable addition to our Transactions could be made than carefully digested facts argued out by experienced men, the conclusions from which should enlighten us as to the comparative merits of the various modes of working our coal. Fully aware of the difficulties attending any great change of system, I am yet satisfied that the experience, intelligence, and skill of my friends and neighbours, the coal-owners, and engineers of the district, and the goodwill of the workmen, are sufficient to enable those difficulties to be surmounted, and to give us a far more satisfactory result than we are attaining now.

My next proposition is of the utmost importance, for it aims at revolutionising the system under which coal is worked. It is simply that we should abolish the use of gunpowder in our mines, and by so doing reduce the number of deaths from colliery explosions to a minimum. For more than a quarter of a century I have steadily looked forward to this end; have upon all favourable occasions agitated the subject among my engineering friends; have tried divers experiments; and have watched and tested with earnest interest inventions which had the disuse of gunpowder for their aim. Nearly twenty years ago, while giving evidence before Lord Wharncliffe's committee, in the House of Lords, I had the honour of suggesting that the Government should offer a premium to any one who succeeded in making such discovery. It should never be forgotten that the existing necessity for the use of gunpowder is the fruitful source of colliery accidents; once abolish it, and the need for naked lights is gone. Safety-lamps might be devised which the pitmen could not open, and the grave disasters which it is one of the first duties of this Institution to guard against, would be diminished to an extent which it is impossible to look for now. Until this change is brought about, we
cannot hope for any material diminution in risk. At present, the phrase "safety-lamp" is a misnomer. No lamps yet invented are entirely safe.

A series of experiments, tried by the late Mr. Nicholas Wood and myself, several years ago at the Killingworth Colliery, showed us that at a certain velocity the flame passed all the lamps in existence, and until it is possible to send our men into the pits with enclosed lights and cases which are immovable, we shall not have grappled with the difficulties arising out of fire-damp and gas.

I have the best reasons for knowing the substitution of mechanical means for blasting by gunpowder to be fraught with difficulty; for, years ago, I, in conjunction with a gentleman of great mechanical and chemical knowledge, the late Mr. Hugh Lee Pattinson, held frequent and anxious conferences on the subject. The experiments we then made were not successful. We endeavoured to burst down the coal with quick-lime and other substances, but failed in every instance, owing to the slowness of the operation. I have tried, moreover, to force down the coal by hydraulic machinery, but failed also, through the water percolating into the coal and exhausting itself by that means. I have, however, the satisfaction of knowing that our labours have not been altogether lost, for their results having been sedulously made known among my younger engineering friends, they in their turn have brought their energies to bear upon the point, and with considerable success. I have recently seen three kinds of appliances for this purpose, some of which are being worked at this moment in my collieries in South Wales, and according to the latest reports - working well. My conviction is, therefore, that mechanical means will very soon make the use of gunpowder unnecessary; that lights which it is possible to explode will in consequence be banished from our pits; that our coal will be produced in a far better condition, as well as at comparatively little risk to human life; and that one great object of my professional career will be attained.

I now wish to remark, that, as a general rule, pits of a less depth than from 60 to 80 fathoms are almost free from gas; that at from 80 to 180 fathoms deep, gas is most dangerously prevalent; and that after the last limit has been passed, the workings down to even 300 fathoms again become comparatively pure. A feasible reason for this singular gradation is that, in the zone first named, the gas has a natural vent at the mouth of the pit, and by means of the various strata through which it can filter to the surface. At the middle zone, or point of greatest danger, the gas has not the same means of clearing itself, while that generated there is augmented by the gas ascending from the greater depths, and the aggregate amount stagnates, to the increased peril of those working in it. Another reason is, that the gas generated in coal at the lower
depths is increased in heat, owing to the additional weight of the superincumbent strata - a principle to which I shall presently refer. The heightened temperature causes it to expand and ascend, and so find its way to the middle distance, which becomes surcharged, through the vents not carrying it off with sufficient rapidity. And in my experience I have found that in this zone (80 to 180 fathoms), a sudden fall in the barometer produces a greater increase of gas than in either of the others; another proof how much more it is charged.

In corroboration of this, I may mention that so far back as 1856, I read a paper before this Institute, on the effects produced by working seams of coal above or under each other - the effect, as subsequent knowledge has taught, being almost the same. What I then stated has since been abundantly confirmed. In the zone nearest the surface the working of seams one above the other has not the same effect as in the other two. But by working seam over or under seam at the middle distance, and at the greatest depths of all, a wonderful improvement takes place in the condition of the coal. The lateral workings provide the gas the same opportunity of escaping as at the least dangerous depth. It finds its way through the strata from the opening out of the seams above and below, just as it does to the surface in the first zone. The result is that coal, which when it is first reached is soft and crumbly, becomes hard and firm, and workings which were originally surcharged with gas are made purer and more safe, as the seams above and below them are displaced. At Monkwearmouth, Usworth, and other deep pits the general improvement from this cause has been very marked.

We here see that the principle on which many of our colliery leases are granted is erroneous. These contain stipulations that all upper seams shall be worked first. But the clauses, designed as they are to preserve the coal and avoid loss, defeat the object in view. To work seam under seam and over seam concurrently, is advantageous both to lessor and lessee; it insures a purer atmosphere underground, and a better condition of coal, and therefore merits the advocacy of all interested in our coal-fields and the extent of their supply. And here let me distinguish between knowledge and hypothesis. The increased freedom from gas at the distances cited, and under the circumstances detailed, is a fact beyond dispute. But the reasons leading up to this state of things are put forth as a theory only, but as a theory based upon experience of the deepest workings in the kingdom, in all of which the state of the atmosphere at the different depths has been as I have described. Here, however, we have another matter, which it would be useful to discuss,

( 28 )

and I should be glad if our members would test for themselves the correctness of my assumptions. The fuller the argument and the more exhaustive the discussions upon all points of this importance,
the more useful will be our labours, and the higher will be the position taken hereafter by this Institution and its members.

Let me now call your attention to, and invite argument upon, a question which has long puzzled philosophers, and which has given rise to a vast number of ingenious theories; I mean the cause of the increase in the temperature below ground. The oldest belief is, that this is caused by a vast volume of internal fire at the earth's centre, which, as it is approached, naturally causes the heat to become more intense. Another view, and one widely entertained, is, that the pressure of the atmosphere produces the heat we have all experienced, and that the greater the column of air, the warmer it will be below. These are the two leading theories of the present day, but to me they both appear to be incorrect. They have been, as I think you will admit, conclusively disposed of by some observations taken at my request at Monkwearmouth, 1600 feet below the level of the sea, and in South Wales, where the coal is on a level with the sea, but where the workings are under a mountain 1600 feet above it. Of course, if internal heat were the solution, the first place would be hotter than the last, through being so much nearer the earth's centre. Again, if atmospheric pressure accounted for increased heat, the Monkwearmouth pit would have a proportionably higher temperature; for as the Welsh mine is worked laterally from the sea's level, it has 1600 feet less atmospheric pressure than the one first named. Instead of this, however, the thermometer shows precisely the same temperature at each pit; and, as I think, the plain inference is, that the heat of our mines depends solely upon the weight of the superincumbent strata, and not upon either central heat or the pressure of the atmosphere. The depth below the level of the sea, and the height of the mountain, put both places on equality in point of temperature. And, carrying the argument a point farther, it will be seen that by abolishing the theory of central heat we place our inland coal-working in a somewhat new light. If the amount of superincumbent strata be the true cause of subterranean heat, it follows that whenever we sink for coal, the height above the level of the sea we are likely to reach will have to be taken into consideration when estimating the probable temperature of deep workings. If, for example, we had to sink a pit as deep as Monkwearmouth, at a point from which the coal-seams run under mountains as high as those in South Wales, the heat would become increased in the ratio of the distance from the summit of the high ground, and would, therefore, be much greater than at Monkwearmouth, where the sinking takes place nearly at the sea-level. This opens out a new field of inquiry, and seems to favour my views as to the practicability of working extensively under the sea. But it is only right to add that the course of experiments from which this general law is deduced has acquainted me with exceptional instances, in which the temperature has not been so high under a mountain as its height would lead one to expect. But in all such cases I have had reason to believe that the apparent discrepancy between theory and fact could be accounted for by the exudation of highly-compressed gas from the strata. This was sensibly cooler to the touch, just as is the air which escapes from the high-pressure
pneumatic engines to which I have just referred. We thus see that some of our inland coal-fields are at a positive disadvantage with those lying untouched beneath the sea. For, if we take the sea-level as our starting-point, all deep workings will be found to increase in heat in proportion to their distance above it at the surface; an important consideration for those interested in sinking pits from high ground.

I pass now to a proposition which I have much at heart, and which I seriously think may exercise a beneficial influence upon the rising generation of mining engineers. It is simply that we should endeavour to amalgamate with the other Mining Institutions of the country, so as to insure a more general recognition of the importance and usefulness of our calling. By putting ourselves in official communication with the authorities of the Government School of Mines, and the great Associations of the Midland districts, of South Wales, and elsewhere, we might, I think, evolve a national scheme which, while preserving to each community that corporate individuality which is so valuable, would enable mining engineering to take high rank as a scientific profession, and its members to be more widely understood and appreciated than is the case. As the oldest and largest Institute of the kind, it would not be thought unbecoming in us to take the initiative, and, by inviting our brethren in other districts to discuss the matter on equal terms, we should, I am satisfied, end in working together to the advantage of all. Neither jealousy nor ill-feeling could arise out of a proposition to stand shoulder to shoulder for the common good; and there should be no difficulty in cementing a professional alliance which would insure considerable benefit to those joining in it. With this view I have recently been in communication with the Senate of the Durham University, and the leading members of the Institution of Civil Engineers, in London. It is my hope and belief that this Institution, and through it the profession generally, may be greatly benefited by the facilities to be obtained from both those distinguished bodies. The authorities of Durham University are laudably anxious to fulfil the great purposes for which it was originated, and their efforts to promote the cause of scientific education merit the warmest thanks of the mining engineer. The additions now made to its classes, and to the subjects taught, are strong evidences of a renewed youth, and will cause that foundation to render the same invaluable services to the students of the present day, which it has been the glory of our venerable colleges to bestow upon those of the past. At a time when the importance of technical education is generally admitted, when, as the interesting report of our own Technical Education Committee has just shown, we are agreed to co-operate with the Coal Trade Association in making the advantages offered by the Science and Art Department available for this district, and when the munificence of private enterprise in making endowments on behalf of technical education has received the approval and co-operation of the Ministers of the Crown, there is something peculiarly gratifying in the fact that so valuable a college as that of Durham should express its willingness to promote the objects of this Institution, and, by placing a portion of its prizes within the reach of our profession, provide an honourable reward for, and supply a valuable stimulant to, the industry of our youth. The provisions made by the University for education in
mining seem to me to be of an extremely liberal kind. The student who presents testimonials of good conduct, and certificates that he has been engaged in practical work connected with mining for a period of not less than two years, may matriculate after keeping three terms of residence in the University; that is, he may pursue practical work either as an articled pupil or a colliery viewer, and may then go up, and by studying steadily for eight months, fit himself for a public examination, and to compete for the prizes offered by the University. A sum of from £700 to £800 a-year is, as I understand, to be devoted to physical science, and will doubtless be apportioned into scholarships, any one of which will be open to the profession to which we belong. Nor does the liberality of the University - which it is cheering to know was never in a healthier condition, and never had more students at its classes than at this time - end here. It is not even necessary that the three terms of residence should be kept consecutively; a single term may be kept, and, should the student think it desirable, he may then resume his practical mining,

(31)

after which he can return to the University for another term, until the necessary period of eight months is made up, and he is eligible for examination and the competitions following on it. There are at present engaged in the mathematical and scientific courses of the University a professor of mathematics, a mathematical tutor, a lecturer in mining and civil engineering, a lecturer in chemistry, and a teacher of modern languages. The academical year extends over eight months, and a term consists of seventy-four days. There are few men of talent about a colliery, whatever their position, who could not, by industry and self-denial, spare eight months for such a purpose as this, so that the University is in practice opening a door to the entire community of practical coal-workers. The University Mathematical Scholarship and the Gisborne Scholarship are already open to students in engineering; and the Senate have the power, and I believe the will, to throw open to general competition several unrestricted scholarships. I have the best reason for knowing, further, that the University is willing to co-operate with this Institution in providing such other means of knowledge as may be thought desirable; and I have full confidence that when this fact is known, many members of our profession will avail themselves of the privileges offered. It is impossible to exaggerate the importance of this concession to the hard-working, capable mining engineer, whose experience has hitherto been of a practical rather than a scholastic kind. In no calling in the world is the lack of scientific education more severely felt. Without it, the most complete practical knowledge falls short of its aim; with it, no position is shut out from the intelligent and industrious aspirant. With ordinary application these eight months' study at the Durham University would fit most of our clever young men for positions which no amount of mere pit-knowledge would entitle them to look for, for there is in our calling a certain border-line or debatable land which the uneducated or the defectively educated have enormous difficulty in passing. The sterling qualities without which no mining engineer is fit for the trusts imposed upon him must be supplemented by scientific acquirement before he can hope for the first rank in his profession. I have in my life known admirable men kept back through the want of the very knowledge which the facilities I proclaim now would have within their grasp; and as a twelve-months' study may now be aspired to by any intelligent pit-worker - from the pony-lads upwards - who chooses to display energy, and exercise
self-denial, I hope to see the time when this term of University study is regarded as a necessary addition to the years passed below ground, or in the mastery of plans and workings

(32)

It will here be useful to remember that it is an Englishman’s pride to do for himself that which the citizens of many other countries have provided for them by their Governments. The centralisation I have proposed is of a strictly constitutional character. We should make our own laws, elect our own officers, devise the regulations under which professional honours are to be won, and prove generally that the mining engineer is not less capable of corporate self-government than the other professions of the country. The systematic course of instruction which would naturally grow up in course of time would be less elaborate, but perhaps as practically useful as that given in the state schools of Paris and of Freiberg.

No branch of physical science - and it is physical science which the University of Durham unites with the classes for mining and civil-engineering - but must be useful to us. The complex duties of our profession, the emergencies certain to arise, in the course of which scientific knowledge is indispensable, make it impossible to ignore the fact that in the competition of the future the uneducated man will be left far behind. There is, of course, much to work out before the connection which I have shadowed forth between the University and our Institute becomes stable and defined; but with a generous disposition for increased usefulness on the one hand, and a judicious appreciation of the benefits to be gained on the other, we may fairly anticipate a time when both Societies - representing as they do, different ages and types of usefulness - shall work in complete unison for the common good. We have seen the effects of this co-operation in the medical school established at Newcastle, and there is no reasonable doubt that the advantages enjoyed by the students of medicine may be shared by those who adopt mining engineering as their profession, and who make proficiency in it the steady business of their lives.

Having endeavoured to show how the engineers of the future may have their studies elevated and their usefulness increased, I have now to offer a suggestion to which I have given equal thought, and which may, I trust, receive the approval of those whom I may term the full-grown members of the profession. It is simply that we should endeavour to co-operate with the Institution of Civil Engineers of London, and, by affiliating ourselves with an Association whose reputation is world-wide, obtain a professional recognition which would be of the greatest value to our members. The Association of Civil Engineers is, as you are doubtless aware, a body possessing a Royal Charter and other privileges, and having the power of conferring various degrees of professional rank upon those obtaining its certificates. None of the learned
societies occupy a more prominent position in the scientific world. It has been presided over by the
most eminent modern engineers; its corresponding members date from all countries; its periodical
meetings are referred to with approval wherever engineering matters are discussed, and its annual
conversazione is regarded as one of the most brilliant of the London season. Such men as
Stephenson, Rennie, Brunel, and, more recently, Hawkshaw, Bidder, McClean, Fowler, and Charles
Manby, have presided over it, or taken an active interest in its welfare. The papers read at its
periodical meetings are followed by discussions, which are absolutely free. It is open to all members,
and to the friends they introduce to these meetings, to question and to examine every statement
put forth; and the Institute offers many other advantages for study and improvement, besides
confering upon its associates professional privileges of the highest value. It would, I think, be a
satisfactory mode of elevating our profession, if we could, whilst maintaining our independence,
graft ourselves upon this great Institution in such a way as to share the advantages it gives. Having
now had the honour of being a member of it for many years, I can personally testify to the great
benefits to be derived; and having recently conferred with several of its leading and most thoughtful
men, including some of those who have filled its chair, I am able to speak hopefully as to the
possibility of this Institution being recognised, and of its members being admitted upon some
footing to be hereafter arranged. I purposely confine myself, as in the case of the Durham University,
to putting forth a suggestion rather than developing a plan, and I make no doubt that some of the
gentlemen present will give the matter their candid consideration, and that the hints thrown out will
be adopted or rejected upon their merits. If the benefits to be derived are in both cases as
substantial as I believe, I trust we shall soon see both university and professional honours brought
nearer to the mining engineer.

And now, Gentlemen, I have almost done. I promised in the outset that such proposals as I made
should be in conformity with the spirit in which this Institution was commenced; and while you have
listened indulgently, I claim to have kept my word. Our valued friend, the late Mr. Nicholas Wood,
in the course of the speech he made at the opening of this Institution, defined its object to be, first,
to so concentrate professional experience as to avert or alleviate the dreadful calamities following
upon accidents in mines; and, secondly, to establish a literary society, by means of which the theory,
art, and practice of mining should be fostered and understood. Passing, then, from the suggestions
opened out by recent discoveries, and from our speculations

as to future modes of working, let us glance at the position of a mining engineer, and consider how
far, by the fusion of the several Institutes in existence into a national union, he may hope to elevate
his profession in the social scale. By this I do not mean that he should aim at being grander, but
better; not more self-conscious, but more useful; and, as I think, education for himself and
recognition by the world are the things most needed for these ends. I have seen it asked, "What is it
to be a gentleman? Is it to be honest, to be gentle, to be generous, to be brave, and to be wise? Ought a gentleman to be a loyal son, a true husband, an honest father? Ought his life to be decent, his tastes to be high, his aims lofty and noble?" In some such spirit would I like the question to be asked, "What is it to be a mining engineer?" Is it to become reverently acquainted with the secrets of Nature? Is it to show courage, wisdom, and tact in dealing with grave scientific problems, and in the discharge of the delicate duties pertaining to all called upon to be leaders of men? For it should never be forgotten that the example and precepts of those in charge of our pits exercise an enormous influence for good or evil. Show me a community of miners, and I will tell you the character of their chief; let me see their daily habits, and I shall form my estimate of his. For the refining influences of education, and the moral elevation attained by an earnest, conscientious, God-fearing spirit in the colliery viewer, are attended with marvellous results upon the character of those working under him. It is a grave error to suppose that coarse language or a rough demeanour is effective or necessary in dealing with our pitmen; firmness and discretion, accompanied by urbanity and knowledge, have, on the contrary, infinitely more effect than the most violent arguments or the roughest mien. I have seen mild, soft-mannered men carry their point with miners by sheer tact, when other and rougher means had brought matters to a standstill.

It is my happiness to know that the social and moral condition of the working miner has been vastly improved during the present generation, and that his amusements and daily habits may be compared with advantage with those of other members of the community. This has been mainly brought about by the different ways in which he can now spend his leisure; and I am a strong advocate for the extension of all means of harmless recreation. Cricket-matches and out-of-door sports generally, as well as reading-rooms and in-door games, are, I am glad to say, gaining ground rapidly in our pit villages; and amusements which were formerly confined to the privileged classes are now warmly appreciated by men who would not have even heard their names when I was a boy. I regard this with as much interest as I do well-ordered discipline in working hours, and am satisfied that it is for the best interests not merely of the coal-owner and the mining engineer, but of the men, that a taste for innocent amusement should be fostered to the utmost. These are points upon which common sense tells us we should take a liberal view. The life of the working pitman is at best a hard one - those who have filled the position only know how hard; and it rests with the coal-owner or engineer under whom he labours whether its alleviations shall elevate or degrade. The sympathies of the employer react upon the men, and the habits of the men follow the tastes and character of the employer, the sum-total of human happiness and human good being diminished or increased in regular proportion.

Let us, then, Gentlemen, in estimating our profession, and in seeking to gauge its future, be true to each other and ourselves. Let us regard our discussions as means leading to a great end. With the advantages open to us in the present day, it is surely not too much to hope that this Association may
join with its neighbours and assume a national title and character. The time is long passed for our objects and aims to be even nominally limited to a province or to a district. The United Kingdom itself need not represent the limits from which the mining engineer may select, or the interests to which he is to look. I submit, therefore, for your consideration, that we should look forward to the title of our Institute taking a national rather than a provincial form; and that when the words "Great Britain and Ireland" have been substituted for "North of England" in our papers and documents, that a corporate connection with the Institution of Civil Engineers should be looked for; that the scholastic advantages offered to us by the Senate of the University of Durham should be secured; and that we should thus follow to their legitimate conclusions the principles we are united together to uphold, and the aims it is our first duty to promote. Believe me, the knowledge and skill of the physician, the chivalrous bravery of the soldier, the gentle charity of the priest, the far-seeing toleration of the philosopher, might all find an ample field for their display in the regular duties and professional emergencies of our career. No vocation can be more useful, more worthy, or more honourable; there is none which we could follow with more advantage to others, or with greater moral and material benefit to ourselves. The teaching of our profession is as varied as it is endless; and the wisest and best among us has but to strive humbly for wisdom to comprehend and strength to improve upon the lessons of his daily life, to become not merely a more skilful miner, but a more useful citizen and a more worthy man.

(36)

[Page 36 is blank.]

(37)

REPORT OF THE COMMITTEE

appointed by the

NORTH OF ENGLAND INSTITUTE OF MINING ENGINEERS,

to investigate the

SMOKE QUESTION.

OCTOBER 24th, 1868.

On the 26th day of March last, Mr. Galloway having explained his views before a special meeting of the Steam Collieries Association, the subject was referred to the Institute, which at a meeting held on the 4th of April heard the views of that gentleman. On the 2nd of May the discussion of the
subject was again renewed, and the matter referred to a Committee, who now beg to hand you their Report.

They cannot, however, forbear remarking that there is really very little left for them to do. A few years ago, in 1855, there was an impression that the North Country steam coal not only made smoke when burnt but was of an inferior evaporative power to that of the so-called smokeless Welsh coal. Since then, on two subsequent occasions, this has been proved most satisfactorily to have been an error. In 1856-7 experiments were made at Elswick, conducted by Sir William Armstrong, Mr. J. A. Longridge, and Dr. Richardson, which fully demonstrated that Hartley could give without smoke 12.9 lbs. and Welsh 12.35 lbs. of water evaporated from 212° per pound of coal in an ordinary marine boiler; and, in 1864, Mr. Miller, at the request of the House of Commons, made a series of experiments which proved again most satisfactorily that Hartley could give without smoke 10.68 lbs. and Welsh 10.13 lbs. of water evaporated from 100° per pound of coal. Again, at Wigan, in 1867, Messrs. Fletcher and Dr. Richardson conducted a series of experiments proving most conclusively that a bituminous coal more difficult even to manipulate in the fire than the coal of this district, can be economically and smokelessly consumed. All these results have been accomplished with the smallest possible alteration of the furnace and bars of ordinary marine boilers. Your Committee, therefore, have from many and various sources the highest authority for stating that, as far as experiments can do so, the question is practically solved, and more particularly in connection with any ordinary quality of round coal, and in Cornish or marine boilers of ordinary construction. It could hardly be expected that any further experiments would produce better or more conclusive results, or be attested by gentlemen of higher reputation and position.

Your Committee would also call attention to the great expense attending such experiments. They think it quite out of the province of the Institute to provide funds amounting to many hundreds of pounds, to enable them to go over the same ground that has so often been trodden before, and with such conclusive results.

Believing as they do that the semi-bituminous steam coal of this district can be burnt without smoke, so as to give as high, if not a higher and more speedy evaporative power than Welsh (as might be expected by its chemical composition), your Committee can by no means aver that this important fact is comprehended by the great bulk of consumers; but they are not of opinion that any further experiments in this direction are necessary, as it seems to them that data on this subject are so numerous already, that the public may very properly be left to draw their own inferences therefrom.
If your Committee were asked for the reason for so much incredulity on a subject so important to the interests of the northern coal owners, they would suggest that it to a certain extent arises from the fact that the steamships built in the neighbouring ports are not, as a rule, by any means successful either in their attempts to prevent smoke, or to obtain the highest results from the fuel of the district. These steamers, going from port to port, and from country to country, assist in advocating the views of those who refuse to recognise the value of the northern steam coal, and your Committee regret that the boilers of these ships at least are not constructed so as to bear out the results so laboriously obtained at such large cost.

With regard to land engines, the same remarks apply to all boilers fired by hand with round coal. A new element, however, appears here, when we come to mechanical stoking, which seems to present many and great advantages over hand stoking. Researches in this direction are not so plentiful as in that of hand firing, and few, if any, have been published; in fact, there is still a field open for experiments with self-

( 39 )

feeding furnaces, and with the egg-ended boiler of the district. Your Committee are glad to find that several members are now engaged in a series of elaborate and extensive experiments on self-feeding furnaces, some of which were nearly ready for being brought before you at the meeting at Seaham. These experiments are being continued and extended, and will shortly be read. Under these circumstances, your Committee suggest that nothing further should be done in this direction until these papers are received.

Since framing the above Report, your Committee have inspected the self-feeding furnaces at the water works at Durham, and at Mr. Henderson’s factory, where to all appearance, as far as regards the prevention of smoke, they seemed to be working satisfactorily. By this they are strengthened in their opinion that there is a legitimate field open here for further experiment, in reference to the use of large coal in such furnaces, especially as to the adaptability of the process to the purposes of navigation, which they trust the association, at whose instigation this Committee was formed, will take advantage of.

(Signed)

G. B. FORSTER,
For the Committee.

( 40 )

[ Page 40 is blank. ]

( 41 )

NORTH OF ENGLAND INSTITUTE
of
MINING ENGINEERS.

GENERAL MEETING, SATURDAY, DEC. 5, 1868, IN THE ROOMS OF THE INSTITUTE, NEVILLE HALL,
NEWCASTLE-UPON-TYNE.

G. B. FORSTER, Esq., Vice-President of the Institute, in the Chair.

The Secretary having read the minutes of the previous meeting and the minutes of the Council, the recommendation contained therein, that books to the value of £25 be presented to Mr. Emerson Bainbridge, as an acknowledgment of his services as Engineer to the Tail-rope Committee, was put to the meeting and unanimously adopted. The following gentlemen were elected:—

Members : -

H. H. Bolton, Newchurch Collieries, near Manchester.

John Batey, Benwell Colliery, Newcastle-upon-Tyne.

A. Harkness, Birtley Iron Works, Fence Houses.

Cornelius Widdas, North Bitchburn Colliery, Howden, Darlington.

Thomas Hepplewhite, Hetton Colliery, Fence Houses.
A paper was then read by Mr. Nelson on the "Mechanical Stoking of Steam Boilers."

The Chairman stated that they were exceedingly indebted to Mr. Nelson for his paper. At this particular time it was a subject of deep interest to the Coal Trade of this district, and if mechanical firing could be successfully carried out both by land and sea, it would mark a new era in the use of coal. It was, however, only by repeated and careful experiment that practical results could be obtained.

Mr. W. Boyd observed that the question opened out by Mr. Nelson was one of the greatest importance to all, and especially to those concerned in steam navigation, and he watched its progress with considerable interest and with many hopes that mechanical firing would ultimately supersede hand stoking at sea. At the same time he could not conceal from himself the fact that much had yet to be done. Mechanical stoking to be effective on board ship, must not only save hands and render the products of combustion invisible, but must get the same amount of calorific value out of the coal as at present, and at an equal speed, and that without materially enlarging the area of the fire grate or the space given up to the stoke-hole, for every thing on board ship had from the necessities of the case to be constructed so as to obtain the very highest possible results in the smallest possible space, and no amount of saving in labour would counterbalance the loss of any of the advantages now enjoyed. He was not so competent as others to enter chemically into the perfect combustion of fuel, but his experience had taught him that a free and adequate admission of air in quantities proportioned to the composition of the various coals burnt was required for perfectly and entirely consuming it, which in other words meant producing a clean chimney top. If, while not obstructing the air, the fuel could be evenly and uniformly distributed over the grate in the proportions called for by the exigencies of the case by mechanical means, he thought that success was not far off. But while admitting the great value of mechanical stoking, he begged leave to differ from Mr. Nelson in his remarks on hand stoking. With some opportunities of investigating the question he unhesitatingly asserted that with proper furnaces, and firemen of only moderate ability, they could smokelessly obtain the highest possible
calorific value from any coal at the utmost attainable speed; he could state from his own personal experience, that the steam coal of this district could be so treated, and he saw from the experiments of Messrs. Fletcher and Richardson, made lately at Wigan, that a still more bituminous coal had been so treated by hand firing, and he would advise those interested in the question of mechanical stoking not to ignore these results but rather to endeavour to realize them, which he was afraid they had not yet succeeded in doing. It appeared to him that Hall and Whitaker's furnace was more likely to suit the requirements of steam navigation than Juckes', and he thought that the Institute should be in possession of reliable data of the results obtained at the Lambton collieries, where he understood these bars were used. In conclusion, he would ask Mr. Nelson, who he conceived, had had considerable experience in the manufacture of mechanical stoking apparatus, what would be the comparative cost between Juckes' rotating bars and those of Hall and

(43)

Whitaker's, which only had a sort of undulating motion given them? Also, he would ask if he was correct in understanding Mr. Nelson to state that the largest quantity of coal that could be consumed per hour per square foot of grate in Juckes' furnaces was 32 lbs?

Mr. Nelson in reply stated, that the expense of Juckes' system would probably be twice that of Hall and Whitaker's. He did not state that 32 lbs. of coal per hour per square foot of grate was the limit of quantity that could be satisfactorily consumed by that system, but that he had repeatedly burnt that quantity per square foot in a Juckes' grate, and that not under the most favourable circumstances.

Mr. W. Boyd remarked that it was usually considered that the most rapid combustion possible was obtained in steamboat furnaces, and rarely reached 24 lbs. of coal per hour per square foot of grate, and he would think from his knowledge of the working of several mechanically stoked furnaces that their results were far below this.

Mr. Nelson in explanation stated that he considered the 32 lbs. per hour per square foot of grate quite an average case, the coal used was analogous to the steam coal of the district, but was small and contained a considerable portion of duff. He did not deny but that coal might be smokelessly burnt by hand firing, but thought that under any circumstances, even the most favourable, much waste of heat must be caused by the necessity of the stoker having to open the fire-door so often, the cold air which entered at these times was also most injurious to the boilers. With regard to the cost, the gear for giving motion to the bars would cost about the same in either case, but the cost of the furnace part of Hall and Whitaker's would scarcely reach one-half that of Juckes'. It must be borne in mind, however, that Juckes' arrangement by having three times the length of bar employed than that on which combustion is effected, and constantly presenting a fresh portion of the bars to the action of the heat, would, therefore, last fully three times as long as Hall and Whitaker's.

The Chairman observed, that although, doubtless, both Juckes' arrangement as well as that of Hall and Whitaker's could be applied to steamboat boilers, he thought that the latter was the more suitable of the two to that particular service.
Mr. Boyd stated that Messrs. Palmer of Jarrow had fitted two boats, the "Colorado" and "Nevada," with bars the invention of Mr. Jordan of Liverpool; he had not yet seen them, but he understood that they were very much like those of Hall and Whitaker, but had provisions made in them to hold loose pieces where the heat was greatest, which pieces could be replaced when worn out.

(44)

Mr. Tweddell stated that these bars were, as Mr. Boyd had observed, similar to Hall and Whitaker's, they had been first used on board the "Manhattan," in three or four of her furnaces, and were a success, and the whole of the furnaces, sixteen in number, in a similar steamship were being fitted with them; and a sufficient proof of the confidence reposed in this arrangement after the preliminary trials in the s.s. Manhattan, was given, when they trusted such a valuable ship on a long voyage with no other means of generating steam. Juckes' revolving bars had been also fitted into marine boilers previous to Mr. Nelson doing so, but hitherto without success. He thought the number of pieces and the complication of the fittings of Juckes' furnaces were much against their adoption on board ship, and should any accident happen to the bars and they should drop down, the difficulty of replacing them by ordinary bars under the exigencies of the service would be very great, and prove, he feared, an insurmountable obstacle to their introduction, whereas the arrangements of Jordan and Hall's admitted of being worked as common bars should the driving gear fail.

Mr. Boyd would ask if Hall and Whitaker's had been placed on board any steamer?

Mr. Whitaker replied that more than twenty had been fitted with them.

The Chairman thought that this description of bar offered great advantages for steamboat boilers, since they could be taken out and replaced so readily, and if anything happened to the machinery working them, they in fact became common bars capable of being stoked in the ordinary manner without delay of any kind.

The Secretary remarked that he could not consistently with his duty to another association allow certain remarks of Mr. Nelson's to pass without observation. With some knowledge of the subject, he emphatically asserted that the semi-bituminous steam coal of this district could be smokelessly burnt in ordinary furnaces by ordinary stokers, if the general proportions of these ordinary furnaces be conformable to the peculiar character of the coal; and there can be no doubt but that, losing sight of this great fact, has done considerable harm to the steam coal owners of this district. Their friends who come to assist them in overcoming an evil which never existed, also do immense harm by exaggerating and inventing difficulties so that the value of their suggestions might be enhanced. What has been the result of all these experiments and contrivances which have been resorted to since the unfortunate moment when it was supposed that this valuable coal was defective in so important a quality? Have they not served to prove, over
and over again, notwithstanding the high premiums that have been offered to those who could improve it, that the coal does best when let alone? Why should they seek to improve that which only requires its qualities to be recognised by those whose interest it is to do so in order to realize their most sanguine desires? This seeming admission of its friends that the North Country coal had a visible defect, was one of the greatest obstacles that had to be encountered at Devonport. At the conclusion of each day's experiment, it was taken for granted that the Welsh coal had made no smoke, and that the North coal had; of course the experiment over, the smoke of both had vanished, but the prejudice remained, and it was with despair that the speaker sought some means of recording, not his own, but his opponent's smoke. But as soon as the happy thought of registering the smoke marks each minute occurred to him, the Merthyr Dale smokeless the day before was found to have 100 smoke marks attached to it, while the Hartley got through its day's work with 29; from that moment a new impulse was given to their exertions, which culminated in the Government officers getting 10.71 lbs. of water per pound of Hartley, with a speed of 43 cubic feet of water per hour, and burning 24 lbs. of coal per square foot of grate per hour, with 3.4 smoke marks per hour; the very best Welsh result being 10.14 lbs. of water per pound of coal, with a speed of 38.6, and burning 23 lbs. per square foot of grate per hour, with 3.4 smoke marks per hour, thus gaining an advantage of 5½ per cent. in calorific value, and 13 per cent. in speed over the Welsh, with an equally smokeless result. Considering that 3.4 smoke marks per hour mean, that for three-and-a-third minutes during that space of time, only the faintest possible trace of smoke was visible, and 360 being the highest possible mark that could be recorded, the difference in per centage between 3.4 and 3.1 is, therefore, practically imperceptible, both results being, to all intents and purposes, perfect. What is the use of any special apparatus after this? From the experience gained by these experiments, the owners of this valuable mineral are in a position to decline all suggestions, having for their object the removal of a defect it does not possess. On a recent occasion, when it was urged before the Lords of the Admiralty, that after such satisfactory experiments the Government were treating the coal with the same injustice as formerly, the speaker could not avoid the remark, that in reality the injustice was considerably greater; for apart from the question of smoke (which may be considered as greatly affecting both coals), at the former period referred to, the calorific value of the North coal was considered to be inferior to the Welsh, and that, therefore, the use of it would involve an extra expense on the nation; but now it is admitted by their own officers that the North Country coal had a higher calorific value and a very much greater speed than the Welsh, this argument is reversed, and the nation is actually mulcted to the advantage of the Welsh coal owner. The speaker did not for a moment mean to aver that mechanical stoking on board steamers would not be a very great advantage; on the contrary, it was calculated to accomplish very important and economical results, and he was very glad that Mr. Nelson had specially applied himself to the question, which, in such able hands, cannot but be brought to a successful issue.

Mr. Waller would support the previous observations by the remark, that he knew a boiler with four ordinary furnaces that was very hardly stoked with Peases' West Hartlepool waste coal, without any smoke being produced, and would further state that he had seen several cases reported in the papers where the owners of Juckes' furnaces had been fined for producing smoke in the
neighbourhood of Halifax. Mr. Waller also gave the result of his experience with one of a set of four plain cylinder egg-ended boilers, 40 feet long by 4½ feet diameter, with ordinary bars about 5 feet long, hand-fired. It was found to evaporate 50½ cubic feet of water per hour, and the result was about 8 lbs. of water per 1 lb. of fuel. The fires were 18 to 20 inches thick - the fuel very small Pease's West, and the above result was attained without smoke. As the ashes were not thrown up, the residue was (instead of 11 per cent.) increased to about 30 per cent.

The Chairman observed that all these facts and many more that had come under his observation proved undeniably that the coal of this district could be burnt smokelessly, either when simply laid on by hand or by any mechanical process.

The Secretary, in answer to a question by Mr. Tweddell, stated that the loss arising from 3.4 smoke marks might be broadly stated thus: - Hartley coal making, say 100 smoke marks per hour evaporated 8 lbs of water per pound of coal, while the same coal, with 3.4 smoke marks, evaporated 107, the difference of 96.6 smoke marks, losing 2.7 lbs. of water; each smoke mark might, therefore, in rough numbers be assumed to represent a loss of .03 lbs. of water; 3.4 marks would thus give .102 lbs. of water, and absolute perfection might raise 10.7 to 10.8.

Mr. Whitaker observed that for sixteen years he had advocated mechanical stoking, but must confess that he had never seen any system that could equal hand stoking in its results.

The Secretary—That really was the whole secret of the question;

the 10.7 calorific value must be kept up, and the 24 to 30 lbs., burnt per square foot per hour, or mechanical stoking would never be a success on board ship; added to this, the furnaces must be so that they could be instantly adapted to hand stoking on any emergency arising.

Mr. Nelson observed, that at present the results had not been uniform; in many cases more steam had been generated by the introduction of mechanical stoking, and in other cases less. And, in answer to a question by Mr. Bunning, stated that the bridges of Juckes' furnaces, if properly constructed, lasted 18 months; that the doors would last even a longer period, but that sometimes the fire crept under them and burned the coal in the hopper, but this only occurred when the draught was bad.

Mr. Goodman - There are some cases where you have not found the furnace answer so well, probably when burning a caking coal. Mr. Lawrence, formerly at Walker, by making the end tumblers of different diameters causes the chain to travel at an unequal speed, by which he tries to prevent the coal from caking. With regard to Mr. Whitaker's furnace, he would ask for what purpose are the bars thickened at the end.
Mr Whitaker - It is to allow for the different sizes of coal.

Mr. Goodman - Is it of any use? Would it not collect the whole of the slag?

Mr. Whitaker - It is only half an inch higher than the rest of the bar.

Mr. Goodman stated that at Walker Iron Works he had been trying a different description of bar. He wanted to get a breaking-up action of coal as well as a moving forward action, and he found it succeeded admirably for the first fortnight or three weeks, but ultimately the bridge got, as it were, completely smeared over with slag, which adhered to the bricks, and proved a serious obstacle, by stopping up the opening, which was only six inches wide; and not only that, but after the first fortnight there was a great hollow burnt in front of the bars, which were of ordinary metal, and indeed, generally, the action of the fire was most severe on the bars, and he found them invariably burn away. He fancied the same action would take place in Whitaker's. Might he ask Mr. Whitaker what he had air-doors for?

Mr. Whitaker - We have no other way of getting air in to keep the door cool.

Mr Goodman said he never let an atom of air in from above the bars, nor had he an atom of smoke. He made bars half the ordinary thickness, and got a more diffused motion. The action of the whole

( 48 )

of the air is under the bars, a deflecting brick arch is thrown over the hottest part of the furnace, which serves to bring the gases generated from the green coal into close contact with the incandescent fuel at the after end of the furnace, and this entirely prevents any smoke from the chimney. He had been experimenting with it quietly for three or four months, trying to bring out something to improve the system of mechanical firing and prevention of smoke. The great objections to Juckes' were its expense and complication. Supposing one of Juckes' should break on board a vessel, how would you repair it? Whitaker's is different. There you could take a bar out and replace it with another in a moment. He had met with a case where there were three boilers working, but the boiler came so close to the wall that there was no room left for Juckes' to work, as it required a pit. Juckes' he fancied was altogether too complicated to come into general use in steamboats. There is another arrangement, in which instead of the chain of bars being fixed at both ends they were only fixed at one end, and they turn over and clear themselves, and also accommodate themselves to the circular form of the flue - these nearest the side lying nearly flat. This was as bad and as complicated in its arrangement as Juckes'. He had been trying a plan which worked beautifully if he could only get the metal to stand, but the bars were burnt hollow in two or three months. Then he tried to cure this by putting a loose piece into the bar. Instead of replacing the whole bar, he replaced (in weight of metal) about one-sixteenth. This he thought would have
been a success, but he found that as soon as the heat came on it the bar split down wherever the fresh piece was put in.

The Chairman - These disadvantages would apply to Whitaker's, Jordan's, and all of them.

Mr. Tweddell said, all the difficulties of detail which had been raised by the previous speakers could be easily removed, but he thought the Society should wait the result of the trial of Juckes' furnace, with Mr. Nelson's experience brought to bear on it. Jordan placed in his furnace a wrought-iron bar which did not split. Mr. Goodman wanted some material that would stand fire. Jordan provided for the application of an incombustible material instead of metal - such as fire-clay, ganister, etc. - and bolting it on to the wrought-iron bar. This was an arrangement in which he had every confidence. There was nothing to prevent its answering. He should like to hear of the steamers that were using Whitaker's furnace, so as to compare the results with those of other boats that were using Jordan's and other furnaces, since they are stated to have answered well, and the results will be of value.

(49)

Mr. Whitaker said the first time their bars were used was in the "Sirius" in her first voyage to Liverpool. Afterwards they were used in the "Royal William." Mr. Hall had spent a life-time and all he possessed in bringing out these experiments. People thought him too far in advance. They must remember that his patent expired three years ago. He did not suppose it would have been brought forward on this occasion if Mr. Goodman had not tried it at Walker. Mr. Goodman had fulfilled every condition that Hall and Whitaker did at the time.

Mr. Goodman said when he introduced these bars he was not aware that they were in use elsewhere. His was certainly not a copy, though Mr. Whitaker's furnace nearly assimilated to his.

Mr. Boyd here moved an adjournment of the discussion, which was agreed to; and thanks having been voted to Mr. Nelson for his paper, the meeting broke up.

(50)

[blank page]

(51)

ON MECHANICAL STOKING OF STEAM BOILERS.

Read by JAMES NELSON, Sunderland.
In considering this subject the writer divides it into three parts.

The first bears on Mechanical Stoking, as a means of substituting machinery for hand labour of the most menial, and laborious description.

The second and third parts relate to the economy of fuel and the prevention of smoke, which are the results of proper firing and of proper firing only.

With so many proofs before us, of the superiority of mechanical appliances, (both as regards the economy and the quality of the work done,) wherever they have replaced the arms and sinews of human beings, it seems extraordinary that at the present day whenever the very first operation common to every user of steam power, the first step in preparing to draw coals from the pit, pump water, manufacture, or navigate by steam, the prima causa, the first work to be commenced, the last to be left off, the labour which must never cease from Monday till Saturday, or in case of a sea- voyage from the beginning to the end, the labour which forms a standing expense in every commercial undertaking, namely, the stoking of boiler fires, should be now in the year 1868 almost exclusively performed by hand.

Before beginning to describe or discuss mechanical stoking it is necessary to particularise the desiderata in proper firing, which may be considered as first, to put a small quantity of coals on at a time, and to do so frequently (the fewer at once, and the oftener, the better). Secondly to put the coal on the front of the fire, and when partially burned, to push it back, and throw more on. Thirdly to conduct the whole operation with as great regularity as possible. Fourthly to make the furnace of Proportionate size to the quantity of steam it has to generate in the boiler above it, and fifthly by practice and experience to determine what amount of coal can be perfectly and economically burned upon the furnace in a given space of time - since neither more nor less than that amount of fuel should be supplied to it.

All the foregoing remarks seem to indicate that a machine is required to do this work.

The boiler should of course possess adequate steam room, to allow for such trifling variations of the engines, as occur in drawing coals, and the intermittent strokes of a pumping engine, or such like.

If the supply of coal to the furnace is less than the proper quantity the steam will of course fall, or if more than the quantity goes into the furnace it will either be improperly burned, or generate more steam than is requisite. The only plan to ensure this regularity, is by making a machine entirely self-acting in all its parts, which will supply the coal to the fire, and also carry or push it forward, and
distribute it. Of these, machines, the writer will only describe two, both of which have been invented, and been before the public for many years, and the patents having expired, they are free to be manufactured by any one, and no impediments such as royalty charges or dues can be levied on consumers.

The first is Juckes' revolving furnace, which may be described as an endless-chain of flat links of iron (cast or wrought) in breadth equal to the breadth of the furnace, passed over tumblers at each end and supported through its whole length by rollers or other means. The coal is supplied from a hopper outside, and is carried into the furnace, by the motion of the chain revolving, the quantity being regulated by the speed of the chain, and the height of a sliding shutter which takes the place of the fire door. The ashes and slag are passed over the back by the motion of the chain. The speed of the bars and the thickness of coal-feed should vary for almost every description and size of coal, and condition of draught, and it is no use trying to lay down any rules. Perhaps 8 feet per hour may be said to be an average speed, although the writer's experience would indicate that a variation of speed of from 5 up to 18 feet per hour is necessary to suit different classes and sizes of coal, and that generally the smaller the coal the thinner should be the fire, its thickness varying from 1½ to 8 inches.

The second invention is the furnace of Hall and Whitaker. In this arrangement the fire bars are made reaching the full length of the furnace, the front ends are moved with cams or eccentrics, which are placed side by side on a shaft reaching across the front of the furnace, every alternate cam being placed opposite the other. The back ends of the bars slide forwards and backwards on a slab plate. The eccentric or cam shaft, is turned round by a rachet or belt, and suitable gearing connected with the engine or any other source of motive power. The action of the furnace is as follows, while one half of the bars are rising and

( 53 )

thus taking the weight of the fire upon themselves, they advance and carry the fire with them, the other half of the bars during the same time fall, recede, and in their turn come round, raise and propel the fire towards the back of the furnace, where there is a flat space on to which the ashes or cinders are delivered, and upon which they accumulate, and become completely consumed, if that operation has not already been effected. They are removed at intervals by moving a handle, which lets a hinged plate on which they rest fall, and so discharges them into the ash-pit. The supply of coal is from a hopper and regulated in thickness by a sliding shutter or door similar to those used by Juckes.

The comparative advantages of these two systems are as follows, Juckes' grate possesses extraordinary durability, a set of bars often lasting as long as five or six years, while Hall and Whitaker's furnace, has the advantage of smaller first cost, and may perhaps produce a little more steam per superficial foot of grate surface than the Juckes', the durability of the fire bars is about the same as common ones, but the disadvantage of their wearing may be compensated by the fact that the cost of them is small and a new one may be inserted without stopping or putting out the fire. There have been several inventions introduced lately which are most direct copies of this, one of these makes the bars with top pieces to fit on to them. There is no advantage in this as these pieces
are almost as costly, and more difficult to replace, than an entire new bar in Hall and Whitaker's arrangement.

Another plan which has taken considerably with the public is Vickers and Smith's patent. This is a clumsy complication of Hall and Whitaker's, it introduces a great number of wheels and extraneous motions, nearly doubles the cost, misses the most vital point, and although the bars wear, "caeteris paribus," as fast, they cannot be replaced without great delay.

It is needless to mention other inventions or rather patents whose name is legion, which have been brought forward without the slightest plea of novelty, or improvement, with views to monopoly. Never has the impetuosity of inventors been so much demonstrated as in the patent records on this subject, for identically the same ideas have been protected over and over again, by men who could not take time, or were not able, to ascertain what had been done before.

On the second and third heads of this paper, there is little to say, except that by the use of mechanical fires a saving of coal is effected, provided that the said fires are in the hands of competent men, may be considered as sufficiently proved in practice; and as regards exceptional failures it can only be said that bad construction or negligent attendance will cause any machine to fail.

There is no doubt that the greatest difficulties have been placed against the success of mechanical fires by the firemen, who are not sufficiently far sighted to see that the introduction of machinery will benefit the labouring classes, a result which has everywhere invariably followed its application.

The adoption of self-feeding fires obviates another great objection in hand-firing, especially that frequent firing which is considered to be the best plan, inasmuch as it prevents the incessant opening of fire-doors and prevents cold air rushing along the boiler, causing it to contract, and to expand again as soon as the coal bursts into a fierce flame. This evil causes the greatest harm to boilers, and to it was attributed a recent explosion which occurred in this neighbourhood.

The prevention of smoke is perfectly achieved by either of these systems of firing and with a certainty which never can be arrived at with hand labour.

Every circumstance has gone to prove that North country bituminous coal, cannot be burned, without producing smoke, unless fired with great care on the part of the fireman.
If firing is to be carried out as theorists tell us it should be, the number of men must be doubled, and a superior class employed.

Stoking on board ship is one of the greatest nuisances connected with Steam Navigation, the firemen are, as a rule, the lowest grade of society, and their labour is the hardest, the most unhealthy, and the dirtiest. In a stoke-hole 5 feet 9 inches long, with the boiler and a row of furnaces facing them, with the temperature from 120 to 130 degrees, who would listen to a lecture on the correct mode of firing and preventing smoke!

The stoker's plan is to get a fire which will last as long as possible and to go where he can cool himself.

The cleaning of fires which entails so much labour and loss of steam (hence of speed) is entirely obviated by mechanical firing, an advantage of itself enough to turn the balance in favour of the machine.

Little has been done as yet in the application of mechanical firing at sea. The writer, however, hopes to be able shortly to report on some furnaces which are being applied by him to steamboats.

It has been the object of the writer to avoid all mechanical details in this paper, and simply to describe principles, leaving the proportions of the apparatus to the manufacturer to work out for himself.

Small coal is generally used for these furnaces, any size however

(55)

may be used, the most desirable being pieces from ½ inch to 1½ inch round free from dust, called "nuts."

The writer has under ordinary circumstances seen 32 lbs. of small coal burned off per square foot of Juckes' grate per hour, and had the chimney been higher (it was 50 feet) the result would have been better.

Mechanical firing considered as a complete and certain prevention of smoke, is a most important subject of consideration, for the north Country bituminous coal owners, as upon it hinges the applicability of this coal to ships of war.

In all steam navigation, whether for purposes of defence or commerce, smoky chimneys are a constant source of accident and collision (especially when the wind is abaft) not to mention the dirt and discomfort they cause to passengers and crew.

The writer is possessed of many authenticated statements relative to the economy of machine fires, but he deems it advisable only to present one to this Institution, which was taken from the books of a large coal company in this neighbourhood, and extends over a considerable space of time. Reckoning the cost of small coal at 2s. 6d. per ton the saving annually amounted to £50 on each furnace, labour and fuel combined.
As a rule the evaporative power of furnaces is increased by the adoption of mechanical firing although there are exceptions.

The writer hopes shortly to be able to lay before the members some results of mechanical firing as applied to marine boilers.

(56)

[Blank page]

(57)

NORTH OF ENGLAND INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING, SATURDAY, FEB. 6, 1869, IN THE ROOMS OF THE INSTITUTE, NEVILLE HALL, NEWCASTLE-UPON-TYNE.

JOHN MARLEY, Esq., in the Chair.

The minutes of the last meeting and the minutes of the Council were read and confirmed.

The following gentlemen were then elected:

Members:

Hubert Laws, 21, Collingwood Street, Newcastle-upon-Tyne.


Graduate:

William Brumwell Wilson, Killingworth Colliery, Newcastle-on-Tyne.

Mr. A. L. Steavenson read a paper on "Lemielle's Ventilator." The paper was illustrated by various diagrams, and a large sheet of results of experiments. Mr. Steavenson stated that these plans had been given in a former volume, but it was as far back as the sixth, and whether they should be reprinted or not it would be for the Council to decide. He had thought proper to bring them for reference. It would be found that the quantities really did improve with the speed. He did not know what Mr. Cochrane would say to this, but they were all gradually improving, showing a better yield per revolution as they got to a higher speed. On the question of different conditions Mr. Cochrane was right, but he had brought this paper as a statement of facts.
The Chairman said, having heard Mr. Steavenson's paper, they must all admit that it was a subject of vital importance as connected

with ventilation. According to the rule, as amended, the subject was now open for discussion; but the discussion would be renewed when the paper was printed. Mr. Steavenson might give explanations either now or hereafter.

Mr. Cochrane said, they were indebted to Mr. Steavenson for being so kind as to have followed, in the paper which he had read before them, the same system of nomenclature as had been adopted in a previous communication on the Guibal and Lemielle ventilators (Vol. XVI. of the Transactions), the discussion on which had been postponed until the practical results of the Lemielle ventilators, which were then in course of erection in this country, had been tested and submitted to the Institute. The details given to them in Mr. Steavenson's paper were in very close agreement with the conclusions arrived at in the theoretical examination of the principles of the Lemielle ventilator, and especially he called attention to the re-entries as tabulated by Mr. Steavenson. So small were the differences between them and the theoretical volumes, that he considered such differences were the result only of imperfect observation. Mr. Cochrane gave the results of calculations he had made from Mr. Steavenson's record of the experiments, to illustrate this point, and said that the fuller development of the agreement of this practical test with the theoretical principles laid down in the before mentioned paper, would require more time than could be afforded at that preliminary discussion. The figures showed that as the water-gauge increased, the re-entries into the ventilator increased considerably; and taking Mr. Steavenson's figures, though he thought Mr. Steavenson had not the correct value of Ve, he had calculated in accordance with the statement made on page 71, Vol. XVI., that if a water-gauge of 20.81 inches were attained (and he begged to inform the Institute that this ventilator was guaranteed by the inventor to produce 10 inches of water-gauge at a safe working speed), no air at all would be extracted from the mine, but the re-entries would be equal to the useful or effective volume. He could bear witness that the construction of this Lemielle ventilator had been most carefully attended to, and compared with those he had seen abroad, was much less exposed to the serious losses by leakages at joints, hinges, slots, and clearances of the vanes; but they must admit that in so large and complicated a machine on this principle, these must, even with the best arrangement of details, continue to be unavoidable, and present, in the course of regular working, the risk of exaggerating themselves. He would instance as the only system of ventilating machine upon this principle, where they could hope to reduce the sources

of leakages to a minimum, the ordinary blowing engine used at blast furnaces. The members of the Institute would probably know the Nixon ventilating machine of South Wales, which approximated to a piston blowing engine, and might be described roughly as a Struve working horizontally; but the necessarily slow speed at which so large a piston must work, and the considerable loss by unavoidable leakages, render it a very undesirable machine for the ventilation of mines. He hoped to
be able to discuss Mr. Steavenson's results more fully at next meeting, after the paper was in their hands; and he concluded by remarking that the per centage of useful effect obtained, which was the most important test of a mechanical ventilator, was very inferior to that of the Guibal centrifugal system, while the objections, which he had on a previous occasion laid before them, to the Lemielle system of ventilator were, he submitted, entirely corroborated by the practical test of this ventilator at Page Bank.

Mr. Willis said, he could not help thinking there must be something wrong in the results Mr. Steavenson had given. Their machine, at Washington Colliery, though but two-thirds the size of Mr. Steavenson's, gave more cubic feet than his per revolution. He had tried experiments yesterday. In sixteen revolutions he got an average of 8215 cubic feet per revolution.

Mr. A. L. Steavenson - What is the water-gauge?

Mr. Willis - We had not the water-gauge on; but the difference is so great that we could not help thinking it was more than would be accounted for by the less water-gauge.

Mr. A. L. Steavenson - That accounts for it.

Mr. Morison said, that Mr. Steavenson had stated, in his paper, that he got a larger quantity of air with the Lemielle fan than could be got with any other fan. They were using at Pelton a Guibal fan, and as large, and in some cases a larger quantity of air had been obtained by it. He had a tabulated statement of results, and would be glad to lay it before the Institute at a future meeting. Sixty-two revolutions was their usual working speed, and they obtained from 96,000 to 106,000 cubic feet of air. The water-gauge was 2.8 inches.

Mr. A. L. Steavenson said, theirs was 6 ¾ inches. Mr. Willis must have had an extreme quantity.

Mr. Willis - 134,000 at 16 revolutions.

Mr. Daglish said, Mr. Willis must be getting more.

Mr. Cochrane - No reliable conclusions can be drawn until all the conditions are given.

Mr. Daglish suggested, that they should have a committee to investigate the fan ventilation, as there seemed to be four or five fans at work.

The Chairman said, no doubt such would be a beneficial committee; but he did not know whether the time had arrived for it. The discussion would not end to-day. They would expect to hear from Mr. Willis on the subject.
Mr. Willis - Our fan is perfectly open to any one.

The Chairman - May we ask you to promise that you will give us some statistics of the working of your fan, either at the next meeting or the meeting after.

Mr. Willis said, he had some remarks in preparation and he hoped to have them completed soon. He thought their fan showed a greater efficiency than Mr. A. L. Steavenson's had shown to-day.

Mr. Cochrane said, as regarded the machinery, that of Mr. Willis must be something very superior to produce better results than those at Page Bank. The day he was there everything worked splendidly.

Mr. Willis said, he thought the fault was in the building; either by reason of the lining being irregular and thereby causing extra leakage; or possibly the height of the "inlet" drift is much lower than the height of the machine itself, in which case the upper part of the machine would have little effect.

Mr. G. B. Forster asked Mr. Steavenson at how many revolutions he could run the fan constantly?

Mr. A. L. Steavenson - 14 to 16.

Mr. Cochrane - Do you think it safe to run 14?

Mr. A. L. Steavenson - Yes; he thought so. It is a very strong machine. We can get something like 100,000 feet with four inches water-gauge.

After some conversation in favour of reprinting the plans, Mr. Morison asked Mr. Steavenson if he took the water-gauge in the mine.

Mr. A. L. Steavenson said, there was a slight difference of about half-an-inch. The difference between the top and bottom was not great.

Mr. Morison - The difference is what is due to the shaft.

Mr. J. Cooke asked what would be the effect of trying 12 inches?

Mr. A. L. Steavenson said, he would not think himself warranted in putting on a greater pressure than six inches water-gauge.

Mr. G. B. Forster moved a vote of thanks to Mr. Steavenson for his paper, and hoped the Council would see the propriety of printing all the plans. There were a great many members who had not the sixth volume.

Mr. Willis seconded the motion, which was carried unanimously.

REPORT OF THE TAIL-ROPE COMMITTEE.
The chair being vacated by Mr. Marley (he being obliged to leave early) it was taken by Mr. G. B. Forster.

Mr. G. B. Forster said, if any one had any observations to make or questions to ask, the members of the Tail-rope Committee were here, and would be glad to answer them.

Mr. Lishman said, there was one question he would like to ask. At what gradient would one of the endless-chains work without the application of the engine?

Mr. G. B. Forster said, it was self-acting at 2½ inches to the yard. Ordinary self-acting inclines would work at a great deal less; but an endless-chain would work along the level for some distance from the incline.

Mr. Lishman said, he thought this was over-stated. He had tried one 160 yards in length, with six inches to the yard for forty yards. The remainder of the plane was level, the average gradient would be an inch to the yard.

Mr. G. B. Forster - A self-acting incline will act at less than an inch; three-quarters.

Mr. G. B. Forster asked Mr. Burn how he liked the endless-chain which he had in use?

Mr. Burn said, he liked the endless-chain very well. The engine was underground, and the boiler on the surface.

A conversation then took place as to the expense incurred in supplying the machinery for working the endless-chain.

Mr. Burn stated, that in the Committee's Report £276 was put down as sufficient to fit up a pit with engine, shafting, &c, for the endless-chain. This he believed to be very much below the actual cost, since judging from the cost of machinery in use at the Rainton Colliery, for working the endless-chain, the cost of gearing at the Burnley collieries, as reported by the Committee, seemed very low.

Mr. Bainbridge thought Mr. Burn would find that the difference between the cost of gearing at the Burnley and Rainton Collieries was chiefly due to the fact, that at the former collieries the engines and gearing were of a very cheap and inferior description, whilst at Rainton they were exceedingly strong and of the best quality.

Mr. G. B. Forster said, the figures were given from actual costs; and the person who built the engines was prepared to build as many more as might be required on the same terms. The object they had in view was to ascertain whether an engine-plane worked with a tail-rope or an endless-chain was cheapest and best.

Mr. Burn said, there would be a considerable saving in stone work. In four years they had spent £2,000 in making wagonways for the tail-rope, and if the same length of road had been to make for the endless-chain it would only have cost £800. This would be a saving of £300 per year. Some of their wagonways cost 10s. per yard, and now that they did not take any stone down for the chain
way, the travelling way could be made for 3s. per yard. The putting is another item of saving. He calculated they would save from 2d. to 3d. per score, as they could always have the chain close to the face; and this would save them from £200 to £300 per year.

Mr. A. L. Steavenson said, did he understand rightly that the endless-chain requires less outlay than the tail-rope?

Mr. G. B. Forster - It requires no stone work.

Mr. A. L. Steavenson - How are your horses got in?

Mr. G. B. Forster - You send them in on a tram.

Mr. Bainbridge said, that as far as the first cost of a wagonway was concerned, at Burnley the endless-chain roads were no larger than ordinary working places, and stone work was avoided owing to the facility with which the endless-chain could be applied on heavy gradients. Neither horses nor ponies were used underground at the Burnley Collieries, as branch ways were so quickly constructed. The coals were put by hand to the terminus of the engine-plane.

Mr. Lishman said, there was a greater liability to breakage with the tail-rope than with the endless-chain.

After some further conversation, thanks were voted to Mr. Marley and Mr. G. B. Forster, for their services in the chair, and the meeting then separated.

( 63 )

ON SOME EXPERIMENTS with THE LEMIELLE VENTILATOR

At PAGE BANK COLLIERY.

By A. L. STEAVENSON.

On the occasion of the October meeting, in 1866, the writer had the pleasure of bringing under your notice the merits of the Guibal ventilator, and then reminded you that since Mr. Atkinson read his very complete paper on the comparative merits of furnaces and machines, in respect to the consumption of fuel, the members of this Institute have no longer any occasion to hesitate in determining as to the adoption of a fan in preference to a furnace. There are exceptional cases where, from the great depth of the shaft, furnaces may be efficient, but the conditions which must prevail, when this is the case, are easily learnt.

By the term "efficient," he implied not only the means of saving coal, but also of exhausting air, under conditions so severe in the amount of drag, that furnaces cannot attain the same effect. He refers to this subject again, because in some districts where the question has arisen the minds of mining authorities are still "exercised" upon it, and they even put the question of merit as one to be tested solely by the difference in value of large and small coals. But it is for us to remember at the
circumstances of one colliery, or even of one district, which render the fan or the furnace advisable, have nothing to do with the real question.

It may be shortly stated thus. What is the depth required with a given average temperature in the upcast, produced by a furnace, to equal in effect the consumption of coals by a ventilating machine in lbs., per hour, per horse power expended?

It matters not to us, as an Institute, what the price of coals is, at any place; we know that heat means power, and power represents a money value all the world over; so we determine how the most power is to be got out of a certain quantity of heat; and we know that if by the application of a boiler, engine, and fan, we can get four, six, or eight times more force out of the same quantity of heat generated, than by a furnace, that the mercantile or money question may safely be left to take care of itself. We measure our air and ascertain the amount of drag which the passages of the mine oppose to it, and having thus the force, in horse power required, we have the simple question for solution, how can this, or still greater results, be most effectively obtained?

Having arrived, we will suppose, at the conclusion (as we most probably will in nine cases out of ten), that a fan is more suitable than a furnace, we have then to decide upon the principle which is best adapted to the purpose, and we have two from which to make choice, viz.: Centrifugal, or as it was lately termed "impulsion," and that of "varying capacities," or the common pump.

Notwithstanding that the writer had fully examined the merits of the former by experiment and the study of the paper on the Guibal system already referred to, he was induced from analogy in the case of raising water and, by the advice of French engineers who had seen the two systems of the Guibal and Lemielle in operation upon the Continent, to recommend the principle of "varying capacities" to "centrifugal force," knowing that for raising water an ordinary pump very far exceeds a centrifugal one in its powers of exhaustion, and that in ventilating a thin seam this should form one of the first considerations.

A reference to the results obtained would, he thought, satisfactorily show that he has not been mistaken, and although the re-entry is large at present, he hopes with practice to reduce it, and to prove that re-entry is more to be feared as a defect in construction than in its effects, under the principles of its action.

He would describe the machine by a reference to the plans first, then explain the tabulated experiments, and lastly, give observations upon the results of the experiments, and treat of them as subject to the laws affecting speed of machine, and drag of the mine.

DESCRIPTION OF THE FAN.
On referring to the accompanying plans, Nos. 7, 8, 9, and 10, you will observe a circular chamber of masonry marked A, which communicates by an air passage with the mine; on the opposite side is the outlet. In this chamber revolves a drum B, placed eccentric with the circumference of the chamber, and to this drum are attached three wings, C C C, moveable on hinges at their base, whose outer edge by means of the eccentric rods D D D, which work upon a fixed metal shaft S in the centre of the chamber, is kept close to the walls, so that they enclose and should throw out three volumes of air at every revolution, hereafter referred to as Ve. The weight of the drum and wings is carried partly by a collar F, placed between two malleable iron girders G, partly by the footstep H, and the remainder by three wheels I, fitted with bearing springs, the axles being radial to the centre. Motion is given by the horizontal engine on the top.

As misapprehension frequently occurs on a first examination of this machine, he especially directs your attention to the centre column, which is stationary, its chief duty being to throw out the wings by the eccentrics which revolve upon it - and that it is a matter of first importance to make the wings fit as closely to the circumference as possible, since any leakage which occurs increases rapidly, as the work to be done or the drag becomes greater. This leakage is hereafter referred to as re-entry and is expressed as Vx.

The experiments he had made were tabulated so as to be readily compared, and it is necessary, therefore, only to point out that in order to test the fan thoroughly every experiment was made under two different conditions of the mine, viz.: - First, when everything was in its ordinary condition; and, secondly, when the separation doors at the pit bottom were open so that a considerable proportion of the air was allowed to return immediately to the upcast pit, relieving the drag as shown by the water-gauge in column L, and upon the diagrams. Every care was used that the indicator diagrams, and other measurements were taken at the same time by means of signals, and each of the experiments extended over five minutes.

The readings of the anemometer are corrected by formulae which were carefully prepared from observations at a high speed (see columns I and J).

The total quantity of air in cubic feet per minute is given under K, and described as

[ Formula ]
In order to show the increase of water-gauge at the different velocities he had prepared a diagram (plan No. 12); and another diagram (plan No. 13) gives the quantities of air, distinguished in like manner, the dotted lines showing the quantities due to the water-gauge under the law [Formula]. Plan 11 is a diagram showing the relative capacities of the discharge and re-entries.

Plans Nos. 14 and 15 are copies of the diagrams taken from the engine by a Richard's indicator, and show the pressure at each end of the cylinder during each experiment (see columns O, P, Q, R, page 69.)

The results show that very large quantities of air are obtained under heavy water-gauges, which he had always anticipated. They would observe No. 13 experiment gave 134,110 cubic feet under 4.55 inches of water-gauge, at 16.50 revolutions of the fan per minute, and that No, 7 experiment, the doors being shut, at 16 revolutions, with 6.65 inches, he got 97,338; this latter is a slight error, the correct quantity being 104,000.

The theoretical law that these machines yield an equal volume of air per revolution at various speeds, under similar conditions, does not appear to be confirmed exactly; but if we take the average of the first series, we get [Formula]; and we see that in column Y, some are rather less and others rather more, so that the differences are apparently accidental, and owing to the difficulty of measuring such high speeds of air accurately. Assuming this average of [Formula] to be correct, and treating all the experiments of the first series with this as a basis, we get (see column K and K):—

[Table of Results]

The difficulty of getting the water-gauge perfectly correct is quite sufficient to account for any apparent discrepancy in these results, and we have now only to see how at similar speeds, with the conditions of the mine altered by opening the separation doors, we find the machine fulfils the law, [Formula]

(67)

which requires a diminution of useful volume under increased water-gauge at equal speeds, as in the notation already referred to, [Formula.]

If the laws we have just considered are correct, then our best way to come at the exact quantities, Q and Q', is to take the average of the results obtained under each different condition, and we thus get,

With doors open, \( Q' = 57,806 \) cubic feet.

With doors shut, \( Q = 6,250 \) do. Vu pi7
Further calculations

The others give results equally near, and warrant us in assuming the law to be the correct one - if it is so, then the object of first importance is to reduce the re-entry to the lowest possible proportion;

At present, with doors open \( V_x = 3223 \) or \( 29\% \)

" with doors shut \( V'_x = 4779 \) or \( 43\% \)

It is thus clear that under certain conditions of drag the re-entry would equal the amount generated, or \( V_x = V_e \), and this we find would take place if the water-gauge indicated 18.10 inches, rather an unusual state of things certainly.

These facts are held up by the advocates of centrifugal fans as quite sufficient to condemn any system but their own. Curiously enough we are never told what the centrifugal fans will do under these extreme water-gauges, neither has it ever been thought advisable to tell us how they act under different conditions, and it is, therefore, desirable to obtain this information at once.

It now only remains for me to state, practically, the benefit obtained by the application of the fan in the present instance.

The furnace yielded, when at its best, 39,997 cubic feet under 0.90 inches water-gauge, and to prove the accuracy of this if we compare it with our first fan experiment we get the theoretical duty of the furnace, [Formula]

The fan gives, at 1.83 water-gauge, 56,621, which is as nearly as possible correct.

The furnace was then consuming 41.10 lbs. of coal per horse-power

per hour. As soon as engine power is applied this is reduced to the usual standard of 12 lbs. per horse-power applied, and in the case of a fan utilising 45 per cent. this becomes 26 lbs., or 36 per cent. less coals with the fan than with the furnace - this upon the quantity of air now passing through the mine amounts to a saving in coals and wages of £448 per annum, assuming that the furnace could have done the work, but it could not do more than it was doing, whereas we have now nearly doubled the air and have a good margin in hand for future requirements.

When the time for discussion upon these remarks arrives the writer will probably be able to report improvement as to the re-entry, and also to give some comparative experiments with the Guibal under various conditions, meanwhile he believes he has fully established facts which will serve for reference as well as a confirmation of important theories.
NORTH OF ENGLAND INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING, SATURDAY, MARCH 6, 1869, IN THE ROOMS OF THE INSTITUTE, NEVILLE HALL, NEWCASTLE-UPON-TYNE.

G. C. GREENWELL, Esq., in the Chair.

The Secretary read the minutes of the previous meeting and the minutes of the Council.

The following new members were then elected:—

Members: -

J. A. Ramsay, Widdrington Colliery.


Thomas Hay Wilson, 40, Dean Street, Newcastle-upon-Tyne.

Addison Potter, Heaton Hall, Newcastle-upon-Tyne.


E. Stutchbury, Mining Engineer, Almondsbury.

George Caldwell, Moss Hall Colliery, near Wigan.

I. B. Everard, Mining Engineer, Leicester.

Archibald Matthias Dunn, Architect, Newcastle-upon-Tyne.

William James Joicey, Tanfield Lea Colliery, Burnopfield.

Graduates:

John Herbert Jenkins, Cramlington Collieries, Northumberland.

James Hunter, Peases’ West Collieries, by Darlington.

G.C. Greenwell, Jun., Towneley Colliery, Blaydon-on-Tyne.

TAIL-ROPE COMMITTEE’S REPORT.

The Chairman said the Report of the Tail-rod Committee was open for discussion. Before coming into the room he had

heard the subject discussed very freely, and he thought, perhaps, it would be as well if a little of the discussion was imported into that meeting, which was the proper place in which to entertain it. There was one point he might mention. The other day he was in the Burnley district, and speaking to one of the managers of the colliery, he made the following remark: "Seeing that many of the roofs of the North of England collieries were bad" - they would bear him out that this was the case in the five-quarter seam - "to make a wide road, such as would be necessary for using an Endless-chain, a very considerable expense would have to be incurred, which seems not necessary in a district where the roofs are chiefly Post and generally good." The answer of that gentleman was, "Well, but our roofs are not good; in the Cliviger Colliery all the main levels had to be arched." He (the Chairman) did not know that this precise case had come under the consideration of the Tail-rope Committee. All the main levels at Cliviger Colliery - some of them eight feet wide or upwards - were arched. He would ask whether this had been taken into consideration, and whether it would operate in favour of the Tail-rod as compared with the Endless-chain?

Mr. G. B. Forster said, he supposed the Endless-chain would require a road nine feet wide. This was only a foot or two wider than the ordinary road.

The Chairman said, the colliery to which he had referred, was the adjoining colliery to Towneley; but at Towneley the examinations were made in the Mountain mines. The works in the adjoining colliery were in the Ardley mines, where, for 300 yards, the roofs were arched in the levels.

Mr. G. B. Forster - It would have to be arched for a single way.

The Chairman said, he did not think it would be necessary for single ways to be arched where they were in the main level; they had Tail-rod roads here without arching where they had not double ways put in. Arching in the North was the exception.

Mr. G. B. Forster said, it would be found that the Committee had been very strict on this point. He did not mean to say that the Endless-chain was recommended in all cases; it was only under certain circumstances. Of course, if great expense had to be incurred in constructive arches, they would not recommend it.
Mr. Lindsay Wood said, there were a great number of districts where the Endless-chain was worked, and no arches were used. He did not think he saw any road that was arched.

Mr. E. Bainbridge said, in regard to the original cost of roads

(73)

for the Endless-chain as compared with the Tail-rope, he might state that at Burnley they were usually nine feet wide and about three feet high. The roads for the Tail-rope system in the North were seldom of less width than this, owing to the space required by the Tail-rope at the side of the way; and besides this, extra width is also generally provided in the way for a travelling road, whilst at Burnley a twin intake is used for this purpose. The difficulty, therefore, arising from the necessity of arching where the roof is bad would apply nearly equally to both systems.

The Chairman asked Mr. Bainbridge if the roads he referred to at Burnley Colliery were in the Mountain Mine or in the Ardley Mine?

Mr. Bainbridge - In the Mountain Mine.

The Chairman - Where it is a Post roof, and not soft?

Mr. Bainbridge - If a soft roof, it is generally arched.

The Chairman - The question is, if the workings are in a seam with a soft roof, where in the one case it is not necessary to put arches in, whereas, on the other hand, the increased width required, renders an arched roof imperative, what difference would that make in the comparative cost between the Tail-rope and the Endless-chain?

Mr. Bainbridge said, the roads at Burnley were no wider than those of the North of England, namely, nine feet; and there were probably very few ways in the North of England less than this.

Mr. Daglish said, the way must be wider necessarily for a double road than a single road. Both for Endless-chains and Tail-ropes it was the custom on extensive planes to have a travelling road. When they commenced at Rainton Colliery with the Endless-chain they made a separate travelling way altogether.

The Chairman said, if they had a certain width of road necessary for the Tail-rope, and they substituted for this a double road for the sake of introducing the Endless-chain system, they must consider what increase of cost was incurred in making it a double road; and the necessity of making such double road must be taken into account in estimating the proportionate cost of working by the Tail-rope system and the Endless-chain.

Mr. Southern said, he quite agreed with the Chairman, and he thought the remark of Mr. Daglish, too, was very important with regard to a separate travelling way where the road was so entirely
filled up with a double way. As to having refuge stalls, they were certainly provided by the Act; but it
did not follow that because they had refuge stalls they must not prepare a travelling road besides,
where, as had been said,

( 74 )

the space was entirely filled up by the two ways, in which case the travelling road would he
indispensable.

Mr. G. B. Forster said, the case which the Chairman had put was where a bad roof confined them to
a limited way. Now, in that case, he thought there was a great deal more danger with a Tail-rope
going at a great speed, than with an Endless-chain. He considered that a travelling road was more
necessary in the case of a Tail-rope going at a high speed, than in the case of an Endless-chain.

Mr. A. L. Steavenson said, it appeared to him very difficult to reconcile the statement that they
would be able to make and work a double width of road as cheaply as a single one, especially if the
first cost was taken into account. It might indeed be said that an engine plane on the Endless-chain
system could be worked without having the top taken down. But there was an advantage in taking
the top down; and if it were possible to work by an Endless-chain without the top being taken down,
it would be as easy to work with a Tail-rope under the same conditions. Further, they would find that
the Tail-rope was able to work in places where it was impossible for the Endless-chain to work at all,
and, therefore, the systems could not be fairly compared. Brought before them very ably as it had
been, still they should give their individual opinions on this question, and there were one or two
elements to which he thought it desirable to call their attention. One was, the effect of the
gradients. It had been stated that where the Endless-chain was employed, a gradient falling with the
load assisted the engine, under circumstances where, with the Tail-rope, no benefit would be
received, and that the application of the brake in the Tail-rope system, in a descending gradient, was
a loss which was not incurred in the Endless-chain system, which, on the contrary, obtained the full
benefit of the descending gradient in dragging the tubs in. This was hardly so important a matter as
it might seem, because the inclination would cause the set to run so much quicker; and if the set
was running some distance it was so much gained. On the other hand, if the gradient was heavy, it
would run too fast, but still it might be possible for the governor of the engine to regulate it. If they
had always a descending gradient, whatever advantage it might give with an Endless-chain, it would
be equally beneficial if they had a Tail-rope. Then there was the weight of the chain to be taken into
account, in one instance thirty-seven tons. This could not but have its effect in friction, when
running, on the wheels. Very often the sheaves were larger than the wheels on the tubs,
consequently, the effect of friction on the wheels was greater than on the fixed sheaves. The weight
of the chain, 13 lbs., per fathom, was, at all events, twice as much as the weight of the rope, which was only 7 or 8 lbs.; and if he was correct in this assertion, it was a very important item. He was not prepared with statistics, because he had been busy with his paper on the Ventilator; but in the previous year, Mr. Daglish read a paper on Haulage by Tail-ropes, where the friction of dragging the ropes was given as 43 per cent, of the entire power used. He (Mr. S.) made experiments shortly after, at Page Bank, and found it the same; but when they looked at the friction given here, they found that it varied from 54 to 83 per cent.; so that in this respect the Endless-chain had not the advantage of the comparison. Then, as to cost. There was one case in which the Endless-chain appeared to cost something like 4d. per ton. He did not see if in one case it cost 4d. how in another case it should cost one penny. This seemed to require a little reconciliation. He believed the cost of applying the Tail-rope, if thoroughly tested, would show that it was not so deficient as had been represented. He was unwilling to admit that South Country practice was able to beat them to this extent. He felt it to be a reflection on the district.

Mr. G. B. Forster wished to know in what district it was impossible to work the Endless-chain, and possible to work the Tail-rope?

Mr. A. L. Steavenson - In your own report it is stated that the Endless-chain may be applied with few exceptions; and that the Tail-rope system should be used where there are numerous branches to be worked.

Mr. G. B. Forster - The report says the Tail-rope is more economical in some cases, but not that the chain is impossible.

Mr. A. L. Steavenson - Impossible, with due regard to economy.

The Chairman said, there was one question put by Mr. Steavenson as to cost. He said in some cases the cost was 4d. per ton, and in other cases a penny; this could be very easily accounted for, since the cost of managing a road was the same whether the quantity of work done was great or small, therefore, if the same number of men were employed and only one-fourth of the quantity carried, the cost would be four times the amount per ton.

Mr. L. Wood said, that was what caused the great difficulty in comparing the actual cost of the two systems. There were so very few of the engine planes working up to their maximum quantity. With
regard to Mr. Steavenson's remark of the great loss of power required to drag the chain, although
the weight of the chain is carried on the tops of the tubs, the friction is less than with the Tail-rod
which is carried

( 76 )

on rollers, the spindles of which are much smaller and revolve at a much greater rate than the axles
of the tubs which carry the chain, added to which, the Tail-rod being so near the ground it is
frequently in contact with it, which causes a great loss of power.

Mr. E. Bainbridge said, Mr. Steavenson had drawn attention to the discrepancy between the results
of Mr. Daglish's experiments as compared with these given in the Underground Haulage Report in
respect to the per centage of power exerted in working the ropes by the Tail-rod system. Mr.
Steavenson would find that the variation was caused chiefly by the variation of the gradient. Thus at
Seaton Delaval, where the plane was nearly level, the proportion of power expended on the rope
was 72 per cent.; whereas at Murton and Seaton, where the planes had average gradients of 1 in 83
and 1 in 64 respectively, the per centage of power required for the rope was much less.

Mr. G. B. Forster said, with respect to the power required for the Endless-chain, the engines were
usually a third of the size used for the Tail-rod. He never saw more than two 12-inch cylinders. It
appeared to him that the great difference between the Endless-chain and the Tail-rod lay in the
rate of speed. It was acknowledged by engineers that there was great advantage in the use of trains
traveling at a slow speed. Nothing so increased the cost of a railway as express trains. Here they had
an Endless-chain travelling at a slow rate and requiring very little power to move it, while the Tail-
rod was travelling at very great speed and requiring large power. In the Endless-chain the power
exerted is nearly always the same, and, therefore, it requires only the average power. In the Tail-
rod the power required is sometimes very large and sometimes very small, and the engine must be
large enough for the maximum power required at any time. The rope travelling at an immense speed
must cause more friction. Mr. Steavenson's expression of regret that this district should be thrown
into the shade was one in which he (Mr. F.) joined. He went to Lancashire with quite as strong an
opinion in favour of the Tail-rod as Mr. Steavenson had expressed; but if men would not go to
other districts to learn they must come to grief. The more they went away from home and learnt
from other people the better it would be for themselves.

Mr. Daglish said, he had taken down Mr. Steavenson's observation, but they had been mostly
answered by others since he did so. First, it was said that there was no great loss in running the set
in if the brake were put on; but they must remember that the engine was exerting its force in pulling
the Tail-rod. The horse-power required
to pull the rope was not reduced in the slightest by the set running inbye retarded by the brake, the 
engine was pulling the Tail-rope all the time. The second point had been answered by Mr. Wood; but 
he would add a single remark. Besides the difference in friction between the Chain and the Tail-
rope, a very great loss was attributed to the resistance by the bending of the rope and from the 
power required to lift it as it went over every roller. In the experiments which were made to 
ascertain the actual horse-power exerted by the engine, it was found that more resistance had to be 
overcome in working by the Tail-rope than was required by simply calculating the friction of the 
rollers and gravity of the tubs; and this was partly due to the extra power required to lift the Tail-
rope over the rollers. Again, Mr. Steavenson said, that in the paper which he (Mr. D.) had the honour 
to read to the Institute, he gave 43 per cent, as the power absorbed by the rope. It might be so in 
that particular case, but it was quite possible to be 90 per cent, if the rope were long enough. The 
amount of per centage depended on the length of the ways. Then there was the great advantage of 
the chain obtaining the benefit of the gradients. If they had a certain number of districts in the pit; 
some inclined towards the pit, and some the opposite way; and these were all connected with one 
gine, they would get the benefit of all the descending planes; and this was a large amount. He 
believed the whole of the gentlemen on the Tail-rope Committee went to Lancashire very much 
disposed in favour of the Tail-rope; but they could not but observe, with surprise, the small power 
that was required to work the Endless-chain. He had applied a small engine at Rainton Colliery, and 
he was quite sure that an engine four times the size could not have done the work with the Tail-
rope. It was quite possible if they had workings coming from the higher part of the pit, they might 
work coals from the dip without any engine at all, if they had a preponderance of coals coming from 
the rise. He would he glad if any gentleman would visit Rainton Colliery; Mr. Burns would be happy 
to show the working of the chain there.

The Chairman said, with regard to the power required in lifting the rope between the pulleys, he 
would remark that as the rope fell on each side of the pulley the one fall would balance the other, 
possibly there might be a loss of power in tightening the rope which otherwise would fall down 
considerably more.

Mr. Daglish - Not with such a length of rope as he was supposing, say a thousand yards, with the 
pulleys sixteen yards apart. Here they would have a fall of from six to eight inches; and before this 
rope had
the whole of the thousand yards run off, they would have the fall to lift over every pulley before it reached to the far end.

Mr. Southern said, there would be scarcely so much loss due to the fall as to the extra friction caused by bending the rope over the sheaves.

Mr. Nelson said, the percentage of friction of ropes was in proportion to the bending of the ropes over the return sheaves, or on partial bends. He had made some experiments on the subject, and he found that by having a pulley suspended with rope of equal weight on each side, a considerable percentage was added on one side before the motion commenced, over and above the friction of the sheaves. He saw Mr. Morison present, and the credit of these experiments was principally due to him.

Mr. Morison said, there was friction due to the rigidity of the rope beyond what he would have expected to find from the friction of the axle of the sheave, and in corroboration of what was said of the friction of ropes passing round the pulleys, he would mention one instance that occurred at Pelton, where the Tail-rope passed one-fourth round a six foot sheave with a pump attached. Even when the pump was disconnected, the increase of engine power required to overcome the friction due to this sheave alone was fifteen per cent, of the total power necessary to take in the empty set.

Mr. W. O. Wood said, they had a wagon engine working at the surface, and they had sheaves every ten yards; but the friction of the extra rollers somewhat retarding the action of the engine they took every other sheave out, and the consequence was the engine could go with a wagon or two more.

Mr. A. L. Steavenson - Then if you had taken them all out it would have gone easier still?

Mr. G. B. Forster - So it would, if the rope could have been kept from touching the ground.

Mr. W. Boyd suggested, that the power required to overcome the bending to which Mr. Daglish referred, might be partially estimated by multiplying the mean depth of the curve to which the rope between the two points of suspension would hang, into the weight of the rope between those points of support. Supposing the pulleys were 10 feet apart, and the rope weighed 12 lbs. per fathom, and that it hung to a mean depth of 2, 1/2 inches, that multiplied over 1,000 or 20,000 yards, as the case might be, would give a representation in part of the amount of that portion of power the engine had to exert in pulling the rope.
over the pulleys; to this must be added the power required actually to bend the rope, and the friction of the pulley spindles.

Mr. Daglish said, that was so. There was also a loss of power in the mere bending of the rope. Every time they bent the rope a certain amount of power was required to overcome the resistance.

Mr. Nelson said, no doubt it was so to a considerable extent. There were no tables which gave the rigidity of wire-ropes, though, strange enough, the rigidity of these was very much like that of hemp. This seemed curious, considering the difference of the material. The sheaves should be proportioned to the size of the rope.

Mr. Steavenson said, he thought Mr. Daglish had not understood what he meant in regard to the gradients. He still thought that the Tail-rope got the advantage of a gradient running towards the shaft. If tubs were running down hill for a hundred yards, the journey did not take the same force of the engine as if it were level; therefore, either they had the effect in increased speed or the steam on the engine was reduced, and the speed was slackened by the man shutting the steam off. He was not obliged to put the brake on to make the tubs run slower.

Mr. Daglish repeated what he had said, that in running the empty set inbye, the engine was pulling the Tail-rope all the time, and getting no assistance from the descending set. At Seaham Colliery there was quite sufficient power for the tubs to run a great part of the way, the engine working up to 23 to 30 horse-power, doing nothing but pull the Tail-rope.

Mr. Steavenson - But there is a benefit from the gradient; it is helping the tubs in.

Mr. Daglish - On the contrary, this is obtained with the Endless-chain. But with the Tail-rope the drum of the main rope is detached, and is then out of gear with the engine, and cannot transmit any benefit to it, added to which the set is retarded by means of the brake.

Mr. Steavenson said, that was very rarely the case. If they had any quickening gradients they were quite as much benefit with the rope as with the chain. There was another point which was brought
as a charge against the Tail-rope. It was said there were numerous sections, and lads had to be employed where the Tail-rope was working into the various districts; whereas, with the Endless-chain there was only one district and fewer lads had to be employed. But it was a great advantage to be able to work more than one district.

Mr. Southern said, in connection with any saving of power by

the Endless-chain system, he confessed he could not see how it was to be gained; because with the Endless-chain the sending out of full tubs was irregular; which would often necessitate the introduction of empty tubs.

The Chairman - That stops the work.

Mr. Southern - If it stops the work where is the advantage?

Mr. G. B. Forster - If no work is coming out it stops the Tail-rope equally.

Mr. Southern - They do put empty tubs on to the chain as well as full ones.

Mr. G. B. Forster - Equally so with the Tail-rope.

Mr. Southern - Having an uneven gradient it is not always possible to have the advantage of full tubs.

Mr. G. B. Forster - No; but an empty tub can help the full tub.

Mr. Douglas - In the case of self-acting inclines with heavy gradients worked in the ordinary way, there cannot be any question but that a large amount of power is available, and, generally speaking, entirely lost. It would seem desirable to make such available power useful; and to effect this he had introduced on two inclines the Endless-chain. In one case there were some 200 yards of level road
between the bottom of the incline and the bottom of a single rope Engine bank, between which points the work was done by horses. The excess of power now given out on the incline enabled the coals to be carried along the level, and so by means of the chain he laid off the one or two horses otherwise required. In the other case a greater distance of level road was worked, owing to the gradient of the incline being heavier. Of course, could the lengths of these inclines have been prolonged by diminishing the gradient, a like saving might have been effected, and the sets have been run in the ordinary way; but in underground work, as in these instances, doing this usually involved too serious an outlay. One great objection he had found in the use of ropes was the introduction of certain descriptions of offtake joints, or links, which he found invariably to destroy the upper coils of rope laid on to the drum, so that, where a number of these existed, a rope really was, in a measure, rendered useless long before it was worn out. He had used several different kinds without yet being satisfied, and would be glad to hear what link other gentlemen found best adapted for the purpose. In the case of broken ropes, he found it much better to splice them, and not allow a socket to remain on longer than circumstances rendered necessary.

Mr. Steavenson said, he must consent to be non-suited. He hoped

(81)

when these gentlemen had got their Tail-ropes done away with, and chains applied, that twelve months after this time, they would come and give the results of their experience.

Mr. W. O. Wood wished to call attention to the comparative economy of engines working underground with boilers at the surface, and those working on the surface with the ropes taken down the shaft. He believed there was a difference. There was a loss in the condensation of steam by the steam passing down the pipes; and there was a loss in the ventilation in taking so much air to ventilate the engine-house; and there was an extra quantity of oil and tallow used to lubricate the engine.

Mr. G. B. Forster said, underground engines were an advantage. He had seen the ventilation raised from 30,000 to 70,000 feet, entirely by the introduction of underground engines.

Mr. Marley said, when the gentlemen of the North of England visited Manchester, and before this Tail-rope Committee was appointed, he happened to be present, and he remembered a number of remarks made which were rather derogatory to the chain system. He hoped that all engineers, wherever they came from, would not be above learning wherever they went. They had found more advantages in the chain system than they expected; yet, notwithstanding this, he thought there had
not yet been sufficient weight given to the difference of ropes and the difference of roads, and to carrying out the Inspection Act in the spirit and not in the letter with regard to travelling ways. He agreed with Mr. Daglish that though they might have their refuge stalls and might be doing everything that could be done in the letter they might still not be in the spirit. Gentlemen of the North of England must not rush wildly and alter what had been in practice many years, till they had fully weighed the questions of roads and travelling ways; as, although it had been attempted in general to attribute advantages to the use of the Endless-chain, he thought they would find there were localities in which the peculiarities of either system might be advantageously utilized. They, above all things, ought carefully to consider the cases under consideration before rushing to a general change. Therefore, this discussion having taken place to-day, and the publication of the Tail-rope Committee being in the hands of members, he hoped when it was resumed (and he had no doubt the subject would be put down for further discussion) every member would come fully prepared with points on which they wished information, or with points of attack. He concluded by moving that the discussion be resumed at a future meeting.

(82)

Mr. G. B. Forster seconded the motion, which was carried by show of hands; it being understood that the Council would decide at what meeting the adjourned discussion should take place.

MECHANICAL RIVETTING.

Mr. Waller said, that he noticed in Mr. Boyd's paper the strengths of the joints for lap single rivetting was given as .76, and double rivetting .97, on the authority of Mr. Fairbairn, but he believed that later experiments, by the same authority proved that the strengths were .56 and .7 of the plate. With regard to steam rivetting he noticed that the forces employed were given at 27, 18, and 13 tons, and thought that if 13 tons were sufficient to close a tin thoroughly, the remainder of the force exerted would be used upon the plates themselves and be injurious. In steam rivetting it was found that a rivet could be used one quarter of an inch longer than by hand rivetting, and this quantity of iron being forced into the holes formed a shoulder or washer between the plates. In punching the holes they were always found to be taper owing to the die being larger than the punch and so when the rivets filled the holes it was almost impossible to get the rivets out again. As an instance he quoted a case where 24 or 26 rivets had to be renewed and only two could be knocked out, the leaving to be drilled out. The heads were not true to the rivet in some cases; indeed they had been found to be altogether at one side of the rivets, which would be caused by the plates being in motion when the blow was struck, or by the spring of the holder-up. He looked upon steam rivetting as an advantage to the boiler-maker at the expense of the boiler user, for he believed that this might be partly the cause of "seam rips." Hydraulic pressure was a slower application of the same principle, and in both there was the same objection. Another feature to be considered was the heating of the rivets. In the handwork the rivets were frequently heated only at the points, and at once knocked down over the
plates without the holes being filled; but in power rivetting the rivets were heated all over, which accounted for more iron being used and holes filled; so that there was necessity for the foreman to see that the rivets were properly heated and the work carefully done in the one case, while in the other the machine might be left to itself. He preferred a hand-made boiler to one rivetted by power, and thought that any one examining the two processes would agree with him in the conclusion that for boilers it was not judicious at least to employ so great force as exerted by power rivetting.

Mr. W. Boyd said, the gentleman who had just spoken had missed

( 83 )

one or two points. In reading the paper he (Mr. B.) disapproved almost as strongly as himself of the system of steam rivetting. He had distinctly expressed it as his opinion that that system was open to many and serious objections; and he endeavoured to show as far as lay in his power the way in which hydraulic rivetting had a distinct superiority over steam. There was one point to which he had alluded - he had not a copy of his paper with him - but as far as his recollection went, he had stated that the holder-up in the case of steam rivetting went back three-eighths or half-an-inch; but in the case of their own rivetting by hydraulic power the shrinking of the holder-up was one-sixteenth. That that could have any deleterious effect he distinctly denied. A shrinking to that amount might be fairly taken as closing the rivet against an unyielding body. Again, as to the washer which the gentleman had spoken of as existing between the two plates, he would state that at the time the paper was read a large number of specimens were exhibited, and not a single washer was in any one of them. The question resolved itself into one of advantage, not into a question of cost to the manufacturer, which was hardly a fair way of looking at it in a discussion like this. It was brought forward to be discussed as a mechanical arrangement. It was in this relation he wished to urge its superiority over hand rivetting. In his own practice they were constantly in the habit of making boilers by hydraulic pressure, testing them with 120 or 140 lbs. water to the square inch. Rivets that leak under these tests were rivets put in by hand labour, and not those by the machine. There was another remark he made when reading the paper; the way in which the rivet was closed in the hydraulic machine was different from the way in which the same rivet was closed by steam rivetting. They had the case of a washer in steam rivetting in one of the plates struck by a sudden blow. The plates when put together always had a tendency to open. But suppose the plates were ever so open they would be closed, and in the case of the hydraulic rivetting machines they had no opportunity of springing back, the pressure being gradually and steadily applied.

Mr. Waller said, if a rivet were inserted in the plates, and pressure exerted on the ends, such pressure would be equal over the rivet, which would expand till it met with resistance, and if the plates were not close together a shoulder must be formed. Unless they had a man to close the plates and keep them together during the process of rivetting, they could not ensure them being close together, and the rivet without a shoulder.
Mr. Southern thought, this was a most interesting question and a very important one to all classes of engineers. So far as the rivetting of boilers was concerned it required the very close study of all mining engineers; and more so now than ever, seeing there were so many mishaps, and so much mystery connected with boiler explosions.

Mr. A. L. Steavenson said, if there was any peculiarity such as Mr Waller spoke of it required a different adaptation of the rivetter.

Mr. W. Boyd - In the portable machine there are special means for closing the plates before the rivetting commences - for one of the cylinders has nothing to do but to close them, while the other rivets them, and he referred to the specimens which he had produced.

Mr. A. L. Steavenson said, in the specimens Mr. Boyd exhibited there was no collar such as Mr. Waller spoke of. He had exhibited some specimens sawn in two which looked perfect.

Mr. Nelson said, they would come across good work and bad in both cases.

The discussion then closed.
GENERAL MEETING, SATURDAY, APRIL 10, 1868, IN THE ROOMS OF THE INSTITUTE, NEVILLE HALL, NEWCASTLE-UPON-TYNE.

G. B. FORSTER, Esq., in the Chair.

The Secretary having read the minutes, the following new members were elected:

Members:

Jacob Joicey, Forth Banks West Factory, Newcastle-upon-Tyne.

William Carrington, Sunderland.

Thomas Pacey, Hunwick and Newfield Collieries, near Bishop Auckland.

ELECTION OF VICE-PRESIDENT.

Mr. Marley said, he was quite sure they would all regret that Mr. J. F. Spencer had resigned the office of Vice-President, on account of ill health, and it was now their duty to elect some person as his successor. As the current year would end in August, it was a pity to be at the trouble and expense of issuing voting papers; and as the Secretary had informed them that the old voting papers had been kept under lock and key, it was thought the best course, under these circumstances, to elect the mechanical engineer whose name stood next on the list; and if the election should fall on any gentleman who was already in the Council, then the vacancy so made in the Council might be filled up in like banner. He begged to move that this course be pursued; and as two of the last scrutineers, Mr. L. Wood and Mr. T. G. Hurst, were present, he suggested that these gentlemen should retire, and after a scrutiny of voting papers, report who stands next on the list.

Mr. Cochrane seconded the motion, which was carried unanimously.

The scrutineers having reported that the name of Mr. Isaac Lowthian Bell stood next on the list, that gentleman was elected Vice-President.
MECHANICAL FIRING OF BOILERS.

The discussion on Mr. Nelson’s paper was then resumed.

The Secretary said, he took the liberty of making a few observations on stoking; amongst other reasons, because the paper prepared by Dr. Richardson and himself, which appeared in Vol. XIV., had never been discussed, owing to the unavoidable absence at that time of Dr. Richardson and himself, and he thought that now it might be discussed with advantage, especially as since the last meeting the coal-owners had had the good fortune to succeed in getting the qualities of their North Country steam coal recognised by the Government. He was very glad to be able to state that the question was now in the hands of a gentleman who thorough ly understood his work, and that the old mode of buying had been set aside, so that he hoped this mineral would now be purchased on its merits by persons capable of judging thereon, without any middle interposition whatever. Having secured this result, it was of the greatest possible consequence that they should retain it; and he hoped that all interested in the matter would see the importance of good stoking and a careful adaptation of the furnaces of steam ships, so that it may be proved to the world that here, at least, the coal can be economically consumed without smoke. He had the permission of Mr. Straker to lay before the Institute the results of experiments on board the steam ship "Weardale," which began at the fall of last year and had been going on during the winter, and which had proved completely successful. The only alteration, he might state, which was made in the "Weardale," was shortening the bars. That seemed to answer all the purpose required, and it fully bore out the experiments made by Mr. Miller, at Devonport. There the bars were shortened to three feet, and not only did they burn the coal more economically, but the boiler with a short bar was actually more powerful; more coal was burnt, per square foot, of grate surface. Short bars were also found to burn the coal more rapidly, and produce a better result, in the "Weardale." By a vote of the Steam Coal Trade Association, the matter was placed in his hands to see if this simple alteration in the furnace would be beneficial, and cause the smoke to disappear. Seeing how desirable it was that the condition of the "Weardale," as a smoke consumer, should be carefully ascertained before any alteration was made, he sent a man on board for a voyage, and explained to him the mode of arriving at the smoke equivalent according to the rule.

[ There follow between pages 86 and 87 :


Plate XII : Diagram of the Water Gauge obtained by different Speeds of the Lemielle Ventilator at Page Bank.]
agreed to by the Government. That mode was already before the members of the Institute in Vol.
XIV; but it might be as well here to mention, that the smoke issuing from the chimney had to be
noted every minute of the hour. Of course, in ordinary circumstances, with bad stoking and
appliances, this would be a tedious affair; but when I practised in the "Weardale" it was not tedious.
Only four or five minutes per hour required to be noted. The mode of noting was simply this. Very
black smoke was called six, and very light smoke was called one; the intermediate quantities gave
the other numbers. These were booked in a printed form every minute for an hour, were added up,
and the addition was called the smoke equivalent. He (the Secretary) was very anxious that this
mode of computing smoke should become general, as it afforded the opportunity of comparing the
relative qualities of different coals. A man said, such a chimney was smoky. Well, but how smoky?
There should be a standard. The man he sent on board the "Weardale" was to ascertain first, what
was her usual smoke equivalent, as she was reported to be tolerably smokeless already, but it was
found that her equivalent was 107.9. The bars were then shortened from five feet to three feet six,
and the result was that 107.9 was reduced on an average of 18 hours to 7.7. He had not seen any of
the experiments himself, his duties confining him here; but the vessel had made frequent voyages to
London, and he was assured, both by the captain and the engineer, confirmed by the owners, that
what he had stated was substantially correct. She was now considered as burning North Country
coal in a smokeless way. It was the knowledge of this fact that induced the Chairman of the Steam
Coal Trade Association, at the interview of the deputation with Mr. Childers, to say, that with a small
alteration of the furnace North Country coals could be burnt as smokelessly as Welsh. It had be
observed with respect to hand stoking that if great care was necessary to stoke in order to prevent
smoke it could not be attended with economy. A better class of stokers would have to be
employed; and their duties being multiplied they would have to be employed in greater numbers.
This was urged against our coal, and not against Welsh coal. He contended, and he believed with
justice, that this objection was groundless. In reality Welsh coal required as careful stoking, and as
delicate manipulation as North Country coal. The nature of Welsh coal required that it should be
burnt in a thin layer over the bars. If it was put on thickly the produce of combustion ceased to be
carbonic acid, and became carbonic oxide. It had not consumed the whole of its carbon but wasted a
large portion,
find any very material difference in the consumption of coal, whether the smoke was burnt or not, though they could immediately stop the production of smoke by air getting in at the back. From the report of the engineer he could not find any material difference in the amount of coal burnt on the voyage. In other words, though the coal was more truly burnt and a certain quantity of heating power produced, yet a less quantity of steam was proportionately raised. He was not able to put it in figures, but the one somewhere about balanced the other.

The Secretary said, he did not make any allusion to the admission of air behind the bridge, for this reason. At Devonport when the bars were shortened there were bricks, as in this case, behind the furnace, but they were built up solid, and seeing that the smoke was effectually consumed, he was not prepared to admit, with Mr. Boyd, the importance of air being supplied at the back. Again, there was but a small hole at the bottom of the bridge plate in the "Weardale." That hole was very small - four inches square - and the quantity of air admitted behind this bridge was very insignificant. When this hole became partially filled with ashes the quantity was still less, and he thought Mr. Boyd was attaching more importance to this point than it deserved. That gentleman further remarked that he was disappointed in finding that consumption of smoke did not produce an extra amount of steam. He was inclined to think that this arose from admitting air too freely behind the bridges. If the bars of steamers were only reduced to three feet or three feet six inches, there would be little or no necessity for admitting air behind the bridge. One thing was very important, smoke must not be made; when once made it was impossible to consume it. In conclusion, he begged to acknowledge the courtesy and assistance he had at all times received from Mr. Boyd in conducting these experiments.

Mr. Wm. Cochrane - What is really the rationale of shortening the bars? Mr. Bunning did not give the reason.

The Secretary said, the only account he could give of it was this. First, it was very much easier to put the coal on short bars. If a man pitched a shovel full of coals at the bottom of a six feet bar, it immediately gave off its gas. With a short bar a man could not do this. If he pitched it at the back it was still comparatively in front, particularly with hot bricks behind. There was this also in favour of short bars, with a perforated plate in front; if this door was a foot high it was equivalent to increasing the air entry by a foot - if the bar was three feet long the area of the air getting to the coals was increased by a third - the coals being piled up in front; whereas if the bars were six feet long, and the
door was perforated, the air entry was only increased one-sixth. The place in which the coal rests is accessible to the air on each side, and it gets more completely enveloped in air than with a long bar. The shortness of the bar prevented the stoker from accidentally throwing coals too far over. Mr. Boyd alluded to the way in which the "Weardale" was fitted. Behind the bridge she had bricks fitted with air spaces between. At the bottom of this bridge there is a hole which admits air, and is supposed to assist in consuming the smoke. This hole was very small. In the experiments he made at Devonport there was one solid mass of brick work behind the bridge, and as the results were equally good in either case, he was not prepared to admit the importance of getting air behind.

Mr. Boyd said, in one of the steamers they had fitted, and in which the air was admitted through holes at the back, there had been a deficiency of steam. They then placed a brick in to prevent the air getting in there; but they did not find any appreciable difference in the steam, but immediately there was an immense volume of smoke; the length of bars was 4 feet 6 inches.

Mr. A. L. Steavenson said, it was quite possible that this was owing to not allowing sufficient air to enter by the door.

Mr. Boyd said that, apart from the question of the consumption of smoke short bars were aimed at for marine engines. They tended to economise the consumption of coal, therefore every day they were trying to get the bars as short as they could, to raise the necessary quantity of steam. Having got the bars reduced, and air admitted through the brick-work, there was hardly any smoke at all.

Mr. A. L. Steavenson - For what reason do you expect economy?

Mr. Boyd - The quantity of fire-bar surface at the disposal of the fireman was reduced.

Mr. Southern - How is the air admitted?

Mr. Boyd - Through the open bars at the back.

Mr. Wm. Cochrane said, Mr. Boyd spoke of the admission of cold air behind the bridge, and to that he attributed the prevention of smoke. Now, what is required is sufficient oxygen at a proper temperature to mix with the gases which escape unconsumed from the grate; if air is thrown in at a lower temperature than that at which combination will be effected, the result is simply a deposit of
soot, i.e., finely divided carbon, which goes off in dense smoke and cannot be utilized. The brickwork behind the bridge would no doubt heat the air to the proper temperature.

Mr. Boyd said, that possibly he had not conveyed his ideas correctly.

He by no means meant to convey the idea that they should admit absolutely cold air, but that no special provision for heating it was used. The favourite idea was that the best way of consuming this smoke was to put a pipe in directly above the furnace, the cold air passing through the pipe is then heated.

Mr. Wm. Cochrane - No matter how the heat was got, provision must be made to obtain this temperature. Throwing air in at any lower temperature would result in a dense deposit of smoke.

Mr. Boyd (referring to the drawing of the "Weardale" furnace as altered, see Plate XVIII.) said, the stopping of the opening B below the bridge distinctly made smoke, and the opening of it distinctly prevented smoke. In the first case the air was admitted of a certain temperature sufficient to prevent smoke. When this was closed, it was not cold air that was admitted, but no air at all. He used the expression cold air comparatively, as distinct from air heated by any special arrangement.

Mr. Southern said, it was an important point with regard to the air being heated or not. Cold air would do injury to the boiler.

Mr. Morison said, he differed from Mr. Boyd. At Pelton Colliery they had Juckes' apparatus, and they had tried air passages along each side of the fire, and the air was thus first admitted at the back of the bridge. This produced smoke from Juckes' furnace. To remedy this they tried to bring the air in front of the bridge. The smoke still continued, and they had to stop up the air passages altogether; Their object in bringing in air at the side was that the process of combustion should not be so rapid; but they found it had the effect of producing an enormous amount of smoke.

Mr. Wm. Cochrane said, this carried out what he was saying. The principle of Juckes' system was that no more gas was given off from the coal than oxygen was supplied to consume it. Therefore they did not want the process of admitting air at the back. The admission of cooler air at this point seemed to
lead to the result he spoke of - the gases which would otherwise be consumed being deposited in the shape of soot. Mr. Boyd said, the passage of the air through this mass of brickwork was sufficient to prevent smoke. The bricks when heated would be of the average temperature of the gases.

Mr. Morison - It is not possible to work the Juckes’ with air admitted behind the fire. The quantity of air passed through the fire is diminished, and the gases evolved from the front are not consumed.

The Chairman - It appears that no air was passed in behind.

The Secretary said, at Devonport they had no air whatever through these bricks. They brought all the air through the bars. Anything which

( 93 )

diminishes the draft causes smoke. All modes would be successful with short bars if there was a good draft. It was his impression, from what he saw at Devonport, that it was not necessary to pass the air behind. Sufficient should be admitted through the door and under the bars.

Mr. Boyd - The shortness of the bar must be taken in connection with the width of the furnace.

Mr. A. L. Steavenson said, he regretted the absence of Mr. Nelson, who, in his paper, asserted that by mechanical firing a saving in coal could be effected - but it appeared to him that in wages and the prevention of smoke were to be found the only elements of advantage. Some persons seemed to think that the coals knew whether they were thrown on by hand or by mechanical means, forgetting that if the conditions necessary for perfect combustion were fulfilled that the results afforded by the coals must be the same in either case. If air was admitted to the fire in proper quantities the gases and hot carbon would yield the same equivalent in heat; whether the air was admitted hot or cold it made no difference, if it was hot more was required to supply the oxygen. He had tried the admission of air behind the bridge but got no benefit, and he did not see the object to be attained by short bars.

Mr. Wm. Cochrane said, he had prepared a few memoranda connected with the use of Juckes' bars, at Elswick Colliery, which he would give to the meeting: -

June, 1865, two boiler fires were set to work.
January, 1866, two ditto.
April, 1866, two ditto.
August, 1866 one ditto. Boilers 30 feet long by 5 feet diameter.
Each set of Juckes' cost £85 to £90, and £5 more for connecting shafting, &c."

One engine, 10 inch cylinder by 18 inches stroke, drives seven sets and feeds the boilers.

Since 1865 only one pinion has broken, the bars in this case having got fast; one worm casting has been worn out for each set; two worm wheels have broken; six water pipes at the back of the fire have been burnt through (the water deposits heavily and stops the flow through these pipes); the bridges require rebuilding and furnace sides repairing each three months; the boilers are at work day and night.

Bars. - Ten complete sets of inside bars (the outside bars last much longer) have been supplied to this date (August, 1868) to replace the wear and tear; cost including labour of fixing, £21 each set; average

(94)

duration of a set is, therefore, about eighteen months (day and night working).

Previously, with Argand fire-bars, a set of pokers and rakes was required for each furnace, and with almost monthly repairs were replaced in twelve months; there was also a heavy destruction of fire-bricks in the bridges and furnace linings, when breaking off the strong clinkers; now only two pokers and two prickers are used for the seven boilers, and these have not been renewed.

A set of Argand fire-bars (with air spaces cast in the bar itself) cost £7, 5s., and lasted about nine months.

[Paragraph with figures comparing the performance of Argand and Juckes' bars.]

Advantages of Juckes' - Perfect combustion of fuel; three firemen in 24 hours instead of six previously employed, and one of these three attends to the ventilator engine. The additional steam produced by the Juckes' enabled one boiler in five to be laid off.

Mr. Southern said, that in Juckes' the quality of the metal was more important than in ordinary bars. He was at a colliery in his district where some of Juckes' furnaces were used. In one furnace the bars were in a good state of preservation, while in the furnace adjoining, which was fired by the same
coals, they were nearly worn out; and those that were in a good state of preservation had been twice the time at work.

Mr. Lawrence said, as to the duration of bars in Juckes', one set of bars might have been neglected - that is, by some mismanagement, being allowed to stand still during the night - as much damage might be done in this night as in ordinary working would be done in six months, or even twelve months. He had had one working for three years twelve hours per day at a carpet factory, so that Mr. Cochrane's one-and-a-half year was just equal to that.

( 95 )

Mr. Morison said, at their colliery the bars of two furnaces had been working 24 hours per day since the middle of 1865, and those bars were really in a good state of preservation yet. He had made some notes on the subject. They had a Juckes' on each boiler. There was one fireman saved for every two boilers - that was Is. 6d. per day of 24 hours for each fire. The coal saved was one ton or 2s. 6d. per day. Each boiler consumed four tons per day, and it formerly required five tons. So that there was a saving per day of Is. 6d. on labour and 2s. 6d. on coals, making a total of 4s. per boiler, which at the end of the year amounted to £73, off which interest upon capital and a few other items had to be taken.

Mr. L. Wood - Almost every set of Juckes' bars burns a different quality of coal. Mr. Morison burns less coal; but he (Mr. Wood) generally found Juckes' burns more coal per foot of grate than the common bars, which enabled him to do away with a portion of the boilers and get more steam. The quantity of coal burnt depends greatly on the width of the set of bars.

Mr. Southern said, he was surprised to hear that more coals were used by Juckes'. He thought there was a saving by this apparatus.

Mr. L. Wood—There is a saving; for although they burn more coals per foot of grate, they burn less per pound of water evaporated.

Mr. Boyd said, Mr. Nelson stated that he was going to try experiments in Lord Durham's steamers, he would wish to know, what result had been obtained.

Mr. Marley said, he was sorry Mr. Nelson was not here, but he was glad that he had read the paper which had brought out this discussion. It was a disgrace to the North of England that so little was done for the prevention of smoke; for this district exceeded most others in producing it. The discussion had rather wandered from the original subject, which was the merits of mechanical firing
as against hand firing, for to-day it had principally touched on the combustion of smoke. They would agree with him that this should not be obtained at a sacrifice of the effective power of their coals. As regards the working of Juckes' apparatus he had before him the result of four or five years' experience with a different result from that given by Mr. Steavenson. He knew, as regarded his own experience, that taking the amount of work done, there were less boilers, less coals, and less firemen. Speaking approximately, in the number of tons of coals there was a saving of not less than 25 per cent. The saving in firemen was very much in the same ratio as named by Mr. Cochrane, and so in every other department. In the wear and tear of the boilers

he found an immense saving in connection with Juckes'. Occasionally they might hear it said - how does it happen that certain parties have had to take Juckes' out? The answer Mr. Lawrence gave was the true solution of this question. That in most instances people were put to superintend them who did not know what they were doing; and then when the apparatus was burnt or choked up, or spoiled, they had not the honesty to tell how the injury was done. Such he knew was the case.

Coming back to the subject of the mechanical mode of firing boilers, Mr. Steavenson had not told them of the method he had been using at Page Bank for supplying fuel to the apparatus, which was one of Vickers', and from Mr. Nelson's account very similar to Hall and Whitaker's. He thought the mode of supplying the fuel in this was an improvement. He hoped Mr. Steavenson would favour them with an account of its working. The drawing before them showed Juckes', where the whole of the coals were put on at the outside; but in Vickers' the coal was put on from above the end of the boiler, and dropped in by machinery almost as gradually as if it were sprinkled in by hand, the result being that the coal would be in combustion almost before it reached the grate. He should be glad if Mr. Steavenson would favour the meeting with particulars.

Mr. A. L. Steavenson said, the only description he could give of it was that it was worked by an eccentric.

Mr. Marley said, he hoped Mr. Steavenson would favour the Institute by supplying a drawing of the apparatus.

Mr. A. L. Steavenson - The eccentric rod was applied, so that it picked off a small quantity of coals which fell by gravity on the fire. He did not see the benefit of it himself. They had taken out the grate. He hoped they did not suppose that he disapproved of Juckes'. He would like to see it applied to every boiler. He only said it did not evaporate more water per pound of coal. He should be glad to take two boilers of equal dimensions, and put in common bars in one, and he would guarantee better effects with it than the other if fitted with Juckes'.

Mr. Southern said, he supposed there were instances where Juckes suffered from mismanagement?

Mr. Marley - Many instances.
Mr. Southern said, he thought there were many other circumstances to consider, for instance, the description of coals used. He had known instances where Juckes' had been used in one or more collieries, and after they had been properly investigated they were done away with. In other collieries of a similar extent they had been in use for some time,

(97)

and were still continued. This was very probably owing to the different descriptions of coal used.

Mr. Marley said, he was glad Mr. Southern had given him an opportunity of explaining. He had had it used with four or five different classes of coal, and it was found that at first only it did not answer with some of them. But experience had remedied this difficulty, for with every different class of coals they had to vary the width of the bars.

Mr. E. F. Boyd wished to ask Mr. Cochrane from what seams his coals were taken?

Mr. Wm. Cochrane - The Elswick Colliery coals are from the Brockwell Seam.

Mr. E. F. Boyd - That would account for the difference. The Hutton Seam had a large quantity of clinkers.

Mr. Wm. Cochrane - With respect to this, Mr. Lawrence had the direction of the manufacture of the first set of bars for Losh, Wilson, and Bell. They gave a good deal of trouble at first. Nothing but dust coal was used, and they were obliged to decrease the width of the bars. The speed of travel and also the thickness of coal on the bars must be experimented upon for each different class of coal; but Juckes' could be adapted to any class of coals.

Mr. L. Wood - Did you use dust coal when firing by hand as well as on Juckes' bars?

Mr. Wm. Cochrane - Yes, in both cases. In the one case it was 6.3 lbs., and in the other 6 lbs. of water per pound of coal.

Mr. L. Wood - It has been found greater than 6 lbs.

The Secretary, in reply to the remark of Mr. Marley that smoke consumption should not be attended with sacrifice of fuel, begged to state that as far as the "Weardale" was concerned the prevention of smoke had been attained with a corresponding saving of fuel, and he asked Mr. Forster to confirm him in that remark; because all their trouble would be cast away if these results were attended with
a loss of fuel. He most distinctly stated, that as far as the "Weardale" was concerned they prevented the smoke with a beneficial result.

Mr. Marley said, his remark with regard to hand labour applied equally to mechanical firing. He had no doubt that they could have the prevention of smoke. His remark was simply to say that they frequently obtained the prevention of smoke at a sacrifice of fuel; but they need not necessarily do so. With regard to his experiments he could depend on mechanical firing when he could not depend on hand firing. He was not calling in question the experiments to which the Secretary had alluded.

(98)

Mr. Morison said, with reference to the remarks which had been made as to his experiments, there might be some error; but he could assure Mr. Steavenson that he had very carefully gone into the matter and he had proved that the saving in coals alone was 26 per cent.

Mr. Marley begged to move that the discussion be adjourned.

Mr. Southern seconded the motion.

The Chairman said this was a very important discussion. No doubt the prosperity of this district depended on their carrying out these arrangements for preventing smoke, and more especially in marine boilers. They might congratulate themselves that owing to the exertions of their worthy Secretary in introducing short bars, they had made the North Country coal a smokeless coal. He could confirm what Mr. Bunning had said, that the "Weardale" had not used any more coal than she did before. And with respect to Juckes' furnaces he had no doubt, speaking from what he had seen of the working of one at the Durham Water Works, whilst there with Mr. Boyd and Mr. Bunning, that it was a great saving of power. There had been three boilers, and one was now laid off entirely. In the case of the water works they had a certain quantity of water to pump, so that there could be no mistake with regard to the power exerted. The meeting had better settle the point raised by Mr. Crone, whether the details of the experiments should be published. In an ordinary way, the Council had the power to decide; but this was not original matter, as they heard to-day it had been published by the Coal Trade before; therefore, the meeting had better decide. He would first take the opinion of the meeting as to the adjournment.

The meeting decided by show of hands that the discussion be adjourned.
Mr. Crone said, though these experiments had been published by the Coal Trade, still to strictly adhere to ordinary practice it was really necessary that the general meeting pass a resolution that those experiments with the plans be published. He, therefore, moved that they be published by the Institute.

Mr. Marley seconded the motion.

Mr. Wm. Cochrane said, it was an unnecessary expense for them to publish what had already been published by the Coal Trade. The documents could be bought for a very small sum.

Mr. L. Wood - All that is necessary to publish is on the black board.

The Chairman - Let the motion be that these, so far as necessary, with the plans, be published in the Transactions.

Carried by show of hands.

[ There follow between pages 98 and 99 :

Plate XVI : Waddle Ventilating Fan for Pelton Colliery
Plate XVII : Waddle Ventilating Fan for Pelton Colliery ]

( 99 )

FAN VENTILATION.

The meeting then proceeded with the discussion of Mr. Steavenson's paper on the Lemielle Ventilator.
Mr. A. L. Steavenson said, he had no further remarks at present. He thought Mr. Willis had promised a paper on the subject.

Mr. Willis said, he did make a sort of promise about a paper which he had not as yet been able to complete. He had made more experiments which would bear out what he had said as to obtaining 60 per cent. He would have the experiments ready for next meeting.

Mr. Morison said, he had a few notes on the performance of the Guibal and Waddle ventilators, at Pelton Colliery, which he would lay before the meeting:

1. GUIBAL.

This ventilator, constructed by a Belgian firm, was completed and set to work in September, 1865. The dimensions are as follows: Diameter, 29 feet 10, 1/4 inches; breadth, 9 feet 11 inches; eight vanes or blades; engine cylinder, 23, 5/8 inches diameter; stroke, 23, 5/8 inches. On its starting work a most complete set of experiments were instituted under the direction of Mr. Atkinson, the Government Inspector of Mines for the district, at which Messrs. Daglish, Cochrane, Armstrong, and several other gentlemen were present.

By these experiments (see Table No. I.) it was found that the average of useful effect realised by the ventilator, at its working speed of sixty-four strokes, was 59.1 per cent, of the power indicated on the engine, and subsequent experiments increased that average to 63 per cent.

At the above speed the quantity of air obtained varied from 91,000 to 106,000, according to the position of the regulating shutter; the water-gauge at the fan also varied from 2.7 to 3 inches.

A few experiments (see Table No. III.) were made recently to determine the amount of water-gauge obtainable by reducing the area of the fan drift, but owing to the difficulty of managing the doors with so heavy a volume of air as was then passing through them (about 140,000 cubic feet per minute) it was not practicable to have them properly completed. They appear, however, conclusively to prove the fact that, with the Guibal fan, owing to its peculiar construction, it is possible to obtain a higher Water-gauge than with any other centrifugal fan.

These experiments will be resumed, and it is hoped will be laid before the Institute in a more complete form.
2. WADDLE.

In May last year this fan was started, having the same underground conditions to fulfil as the Guibal. Diameter to exterior of trumpet-shaped circumference, 31 feet 6 inches; to circumference of blades 28 feet 10 inches.

The useful effect was found by experiments, given in a tabulated form (see Table No. II.), to be only 39, 1/2 per cent.; and although different means were adopted for altering the conditions of the fan, in the hope of increasing that per centage, none of them succeeded in so doing.

By a comparison of the Guibal fan with the furnace, of which some data are subjoined in Table No. IV., it appears, in round numbers, that the quantity of air is doubled by the use of the ventilator, while the quantity of coal consumed is reduced by one-third; and that the comparative annual cost of the two is in favour of the fan by about £100.

Since that note was written he had made some further experiments by altering the shutter (see Table No. V.).

Mr. A.L. Steavenson said, Mr. Morison was overlooking the question he had asked him - whether he had a difference of result at the same speed from the different water gauges - the conditions of the mine being altered?

Mr. Morison said, in the experiments of the water gauge by diminishing the drift the water gauge differed from 3.55 to 4.3 in the same sleugh.

Mr. A. L. Steavenson - By altering the condition of it one-tenth of an inch something like 20,000 feet of air is lost.
Mr. W. Cockburn - I wish to ask Mr. Steavenson whether in his further experiments they would get any information as to the original cost of the two fans?

Mr. A. L. Steavenson - The cost of the fan at Page Bank was very great; but if no Guibal will do the work, what is the use of comparing?

Mr. Wm. Cochrane - That is not yet proved. He had no hesitation in stating that the Guibal ventilator could be adapted more economically than any other ventilator for any practical experiments of mine ventilation whatever - and, that it would be a satisfactory apparatus under the combined circumstances of high water-gauge and large volume, where the Lemielle would entirely fail.

Mr. Willis said, he would give the cost of the Washington Ventilator. With the furnace they used nearly 72 lbs., and now but 12 lbs. per effective horse power per hour.

Mr. A. L. Steavenson - By increasing the drag of air with the Guibal it would soon produce no air at all.

The discussion was then adjourned, and the meeting separated.

[ Table No. 1 : Experiments on Guibal's Ventilator at Pelton Colliery, September and October, 1865 ]

( 101 )

[ Table No. II : Experiments on Waddle's Ventilator at Pelton Colliery, August 29th., 1868 ]

( 102 )

[ Table No. III : Guibal Fan Experiments on Water Gauge Obtainable by Diminishing Airway, Pelton Colliery, 4th. March, 1869 ]
Two furnaces placed in the Hutton-seam ventilated both that seam and the Busty Bank. Area of fire-grate, 48 square feet; average temperature of upcast, 207°; depth of upcast, 53 fathoms.

The Guibal ventilator which replaced them was set to work to ventilate both the above seams, and the above results were obtained at an average speed of 56 revolutions. The above horse-power obtained is that in the mine for the sake of comparison, the actual consumption at that time was 7 lbs. per indicated horse-power per hour, or about 11 lbs. for utilized horse-power.

EXPERIMENTS ON BOARD THE "WEARDALE."

The following tables or diagrams hardly call for any further explanation than that already appended by the author in the discussion. Each experiment is of an hour's duration, and records every operation performed by the stoker. It will be seen that each diagram is divided into squares, numbered in the top row from 1 to 60; these squares represent the minutes during the hour occupied by each experiment, thus, by recording any observation in the square representing the minute at which it was made, the different operations of firing, slicing, pricking, &c, and the exact amount of smoke made by such operation are placed clearly and relatively as to time before the observer. The figures 1 to 6, in the squares along the row styled smoke marks, indicate the intensity with which smoke issued from the chimney at that precise minute; a simple dot showing that no smoke whatever was visible; 1, that the very faintest indication of light coloured gas appeared; 2, that this was slightly increased, and so on to 6, which represents dense black smoke. The addition of all these marks, recorded during one hour, gives the "smoke equivalent" for that time. It will be seen that before the alteration this smoke equivalent averaged 107.9 over 25 experiments, that
frequently and for several consecutive minutes dense smoke was issuing from the chimney, and that there was rarely any actual cessation from smoke, while after the alteration no smoke of greater intensity than 2 was ever visible, and this only nine times in 18 hours, for a minute each time, and that during the same 18 hours the average smoke equivalent was 7.7; and as each mark so rarely exceeded 1 this indicates that the very faintest possible smoke was visible, only for 7.7 minutes each hour, no smoke whatever being visible for the other 52.3 minutes, it would be in vain to look for nor indeed can better results be found even when the best of the so-called smokeless coals are burnt; for all practical purposes, therefore, good Hartley coal, as consumed in the "Weardale," may be considered as smokeless as any known coal. The plate shows the alteration

made to the fire bars and bridge; the former were reduced from 5 feet to 3 feet 6 inches. The doors were not changed, and those shown are those used by the Admiralty, admitting air through the bottom. The secret of burning the North Country steam coal, and in fact all other good steam coal, is to put it on as large as possible, as thick as possible, and to have as great a draught as possible, so as to burn off as large an amount per square foot of grate surface as possible.

As far as the saving of fuel is concerned the owners affirm that the quantity supplied cannot accurately be given, but that since the alteration it has been somewhat less.

The chief value of these experiments is that they confirm the Government ones at Devonport, and form an interesting record of the exact process of stoking with medium and short bars at sea under the ordinary circumstances of a voyage, and in the absence of "dillitante."

The author has to acknowledge the kindness of the owners of the steamer, and to state that he is indebted to the captain and engineer in charge, and also to the engineer sent out to register the smoke equivalent, for the very intelligent way in which they carried out the operations decided on.

[There follow between pages 106 and 107:
Plate XVIII: Furnace fitted with Short Fire Bars in Steamship "Weardale"
Plates XIX to XXIV: Experiments on board the "Weardale" - Blyth to Havre - Before the Alteration
Plates XXV to XXVIII: Experiments on board the "Weardale" - Havre to Tyne - Before the Alteration
Plates XXIX to XXXII: Experiments on board the "Weardale" - Blyth to London - After the Alteration
Plates XXXIII and XXXIV: Experiments on board the "Weardale" - London to Shields - After the Alteration]
NORTH OF ENGLAND INSTITUTE of MINING ENGINEERS.

GENERAL MEETING, SATURDAY, MAY 8, 1869, IN THE ROOMS OF THE INSTITUTE, NEVILLE HALL, NEWCASTLE-UPON-Tyne.

ISAAC LOWTHIAN BELL, Esq., Vice-President of the Institute, in the Chair.

The Secretary read the minutes, after which the following new members were elected: -


James Dunn, Drummond Colliery, Pictou, Nova Scotia.


J. F. Ure, Engineer to the River Tyne Commissioners, Newcastle-on-Tyne.

J. B. Robson, Paradise, Newcastle-on-Tyne.

Mr. Marley said, as they expected in August next to have the pleasure of meeting the Mechanical Engineers from Birmingham as visitors, it was thought that it would be better to give notice to-day to make the June meeting special to consider certain proposed alterations in the rules, which he would now hand to the Secretary. This would take away as much routine as possible from the August meeting. Mr. Marley then handed to the Secretary notice of the proposed alterations, stating that at the June meeting he would give his views why they should be adopted.

STEAM BOILERS.

Mr. Waller read a paper on steam boilers, premising that it bore on the discussion of Mr. Nelson's paper which came on to-day, though it was put down as an independent paper. He added that this paper was written before he saw the advertisement of the Whittle boilers, with which he had no connection. At the request of Mr. Wm. Cochrane,

( 108 )

Mr. Waller made a sketch of his proposed arrangement on the black board. (See Plate XXXV.)
Mr. Wm. Cochrane - It cannot be cleaned at all without taking out the tank.

Mr. Waller - But the tank can be easily removed, or being made of sheet iron can be turned up at the sides.

Mr. Wm. Cochrane said, notwithstanding Mr. Waller’s remark that besides effecting a circulation, it afforded greater facilities for cleaning the boiler, he was of opinion that incrustation would be very difficult to remove from the boiler, when it took place below the tank.

Mr. A. L. Steavenson said, there were three important points in the paper - one was the mode of keeping a boiler clean, another was the comparison between the Cornish and other boilers, and the third was the distribution of air. As regarded the plain boiler he always preferred it himself to every other, not only for results, but because he thought it was safer. The inner tank was an idea which he had had for some time. Twelve months ago, he had spoken to one of their men to get a sheet iron tank, not for the purpose of saving fuel, but as a means of promoting the circulation of heat. The water was apt to be hot at one end and cold at the other. Mr. Waller confirmed what he had said about Juckes' bars. They do not economise fuel, but prevent smoke and save labour.

Mr. G. B. Forster wished to ask Mr. Waller whether the quality and description of coal used are given in his experiments

Mr. Waller - Yes.

Mr. G. B. Forster said, it was most important they should be. So many different results had been got from Juckes' and other furnaces that it was necessary to know the different kinds of coal used. One might be suitable for Vickers' and another for Juckes'.

The Secretary wished to know if any of these tanks had been in operation, and with what results; whether any formation of sediment took place in the tank?

Mr. Waller said, the idea was originally obtained from an old work of Galloway's, published in 1832, or thereabouts. The object of this separate tank was to collect all - both scum and the stuff held in solution, and with this addition, he did not anticipate anything would be deposited at the bottom of the boiler. With regard to cleansing the inside, he proposed to have the tank to stand on a frame. It was made of thin plate, and simply rested on a few bricks. It was suggested to put it on points of studs but he would put bricks in, in preference.

(109)
The Chairman said, the average number of boilers held by the gentlemen in that room must be considerable, and he hoped to hear remarks from some of them.

Mr. W. O. Wood said, that at Brancepeth Colliery they had been using Juckes', and after a month's experience he was sorry to say they had not given the result expected, or that they had been led to expect. They had five ordinary cylindrical boilers, and two Cornish boilers. Before they got Juckes' they could easily get steam with four of the ordinary boilers and two Cornish ones. Since they had got Juckes' put in, though they had taken great pains to get them put right in every possible way, they could scarcely get steam with all the boilers they had. They did not boil off nearly the water, or give nearly the results they had from the ordinary furnaces. At Oakenshaw, Vickers' improved furnace was used, and it gave satisfactory results. It boiled off a large quantity of water, as much or rather more than the hand firing, and it made no smoke at all. Not having any water meter, he could not say what quantity of water was evaporated in the respective cases. He took the practical results as compared with the work got from the boilers before. They could not get the same quantity of coals drawn at Brancepeth Colliery as before Juckes' were put in.

The Chairman - That is not a very bad way of judging.

Mr. W. Spencer said, that it had often occurred to him whether it would not be better to cleanse the water before it was admitted into the boiler instead of taking measures to collect or blow off the scum or sediment, or prevent damage done by the sediment after it was there. Mr. Bell's chemical knowledge being superior to that of most mining engineers, he hoped he would kindly favour them with some opinion on the subject if it were not asking too much.

Mr. A. L. Steavenson said, the results he had obtained confirmed Mr. Wood's experience, although many difficulties might be obviated by making the bars wider and using larger coals. With respect to Vickers', the experiments he had made showed that it had obtained good results; its only fault being that instead of working at the present day it was lying in the waste heap. He gave it every chance; a short trial, however, had proved that it was of no use. At the last meeting, Mr. Marley had called attention to a method of putting coals on to the fire, which was almost like Juckes'.

Mr. Marley said, he saw the Vickers' feeding operation at Page Bank, and he thought it was a great improvement.

Mr. A. L. Steavenson said, they had another mode of feeding
supplied by the same parties - the plunger - which he thought better than the arrangement of Juckes'. The difficulty was to get the coals carried forward over the grate. All the bars were entirely burnt away in the Vickers' supplied to him.

Mr. W. O. Wood said, they had had Vickers' in operation six weeks, and the fire was never touched from morning to night. There was no feeding at the front end of the bars necessary. He thought the difference was merely owing to the mode of construction.

Mr. A. L. Steavenson said, they had had Vickers' man himself to superintend their erection, so that it could not be from any fault of their own.

Mr. Southern said, the statements with respect to Juckes' and Vickers' were incomplete. He thought it was desirable that some of the members of the Institute should test the results in figures. Let them give the quantity of coal used and the water evaporated - whether steam coals were used, and whether the boilers were connected with the same engine. He would be very glad indeed if some one would take it up and give them experiments.

Mr. A. L. Steavenson suggested the use of a square box containing 50 gallons at a time, which could be pumped out, and which would avoid the necessity of a water meter altogether.

Mr. Nelson remarked that when he read his paper he stated that the results were conflicting. With one class of coals one or two boilers might be dispensed with out of six. In others, if they had six boilers, one or two must be added. As far as he could see steam coal was well adapted, and soft coal was not well adapted to Juckes' system. He inferred from what Mr. Steavenson had said, that they used soft coal.

Mr. Wm. Cochrane said, he used soft coals. The government inspector had thrown out a very proper suggestion. Let them ascertain how many pounds weight of water they could evaporate per pound of coal - not whether more boilers were wanted, or less; because it was quite possible that in hand firing, they were abusing their boilers and wasting a great deal of coal. This would be the only fair way of comparison. In hand firing with too few boilers, everybody knew a great quantity of coal was burnt with great damage to the boilers and waste of fuel. By having an increased number of boilers the wear and tear would be much less.
Mr. W. O. Wood said, he did not find that in his case the hand firing did any such injury to the boilers as Mr. Cochrane seemed to expect. As a proof of this, two boilers had been taken out recently which had been at work no less than 27 years, and replaced with new ones. This was as a precautionary measure, and not because there was any fault in the condition of the boilers. Apparently they were in very good condition, but he thought they had done duty long enough.

Mr. Wm. Cochrane said, he had given the results per pound of coal with Juckes', and then with hand firing. He had also given a careful record of the cost of the bars.

Mr. Cockburn said, a pamphlet had come into his hands containing a paper read by Mr. Head, at the Institute of Cleveland Engineers. One question he raised was, how much water could be evaporated with one pound of coal. It appeared that he tried a 45 feet boiler of four feet diameter, with a flash flue of the usual proportions. The water was measured in the way suggested by Mr. Steavenson. The top of the boiler was protected. The coal was first-class South Durham coal, giving one-and-a-half per cent of ash. He used the usual mode of stoking good coal. 750 degrees escaped from the boiler, and one pound of coal evaporated 7.3 lbs. of water. He did not say whether they were small coals or round.

Mr. Nelson said, he obtained like results with a Juckes' furnace 2 feet by 3 feet 6 inches. Having all his coals to buy, he could observe the saving, and he found in a decidedly pleasant way that it was very considerable.

The Chairman - You did not mention what the saving was.

Mr. Nelson - It is mentioned in some instances, but in general terms.

Mr. T. Douglas said, that in looking at the arrangements at Page Bank, which Mr. Steavenson had kindly allowed him to do, he thought something might be said as to the kind of coal employed; he
thought he noticed at the time, and made the remark that it was unscreened coal; and that at the end of the bars there seemed to be passed over coal merely charred, and to a considerable extent unconsumed. It always struck him — though not having much experience he could not speak with authority — that coal of a thin character or size was most adapted for these Juckes’ furnaces. He would ask Mr. Steavenson if he had tried small coal, and what result he had secured. He thought, however, at that time he was using unscreened coal?

Mr. A. L. Steavenson - Yes, on that particular occasion, but generally he used small. Small was almost as valuable as the rough. If the coal fell over unburnt it was put on the fire again. He did not think this loss of coal, as Mr. Douglas seemed to imply, was the cause their not obtaining economy. He was not aware of the difference in

(112)

cConsumption when using large and small. When they used large coal they could afford to have the bars more open; and to burn a larger quantity per foot of grate.

Mr. Waller said, the experiments which Mr. Head conducted gave 50 cubic feet of water per hour for 126 hours per week. He had taken 7 lbs. of water to 1 lb. of coal as the standard, to which other boilers were expected to come up. The plain cylinder gave 7.3; he took it another way and got 7.5. The coals were South Durham small.

Mr. W. Boyd said, at the last meeting he asked a question, but Mr. Nelson unfortunately was not present, and he could not get it answered. He ventured to ask it again; that was, whether he had not made some experiments in some steamers with Juckes’ bars, for the prevention of smoke?

Mr. Nelson said, he was unavoidably absent at the last meeting. The furnace tried, on board the steamer, was the ordinary construction of Juckes’, but it was tried for two voyages only, and though it was not successful, the failure was attributable to circumstances which, he thought, could be remedied. Certain objections which were previously raised, and which, in point of fact, were most serious objections, were answered. It was said that it was a complicated apparatus, and if such a thing went wrong on board ship the results might be serious. On the second voyage the thing did go wrong. It was then fired by hand, and as much steam was got as if it had not been there. He had no hesitation in saying, if the thing were followed out - for it required a certain amount of experiment - it could be brought to perfection. His opinions were confirmed by what he saw on the voyage. One feature in firing all mechanical furnaces was in the fire-brick arch in the front. It was necessary that the fire-brick arch should be raised to a certain temperature before the furnace
began to work properly. Great importance was attached to the placing of this arch. If it was more than a certain distance off the fire would not work. He found great difficulty in attaching this to a marine boiler. That kind of boiler required some special construction before it could be applied.

Mr. W. Boyd said, he would like to know whether all idea of prosecuting the experiments further had been abandoned.

Mr. Nelson said, some experiments had yet to be made.

Mr. W. Boyd - With large or small coals?

Mr. Nelson - The first trials were made with nut coal, but the coal was so extremely small, and not being steam coal it did not work so well as large steam coal would have done; though he believed if steam nut coal had been used it would have been the best coal that could be tried. But it was not steam coal at all, it was a soft friable gas coal.

Mr. W. Boyd asked in what particular respect the furnaces had failed?

Mr. Nelson - They gave way owing to the intense heat of the furnace. The draught was so very strong, and the expansion of the bars became so great that they stuck. Every provision was made against a deficient draught; but when the thing was fairly got to work it was found that provision was necessary against an excessive draught; so that all the provision had been made in the wrong direction. Things which ought to have been stronger than usual were lighter than usual. The experiments, however, proved that it was possible to burn an amount of coal per hour by Juckes' apparatus which was previously considered impossible.

Mr. W. Spencer said, he observed the distance of the grate from the boiler was not mentioned. He had known a very great difference arise from putting it nearer to or further from the bottom of the boiler.
Mr. W. O. Wood - At first we put our Juckes' 2 feet 2 inches below the boiler. They were then altered to 18 inches, which answered much better. The furnaces have flash flues.

Mr. Forster - Are you burning as many coals as before?

Mr. W. O. Wood - Quite as many - in some cases more. At the A Pit we are using small coals. In one instance Juckes' is using nearly twice the quantity. It is only fair, however, to state that this is owing to the nature of the coal.

Mr. Nelson said, when the apparatus got out of order on board the steamer and they had to fire by hand the results were the same as before; he meant before any apparatus was introduced. Only one furnace was tried out of three. The apparatus was put in to try its efficiency for steam getting. In answer to Mr. Waller, he knew one instance in which considerably more steam was raised by Juckes' system, and where seven furnaces did rather more work than was previously done with nine; although this might be owing to other circumstances.

Mr. G. B. Forster said, this showed the desirability of keeping to Mr. Cochrane's plan to ascertain the quantity of water boiled off. With regard to Mr. Wood's experiments, perhaps the engine had gone wrong, and something was the matter with the condenser.

Mr. W. O. Wood said, the engine was perfectly right.

Mr. T. Douglas said, Mr. Coxon was here. Perhaps that gentleman

(114)

would favour them with his experience of Juckes' furnaces as constructed at Pensher.

Mr. Coxon said, they had tried two of Juckes' at Pensher Colliery. The engine was driven by two boilers which required very hard firing by hand. After they had put in Juckes', they had to have another boiler to work the engine. He had made some experiments as to the comparative power of
mechanical firing, and he found that he could raise one pound more of water per pound of coal by hand firing than by Juckes'. He had taken out Juckes', and would be glad to sell it to any gentleman.

The Secretary said, perhaps his friend Mr. Wallau could give them particulars respecting some mechanical furnaces which had been used for steamboats at Messrs. Palmer Brothers, and which he had heard had been eminently successful.

Mr. Wallau said, he had left Messrs. Palmer's, but Mr. Tweddell could give the information.

Mr. Tweddell said, he had mentioned before a mechanical arrangement which had answered when Juckes' had entirely failed. It was put in by Mr. Jordan, of Liverpool. It was something similar to Hall and Whitaker's, but not exactly the same; it was patented; it was first fitted on board the "Manhattan," and afterwards in other steamers, where without smoke, the quantity of water raised per lb. of coal was better, he believed, than that obtained by hand stoking on board of the same class of steamers. These steamers were running in competition with the Inman and Cunard lines, and they answered well. The bars which Mr. Nelson alluded to melted away, and yielded no advantage whatever. Simply as a matter of construction, he would be glad to hear why Vickers' seemed to answer and Juckes' did not. It seemed to be simply a matter of mechanical arrangement. However, Jordan's answered every purpose on board ship.

The Secretary wished to ask if they had any mechanical contrivance connected with the firing apparatus which took the coal from the bunkers and placed it on the bars?

Mr. Tweddell said, the bunkers were of the ordinary construction, and he did not think there was any special apparatus for bringing the coal from them.

The Secretary said, that mechanical stoking, as applied to steamboat purposes, was a most important matter. No doubt a large number of stokers could be dispensed with if some mechanical apparatus could be fitted up where they had a long row of furnaces - some large ships had as many as forty. It would tend to economy in the working of the ship;
and also increase the comfort of the stoke-hole, as this part in ships of war was entirely under water. It was desirable that these experiments should continue and the system of mechanical stoking on board steamers be perfected as much as possible. He hoped Mr. Nelson, with his experience, would not be discouraged by the little check he had met with. He (Mr. B.) had had a long conversation with Mr. Straker on the subject of putting Juckes' furnaces into his ships, and strongly urged the desirability of so fitting not one only, but the whole, for it could not be ascertained if the smoke was done away if only one furnace was put in. Also, there were many improvements for taking the coals from the bunkers, and many other arrangements that could be made to perfect the apparatus and give it a fair trial, if all the furnaces were so fitted, which it would be hardly worth while to go into where only one was altered; and if the coals are put into the hopper by hand, it would require almost the same amount of stokers as to stoke at once by hand.

Mr. Rake inquired whether the furnaces in the "Manhattan" were all fitted with Jordan's bars, or only a portion?

Mr. Tweddell said, he believed only three. But the "Colorado" had 32 furnaces, all fitted up with these bars.

The Chairman said, he agreed with Mr. Waller as to the desirability of keeping a record of experiments; but it should be a record of all experiments, successful and unsuccessful. He might mention that a machine something like that which was laid down in the drawing (see Plate XXXV.) was made at Washington by himself, for the purpose of feeding the fire gradually, but instead of the moveable furnace being so placed that its machinery was liable to destruction by the fire, it occurred to him that the regular feeding might be accomplished without exposing the apparatus to the action of the fire. There was no difficulty in consuming fuel without smoke, if the air going into the furnace regularly was sufficient to combine with the hydro-carbon which was given off by the supply of coal, but the moment this was not the case they had smoke. The youngest student of chemistry was aware that the hydrogen in the hydro-carbon, having a greater affinity for oxygen, was the first to be consumed and converted into water; and the portion of the carbon that was not so oxydized escaped in the form of smoke. To prevent smoke we must always give the furnace the same work to do, and this he was enabled to do by means of a travelling web of cloth, which supplied coal with the regularity with which oil was delivered to a moderator lamp. This was the idea he had in his mind when he constructed the apparatus; but there was an unforeseen difficulty upon which he had not calculated. The value of our Northern small
coal consisted in each small piece having the agglomerating power of attaching itself to another fragment, and so forming a mass of larger pieces of fuel. Now, the consequences of the arrangement described above was that each fragment of coal was separately coked when it got into the fire-place. Each piece, when used in the ordinary way, however small, went to form, as it were, a large piece of coal, which was only broken up by the fireman. But his process, which on paper looked very well, and for a time answered perfectly, eventuated in an entire failure. The fire became a mass of separate small minute cinders, in which no vivid combustion could be kept up, as there was no getting air through it. Mr. Spencer had appealed to him to say whether there was any means of purifying the water before putting it into the boiler. In many cases it was quite easy to do so. For example, Professor Clark, of Aberdeen, had taken out a patent* for providing purified water. The impurity of water, generally speaking, consisted of bi-carbonate of lime. Professor Clark added another equivalent of lime, and thus forming two equivalents of insoluble proto-carbon, threw them both down. Another way would be to boil the water by which they would get quit of most of the lime, but there was another substance - sulphate of lime - which was not so easily got rid of. Then there were impurities brought into the boiler in the shape of mud - and occasionally iron dissolved in caronic acid. This on being boiled was precipitated. They all knew that flocculent matter suspended in water was much more speedily precipitated after boiling than it was before. Whether this apparatus of Mr. Waller was capable of doing all that he proposed seemed rather doubtful. He should have been much better pleased with the plan if Mr. Waller could have referred to a boiler in which the plan had been in operation for six months, and had never produced any incrustation. He must himself confess some little fear whether the process of circulation would not deliver into the exterior space a portion of flocculent or precipitated matter. With regard to the important question as to the greatest amount of work they could obtain from their coal, of one thing they must be perfectly satisfied, that a pound of coal or anything else that they distinguished by the name of a combustible, when perfectly burnt, never gave more and never gave less heat at one time than another. It was quite true that our coal was not always perfectly burnt, from a variety of causes - one of which met them in the most offensive form in the shape of smoke. He blamed the North of England, himself included, with this manifestation of imperfect combustion as evidenced by the smoke which they saw around them-

* Clark's Patent, No. 8875, 1841.

( 117 )

But while he said this, he must protest against the nostrums of the smoke doctors and mechanical furnace speculators. He seldom had met with one of them in his own experience who did not claim the power to effect a saving of 30 per cent. Now, the first thing which we have to consider was the quantity of material given off in smoke. They could calculate the number of thousand feet of gas in a given quantity of coal, and knowing the composition of hydro-carbon it was easy to ascertain the amount of carbon in every cubic foot of gas. He spoke from recollection, but he had been at the trouble to ascertain the extent of carbon in smoke given off from our coal when under combustion.
Taking the worst furnace, not much above one-third of the time was the smoke visible, and the total quantity of carbon given off in that smoke was from 5 to 10 per cent, reckoned on the weight of the coal. On what principle, then, could these gentlemen effect a saving of 33 per cent, from the consumption of smoke, a portion of which was still burnt even with the worst furnace? This, however, was only one way which caused loss of fuel. There was another to which he had always attached some importance, and that was the imperfect way in which the solid portion of the coal was frequently consumed, and this Juckes' bars avoid, they consume the coal better, and they consume it with the regularity of a machine. The question, as Mr. Cochrane had put it was, what was the effect of a pound of coal measured by pounds of water evaporated? It was of great importance to determine to what extent the heat was escaping up their chimney, as well as whether they burnt their coal so as to get all the heating power from it. Every degree the temperature of the flue at the far end was above that which was necessary to get a perfect draught, was a direct loss. It had been laid down by experiments, and proved mathematically, that every degree of heat in the chimney above 572° F. was a loss. He did not know that he had anything more to say, further than assuring them it was a question in which he took a great interest, and he should be glad to assist the mining engineers in the prosecution of so important a question as the combustion of coal.

Mr. W. Boyd inquired if it was a boiler furnace to which the self-feeding apparatus was applied alluded to by Mr. Bell?

The Chairman - It was a boiler furnace.

Mr. Nelson remarked, that when he read his paper he was being supported in many ways by Mr. Whitaker, about whose furnaces he had made some observations. That gentleman died, without a day's illness, very suddenly, between his reading the paper and the first discussion; so that in this discussion and the experiments, he had been deprived of that gentleman's valuable assistance.

Mr. Marley said, he partly expected the Chairman would have followed up his excellent address with some proposal for testing the merits of Juckes' and other furnaces. Mr. Steavenson, on the one hand said, he had taken out Vickers' and left Juckes'; and Mr. Wood on the other, said, Juckes' does not answer and Vickers' does. It had been suggested to him whether they should have a committee appointed to carry out experiments; but perhaps it would be better to ask voluntary assistance from those who actually had these various apparatus, Juckes' and Vickers', at work, or better still, first let the Council agree on certain rules to be laid down by which to carry out these experiments, each stating the class of coal used, the depth and length of bars, and also the area of furnace, and what
distance the grates are from the boilers, so that they might have some data to go upon in deciding whether Juckes', or Vickers', or hand-firing was the best. He suggested that it would be best for the Council to lay down fundamental specifications, and then ask the volunteers to pursue their experiments over a specified number of hours. He did not know whether it was necessary to move a resolution on the subject. The Chairman, in one part of his address, spoke as though the only mode by which Juckes', Vickers', or other apparatus could effect economy was by perfectly consuming the fuel and preventing smoke, but there was another advantage, viz., prevention of waste, which, he felt sure, every person would willingly accord to every self-acting contrivance, who had seen the barrows of half-burnt and even wholly untouched fuel which were constantly wheeled away from hand-stoked boilers. With regard to the mode of conveying the coals to the furnace, the Chairman had not stated at what period of his experiments the fires were put out; but he would suggest whether a remedy might not be found in connection with the cloth, if once per hour, or at some other interval, some small quantity of coal was put on by hand, and so still have the advantage of mechanical feeding for the bulk of the time. Another point alluded to was the impurity found in water. Now, it appeared somewhat paradoxical when he stated that a friend of his in connection with a large mining establishment in Cleveland, where they had eight or nine boilers, which had only been erected a short time, found they had suffered considerable injury; and after the best investigation by chemists, as well as by himself, it was ascertained that this injury arose from the purity of the water. They had to add impurities of a given class; and until they did this, the plates were positively cut, and the deterioration of the boilers was very alarming.

The Chairman said, Mr. Marley's remarks as to the essential purity of water affecting iron were borne out by his own experience. At Clarence they put in surface condensers, and delivered the water so condensed to a locomotive. The result was, that they found a considerable deterioration of the iron of the boiler; and this was remedied by using a proportion of water that had not passed through the condenser. If the matter was inquired into this result was not so paradoxical as it might appear, however unexpected it might be. It was quite possible, however, that pure water might set up between the different portions of iron an electric action. If they immersed metal of a perfectly uniform character in any liquid no electric action could be set up. They must have two poles in order that action be set up. Iron, however, was not perfectly uniform in character. There was an oxide which iron-makers called scum. No doubt between the silicate of iron and the metal itself an electric action was set up; and it would seem as if pure water was best adapted to promote that action. A quantity of impurity being constantly found in the iron, the more perfectly pure the water was the more the boilers suffered.

Mr. Marley said, in the case he had just alluded to, where the water had been found so excessively pure, a certain proportion of lime was added in the cistern through which the water had to pass.
before it got to the boiler. This formed a thin film on the plate which could be rubbed off with the finger without causing injury to the boiler.

The Chairman - Water had been looked upon as an indifferent substance; but it had ceased to occupy that position. It was looked upon now as an agent, he would not say of great intensity of action, but it was quite possible that pure water might have this action in the highest degree.

Mr. W. Spencer said, he had known great damage arise from tallow.

The Chairman - Yes, if it contained acid. For instance, the acid would act on copper.

Mr. W. Boyd said, in marine engines with surface condensers the water was used over and over again, and was found to act on the boiler. This was remedied by a certain admixture of salt water. This action was generally about the water level. The same effect was produced by the fresh water of the lake of Windermere, where the water was very pure. The boilers in each case were eaten into small holes, something like the marks of small-pox.

(120)

The Secretary said, some years ago the Admiralty used deliberately to whitewash their boilers inside, and this prevented corrosive action entirely, where surface condensers were used.

Mr. Nelson said, a small quantity of sal ammoniac introduced was beneficial. It did not act on the plate, but simply on the carbonate of lime. The sal ammoniac became decomposed. Of course it should be introduced with very great caution.

The Chairman - It greatly depended on the nature of the impurity. Its action produced carbonate of ammonia and chloride of potassium, both of which were extremely soluble.

Mr. Marley said, that in the case of the pure water he had alluded to, there were occasionally to be found in the boiler the pimples, compared by Mr. Boyd to small-pox, but the more serious and particular action was a regular marking in the plate, so that ultimately the plate would have been, as it were, cut through.
The meeting then broke up; the discussion on Lemielle's Ventilator being adjourned.

( 121 )

ON STEAM BOILERS.

By WILLIAM WALLER.

As this is more a supplement to several of the valuable papers which form the Proceedings of this Institute than an independent paper, it will be unnecessary to preface the remarks. The object of the writer is to lay before the members, in a concise form, the results of some experiments which might otherwise not become known to them, but which are at least worthy of being recorded, and to draw from them certain conclusions for consideration, if not for adoption, and to invite discussion upon them.

It has often been a matter of regret that there has been no place in which to record, for reference, experiments that have been made, and, therefore, the same, or similar, have been repeatedly gone into without any result being known except by the persons making them; but it is to be hoped that the Proceedings of this Institute may in future receive such communications as will enable the time and labour thus expended to be made available to others wishing to follow similar investigations.

It seems to have been admitted that the two examples of tubular boilers, the locomotive and marine, are the most economical generators of steam, but whether this position can be maintained in future experiments, seems open to doubt; next to these have been placed the Cornish (one tube), the Lancashire or Fairbairn (two tube), and the Galloway boilers; while lowest on the list comes the plain egg-ended cylindrical boiler, the boiler of this district, and the one especially adapted for colliery and other out-door work.

But in the reverse order to the above, as to their first cost, the cost of repairs, and their durability, these boilers offer scope for enquiry; although it is not proposed to enter upon this part of the question now.
A series of experiments, not yet completed, have shown the quantity of water evaporated by one of the plain cylinder boilers, with Juckes' furnace, as from 4 to 6 lbs. water per 1 lb. of small smudge or refuse coal.

With the wheel flue and hand firing the result has been 5.2 to 5.5 per 1 lb. fuel as above. The Cornish has given from 7.5 to 8.7 per 1 lb. of the same fuel.

The plain cylinder, with flash flue and hand fired, has given results from 6.9 to above 9 lbs. water per 1 lb. of the same fuel.

The writer hopes to be in a position to lay these experiments in detail before a future meeting, but the results of the experiments given in the tables annexed will show how far the assumption of the superiority of one class of boiler over another is justified.

The writer was quite prepared to find the low results given by Juckes' furnace, as he has almost invariably found that where that has been applied to avoid smoke the boiler has been found to be insufficient. That the wheel flue is not so efficient as the flash flue has been before proved, and in the above instance there appears to be a reason for the difference. The boilers were exactly alike, but one had been altered to the flash flue and more fuel was consumed than with that set with the wheel flue, in the same time and with increased economy. The value of the method of seating with the wheel flue may be better estimated by reference to the Wigan experiments given, where by dispensing with the external flues the evaporation was reduced only about 14 per cent.

The one tube (Cornish) was tried under exactly similar circumstances as the plain cylinder boiler, and the chief reason for it not giving a better result appears to be that a sufficient quantity of fuel cannot be consumed on the bars.

While the small value of the side flues is proved, the great value of bottom heat is also confirmed, and from these it would seem that the extension of the flash flue up the sides of the boiler was wrong. It has come within the knowledge of the writer that where the side flues of the flash flue have been lowered there has been more regularity in working.
There are some boilers in this district now being seated with flash flues, having the grates and flues the width of the boilers, but the upper portion of the flues gathered in to about two-thirds of that width so as to keep the whole of the flame under the boiler without any being lost in the brickwork. There is another advantage in this plan which, though trivial at first sight, will be found to be of great value. The knees and brackets may be dispensed with, and the boiler lies upon its bed in the same way as the Cornish and Lancashire boilers. The boilers referred to above are 4 feet 6 inches diameter, and the flue is contracted at the top to 3 feet 6 inches, the boiler forming the crown of the arch, a plan suggested by Mr. Giers, of Middlesbro', and they are to be worked with only 1 foot 9 inches of water in them, giving large steam space. This plan, combined with the inverted bridges adopted at Wigan, considerably increases the value of the plain cylindrical boiler, and dispenses with the knees, which are such a continual source of leakage and expense.

(123)

It may be interesting to know what are the objections raised to the plain cylinder boiler, of which it is fair to assume there are fully eight times as many in use as of any other kind. It is called "treacherous," "dangerous," but why? It is certain that when at rest, the earthy matter previously held in the water that has been evaporated, and kept in circulation by that water remaining in the boiler with itself, is allowed to fall to the bottom and become a deposit upon the plates upon which the fire acts, so the free transmission of heat is stopped by this nonconducting covering, and the plates suffer from the flame. But while admitting such to be the case, it will be fair before accepting the condemnation of the boiler, to see in what way we are behind those who are advocating the Lancashire boiler and Juckes' furnace combined; for it may not be known that here also the furnace is under the bottom and the furnace tubes are return flues! The evil exists in the one case as much as in the other, and, therefore, instead of condemning the plain cylinder boiler they ought rather to assist in finding a remedy for the evil above-mentioned. Before continuing the question as to the remedy, there is a subject which the writer has not seen named before, to which he wishes to call attention. During the experiments with the plain cylinder boilers, it was found that when ebullition became very rapid, there was a wave formed in the boiler; this may be verified by watching the motion of the floats or the water in the gauge-glass, and may have given rise to the theory of gases formed under the water; but it will be easily accounted for by the large fierce furnaces under the front of the boiler, causing all the circulation to be from the front to the back, without any arrangement for a supply to the front, which may be obviated by a pipe being brought from the back to the front of the boiler. There is a plan now being tried, which will meet both these evils, and its simplicity will not be its least recommendation. A sheet iron liner, or internal tank, placed about four inches from the bottom and sides of the boiler, and extending to about the centre, but below the water line, and nearly the whole length of the boiler, is provided, and into this the feed water is carried. It will be seen that the circulation will be up the outside of this vessel, while inside of it the water will be in a comparative state of rest, allowing the earthy matters to be deposited, and the
circulation will assimilate to that of the Cornish and Lancashire boilers in the point for which their superiority is claimed.

By this simple and inexpensive plan the cost of repairs and cleaning, will be lessened, and a superiority obtained over any other boiler at present in use.

One important consideration is the best length for a boiler. Boilers are in use up to 83 feet long. About four years ago there was some difference about this point, and from the results of experiments then made, 60 feet was adopted. In some more recent experiments a small boiler was placed at certain distances, in a flue, which passed the heated gases from a boiler to the chimney stalk, and the time taken to raise steam to 10 lbs., and so on to 50 lbs. was noted.

So that in this case 50 to 60 feet was adopted also.

In the question as to the fire-grate, so little remains to be said, that it is hardly worth alluding to it, except for one point. It has been shown that thick hand firing, with short bars, is unsurpassed; on the other hand the evil of admitting air cold, while firing, is urged against hand-firing, and justly, but there is no reason why cold air should be admitted even then, if the furnace is withdrawn from under the boiler altogether, which arrangement presents also other great advantages, both in the saving to the plates, the greater quantity of fuel that may be burnt with even a small tube Cornish boiler, and consequent better result per pound of fuel. There is no new theory involved - it is but a slight variation of the deflecting arches or inverted bridges of the Wigan experiments, and with reference to Plate XXXVI. may be described as follows: -

The boiler a is provided with a liner or inner case b c, extending the full length, but with the front end b "lipped" to allow the water to pass over there, and to regulate the circulation. The furnace front e may be made of firebrick or iron bars, and either fixed or rocking; if rocking the motion may regulate the feed, as well as prevent the fuel caking over. At the bottom of this front is a space f left for clearing out clinkers and ashes, the bottom grate also allowing ashes to fall as in the present bars. The furnace has a back wall or bridge g, and between this and e the fuel is burnt. Behind the bridge g is a hanging bridge or deflecting arch h, protecting the end of the boiler from the direct impact of the flame and cold air, and a similar bridge at the back
end closes the combustion chamber or flue. The wall may be protected by water boxes or air chambers. The furnace is made on wheels or fixed, the former being preferred for the more ready opportunity of cleaning and examining the bottom of the boiler. The furnace, when in use, is placed within the arched chamber. The hopper being filled with fuel, various means may be used for feeding the furnace by mechanical action, such as rollers, brush, or vibrating plate. Air is admitted through the front of the furnace for the combustion of the fuel, and the gases evolved receive a further supply passing through the top of the front where little, if any, fuel will be regularly kept, and these passing over the bridge strike the hanging bridge, and pass downwards into the flue. Any cold air which may be admitted will be mixed with the gases and heated by the brickwork before reaching the boiler itself, and a steam jet may be introduced through the bridge wall. Instead of the heat being carried along the sides of the boiler, the whole is kept under the bottom as more effective, and the communication with the chimney is at the bottom of the flue instead of being at its highest level; thus the denser gases are taken away instead of the lighter, and the heat is detained under the boiler. The advantages to be derived are more steam space and drier steam, greater duty from each pound of fuel, fewer repairs, and the absence of furring on the inside of the boiler. One furnace may be made to provide heat for several boilers, on a plan similar to that adopted with the gases from the blast furnaces.

Since the above was written, the Iron and Coal Trades Review of April 21 has appeared, containing an advertisement of the "Whittle Boiler," which is somewhat similar to what is recommended here, but differs in some essential particulars, such as the level of the water and the bottom pipes.
G. B. FORSTER, Esq., Vice-President of the Institute, in the Chair.

The Secretary read the minutes of the previous meeting, and also the minutes of the Council. A communication had been received from Mr. Willis, stating that circumstances had prevented him from getting his paper ready.

The following new members were elected:

Honorary Member

Warrington W. Smyth, Jermyn Street, London.

Members

Thomas Douthwaite, Wallsend, near Newcastle-on-Tyne.
Thomas Gray, Underbill, Taibach.
Monsr. Legrand, Mons, Belgium.
Monsr. baeck, Mons, Belgium.
George Bailey, Colliery Proprietor, Wakefield.
Thomas Pickersgill, Waterloo Main Colliery, near Leeds.
John Cross, 78, Cross Street, Manchester.
Mr. Marley brought forward the proposed alteration of rules, which, with some modifications by Mr. Cochrane and Mr. Waller, were adopted by the meeting; Rules 10, 11, 12, and 25 will now stand as follows.

10. - Persons desirous of being admitted into the Institute as Ordinary Members, Life Members, or Graduates, shall be proposed by three Ordinary or Life Members, or both, at a General Meeting. The nomination shall be in writing, and signed by the proposers, and shall state the name and residence of the individuals proposed, whose election shall be balloted for at the next following General Meeting, unless it be then decided to elect by show of hands, and during the interval notice of the nomination shall be exhibited in the Society’s room. Every person proposed as an Honorary Member shall be recommended by at least five Members of the Society, and elected by ballot at the following General Meeting, unless it be then decided to elect by show of hands. A majority of votes shall determine every election.

11. - That the Officers of the Institute shall consist of a President, six Vice-Presidents (four of whom only to be Mining Engineers), and eighteen Councillors (twelve of whom only to be Mining Engineers), who, with the Treasurer and Secretary (if Members of the Institute), shall constitute a Council for the direction and management of the affairs of the Institute; all of which Officers shall be elected at the Annual Meeting (except in case of Vacancies), and shall be eligible for re-election, with the exception of any President, or Vice-President, who may have held office for the three immediately preceding years, and such three Councillors of the Mining Engineers, and two other Councillors, who may have attended the fewest Council Meetings during the past year, but such Members shall be eligible for re-election after being one year out of office, and such elections to be in manner following:

A. - Ordinary and Life Members shall be at liberty to nominate in writing, and send to the Secretary, not less than thirty days prior to the Annual or Special Meeting, a signed list of such persons as are considered suitable to fill the various offices, and to specify in such nominations respectively who are intended to represent the Mining or Mechanical Engineers and other persons interested in Mining; which list, having been duly stamped with the Institute Stamp, together with the List of such Officers as may be eligible for re-election, and a copy of this Rule shall be posted, at least fourteen days previous to the Annual or Special Meeting, to all Ordinary and Life Members of the Institute, who must strike out from or add to such list, so as to leave a record of their Votes for Officers, not exceeding the number to be elected; but nothing shall prevent any Ordinary or Life Member nominating in writing subsequently (specifying the classes as aforesaid), and up to, and on the day
or absent, from having power to vote for any other Member or Members, although he or they may not be nominated as before provided for. The Voting Papers being so filled up, must be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman, in all cases so as to be received before the hour fixed for the election of Officers.

B. - The Chairman shall, in all cases of voting, appoint Scrutineers of the Lists, and the scrutiny shall commence on the conclusion of the other business of the meeting, or at such other time as the Chairman may appoint. On the conclusion of the scrutiny the Voting Papers shall be destroyed, and the List, prepared and verified by the Scrutineers, shall be kept until the expiration of time for holding the ensuing three General Meetings.

C. - In the event of any vacancies occurring in the number of Officers subsequent to the Annual or Special Meeting at which the election of Officers shall have taken place, such vacancy or vacancies, except as to President, occurring within the time for holding the three next General Meetings, after such Annual or Special Meeting as aforesaid, shall be filled up by appointing a successor from those standing next highest on the Scrutineers' List, but in the case of a vacancy for President, a new election by nomination and voting shall in all cases be proceeded with. After the expiration of time for holding such three General Meetings, in the event of any vacancy then occurring for Vice-Presidents and Councillors, the Council shall have discretionary power either to appoint a successor or successors, or instruct the Secretary to issue Nomination and Voting Papers in the usual way.

D. - At Meetings of the Council five shall be a quorum, and the minutes of the Council's proceedings shall be at all times open to the inspection of the Members of the Institute.

12. - That the Vice-Presidents who have become, or may become, ineligible, from having held office for three years, shall be, ex-officio, Members of the Council for the following year; and all past Presidents (they continuing Members of the Institute) also to be, ex-officio, Members of the Council for the following three years after their Presidentship.

25. - All Members of the Institute shall have power to introduce a stranger to any of the General Meetings of the Institute, and shall sign, in a book kept for the purpose, his own name as well as the
name and address of the person introduced; but such stranger shall not take part in any discussion or other business, unless permitted by the meeting to do so.

(130)

FAN VENTILATION.

Mr. A. L. Steavenson's paper on the Lemielle Ventilator then came on for discussion, and that gentleman read a supplementary paper on the subject, after which,

Mr. W. Cochrane said, he also had prepared a few notes on the subject. He was glad Mr. Steavenson had entered so fully into it, and it was only a pity they had not yet got the paper promised by Mr. Willis because there was much trouble required to work out these comparisons and if the results were so different at Washington from what Mr. Steavenson had obtained at Page Bank, they would have to reconsider the whole matter. Before reading his notes, he would make a few remarks on what Mr. Steavenson had just communicated to them. The working of the fan at Elsecar had been referred to, and the conclusion to which Mr. Atkinson had come was stated to be that a centrifugal fan was not adapted to overcome heavy drags. Mr. Atkinson's remarks were confined to the Elsecar open running fan, which differed in a most vital point from Guibal's. Mr. Steavenson thought the speed of 150 revolutions per minute, as mentioned in the paper on the Guibal Ventilator, had been an exaggeration. At that time, he believed, the diameter of 23 feet was the largest that had been made. Now, they were frequently made of 30 and 36 feet diameter. There was one started the day before yesterday, of 40 feet diameter. The speed of 150 revolutions per minute might easily be obtained from one of 23 feet diameter. The Elswick ventilator had been worked without any trouble at 120, and it was no exaggeration to say that they could be worked at 150 revolutions per minute: it was a common speed of these ventilators in Belgium, and he as well as the Chairman had seen them working at this speed for the ordinary ventilation of the mine. Another point alluded to by Mr. Steavenson was the water-gauge yielded by the Guibal ventilator. When he made the remarks that the water-gauge produced by the Guibal was greater than the water-gauge theoretically calculated, the theoretical water-gauge alluded to was that due to centrifugal force only, as Mr. Steavenson could not fail to observe in following the calculations. Another element enters into the consideration of the maximum water-gauge, which is possible to be attained in the case of a perfect fan, and if he would refer to Rankine's work, a reliable authority on the action of fans, he would see it explained that such maximum water-gauge is twice the height due to the centrifugal force, and not that calculated from the velocity of the periphery of the fan only. When he (Mr. C.) said he obtained a water-gauge greater than the theoretical, he ought to have said

(131)
than that due to the velocity of the periphery. The last point he would notice was opening the separation doors at the bottom of the shaft, and expecting the fan to go at a higher speed.

Mr. Steavenson said, that it was contrary to what at first sight would be expected.

Mr. Cochrane - If you close all access of air you will find the fan run away; as you decrease the opening and prevent air from reaching the fan, thus giving the fan less work to do, the same power being applied, the velocity of the fan must increase; and the reverse action takes place if you increase the opening. It was simply the result of a natural law.

(132)

[S Page 132 is blank]

(133)

SOME REMARKS ON MECHANICAL VENTILATION.

By A. L. STEAVENSON.

When this question was last before you, it was understood that the whole subject of fan ventilation was to be re-discussed. The writer has, therefore, prepared a few remarks, first, upon it generally, recalling how and to what extent in our earlier volumes it has been noticed, and next, upon the merits of the two rival systems of "varying capacities and centrifugal force."

The first notice he finds was in a comparison between the furnace and fan made by Mr. Atkinson, see Vol. III., p. 112, when the Hartz ventilator was shown to require only 9.78 lbs. of coal per minute to produce a quantity of air, which under the furnace system at Haswell, the pit being 150 fathoms deep, required 17.32 lbs., the quantity of air
being 94,900 cubic feet per minute.

The various formulas which these results are intended to illustrate are very interesting, and well worth the study of any one wishing to understand thoroughly this important question.

In the same year 1855, Mr. T. J. Taylor supplied us with information about Struve's ventilator, at Middle Duffryn Colliery, which, being upon the principle of varying capacities, yielded 5/6ths of the quantity generated.

The machine had two 20 ft. cylinders of 4, 6, or 8 ft. stroke, and was worked up to 12 strokes per minute. With both cylinders working and at 8, 1/2 strokes, the estimated quantity was 64,000 cubic ft. per minute; the actual 55 to 56,000.

With one cylinder at 12 strokes the quantity generated was 45,200 and the quantity yielded 38,500.

In this case a yield of 86 per cent., in the other 85, showing in both cases very good results.

In the year 1857, we had brought under our notice the Lemielle system by Mons. Laurent; it was simply described, and no very important information given. This led Mr. Atkinson to give us his interesting paper "On the Consumption of Fuel by Furnaces and Ventilating Machines" which it is impossible and unnecessary to refer to, further than to point out that at p. 145, Vol. VI., he shows in experiments upon Struve's machine, and Fabry's pneumatic wheels, more than 60 per cent, of the engine power was utilized, these being upon the principle of varying capacities.

Very shortly after this, from the same gentleman, we have experiments on Brunton's fan applied at Gelly Gare Colliery; the fan is not described, but the quantity of air discharged was directly proportional to the number of revolutions of the fan, and that if the pressure or W.G. were proportional to the square of the quantity of air circulating in the unit of time, the revolutions in the unit of time should be proportional to the square root of the water-gauge indicating the resistance.
And these results are shown to have been actually obtained. This subject is again referred to, by Mr. Atkinson, at page 235 of the same volume, as an additional evidence of the square of the quantity of air being proportional to the resistance.

We heard nothing more about mechanical ventilation until the year 1861, when we had a paper upon the Elsecar fan by Mr. Atkinson. The concluding remarks upon this fan (a centrifugal fan) are to the effect that the Elsecar fan "is capable of circulating large quantities of air at a low water-gauge", and that it is not adapted to overcoming heavy drags, that it only gave 12.69 per cent, as compared with Struve's and Fabry's pump system.

Three years after this, in 1864-5, we first heard of the Guibal, or covered centrifugal fan at Elswick and Tursdale, in a paper read by Mr. Cochrane. We are told that it is so constructed that one 23 feet diameter and 6 feet 6, 3/4 inches wide is able to run up to 150 or 200 revolutions. This speed seems excessive, and would probably cause much wear if continued. Mr. Cochrane also states that it was resolved to adopt the covering and chimney to the Tursdale fan. In this paper it is marked as worthy of notice, that the water-gauge obtained by the fan is "greater than the theoretical result obtained by calculation," but it seems probable that the theory has been erroneous or the observations incorrect, rather than that the laws of nature have been deceived.

We next come to the paper on Guibal's fan, read by the writer, to which he will refer hereafter; and then the controversial contribution by Mr. Cochrane on the Lemielle introduced a discussion which we are here to-day to go into more fully.

Having been supplied with the Lemielle experiments, and the Lemielle and Guibal fans being taken as types of the rival systems, we have got to consider first, the charges brought against the Lemielle; second, the properties, laws of action, and demerits of centrifugal fans.

The first and greatest alleged defect in the Lemielle is that "if there are sources of leakage in the apparatus, the volume of exterior air, which is thus let in, will increase as the depression increases, and, therefore, the air drawn from the mine will proportionally diminish," that is when the variation of the water-gauge is caused by an altered condition of the mine.

When the mine continues in the same condition, by varying the speed the water-gauge is altered, then the quantity of air per revolution continues the same.
These laws the experiment (given in the writer’s paper on the Lemielle) appear to confirm, although he is not yet prepared to say that he is perfectly satisfied of their correctness, further experiments seem desirable to establish them. The effect of the first law is exemplified by Mr. Cochrane, when speaking of the Lemielle ventilator at Creusot, in the following words, "It is easy to see, as the useful effect in air yielded decreases from .71 to .33 when the depression of water-gauge increases from 1.95 inches to 11.70 inches, that there will be a depression at which there will be no air drawn from the mine.” Such, he says, would be the case when the water-gauge at 16 revolutions equalled 25.16 inches.

Allow, for argument sake, this to be true - what then? Surely a fan that can produce a water-gauge of 25 inches must be superior to any other that can only produce a half or a third of such a result.

Notwithstanding that it is almost idle to talk of fans upon mines working under these great depressions, yet to enable us properly to understand the subject, and to arrive at the true principles of action, it becomes a necessity.

The common pump, raising water, ceases to yield anything when applied to draw water above a depth equal to the pressure of the atmosphere, and so all fans must have a limit, but we require to know for the sake of comparison, whether the consequences predicted of the Lemielle are not to be feared in a tenfold extent in the Guibal.

And first, as to the laws and properties of centrifugal fans. A centrifugal fan, properly proportioned and employed merely in displacing air; i.e. under no drag, should deliver (at a velocity equal to the tips of its blades) a stream of air having a sectional area equal to the breadth of its blades at their outer ends, multiplied by the circumference of the circle described by those ends.

While the general principle of their action under varying drags or depressions is, for each fan driven at a certain speed, there is a certain pressure which is the maximum pressure against which it will deliver or rather there is a certain opposing pressure which will first cause all delivery to cease. Let
us call this pressure A. Now the delivery against any pressure less than this (which we may call B) will be to the maximum delivery of the fan when working against no opposing pressure, as [Formula].

The greatest water-gauge which any centrifugal fan can afford, is dependent upon the speed at which the tips of the blades can safely be driven.

Experiments prove that the shutter and chimney give a certain amount of benefit, which will hereafter be shown; but if we take the case of a 36 feet fan, and allow it to run at 70 revolutions per minute, we shall then be doing as much as any fan now being constructed will safely bear, and we find from the law $h = \frac{V^2}{64}$ that the water-gauge thus obtained by an ordinary centrifugal fan would be 3.95 inches; a Guibal would probably exceed this to a slight extent.

It seems well here shortly to refer to the efficiency of Guibal's chimney, and to enquire how far it is possible for it to effect economy by a saving in final velocity. At p. 20, Vol. XVI., it is stated the effect of the chimney is rendered visible by the vacuum shown at its base, now that there is some benefit in the chimney, it is not for a moment denied, but that it has such an effect as is stated on p. 20 of that volume, is, to say the least, doubtful.

That "if the chimney did not exist the depression or vacuum in the air chamber would be reduced from 2.28" to 0.92", an obstruction to be added to the resistances of the air in the ventilator."

It seems desirable to read this by the light of Mr. Atkinson's paper; in the year 1854, Vol. III., p. 95, where he says - "It is highly probable that a smaller proportion than even 6 per cent, of the ventilating pressure, as in this case, will in other less effectually ventilated mines, be employed in creating the final velocity, more particularly in cases where the upcast shaft is of greater area in proportion to the extent of the galleries requiring ventilation."

I will now only detain you by a short reference to some of the results obtained in experiments upon the Guibal fan under different conditions.
see Vol. XVI. Thus, with the fan in its usual condition, the greatest yield was at 89 revs., 50,328 c. ft.
3.34 in. W.G. (see table of experiments).

MM. Baux and Franquet made as many communications as possible between the down and upcast.
The results were at 87 revs. 175,620 c. ft., and 1.99 in W.G.

Thus a difference of 1 1/3 inches reduced the quantity 73 per cent.

Other experiments to a similar purpose might be quoted, but the writer will only refer to a few cases, showing how closely the water-gauge obtained agrees with the theory, \( h = \frac{V^2}{64.4} \) when \( V \) = speed of the tips of vanes per second.

At Trimdon Colliery, with a Guibal fan 24 ft. dia., on July 20th, 1867, experiments were tried mainly with a view to ascertain the best position of the shutter.

[ Table of Results ]

The effect is seen in the water-gauge, from one-half to seven-eighths open appears to give results much alike, and both slightly in excess of the theoretical quantity.

It does not seem necessary to do more than point out how the Lemielle system is practically without a limit, the water-gauge it can afford being 25 inches, whereas, the Guibal of the largest dimensions fails to reach the odd 5 inches.

However, in many cases a Guibal fan will do good work, and it has proved itself to be very efficient under small water-gauges, which has never been disputed. Of course all fans are more effective, as the work they do increases, the dead weight being less in proportion; and this was clearly shown in the Lemielle experiments.

[ There follow between pages 137 and 139 : ]

Plate XXXV : Mode of Feeding Boilers by a Rotating Apparatus not in Contact with the Fire.
REMARKS

on the

GUIBAL & LEMIELLE SYSTEMS OF VENTILATION.

By WILLIAM COCHRANE.

In connection with the paper on the Page Bank Lemielle Ventilator and the resulting discussion, the following points seem to require attention:—

Can \( V_u = V_e - V_x \) in practice ever become zero? Would not the Lemielle ventilator always draw some air from the mine so long as the access of air is open to it?

From the formula it is quite clear that theoretically \( V_u = 0 \) if \( V_x = V_e \), and though the practical objection seems at first sight plausible it will not bear examination; if the mine is placed under the required conditions, so that \( V_r = V_e \), there will actually be no air drawn from the mine by the Lemielle ventilator.

[ Two further paragraphs of calculation ]

In the paper under discussion it is questioned whether the Guibal could do the work of the Page Bank Lemielle; and it is asserted that though no facts have been given as to the action of centrifugal fans
under extreme water-gauges, by increasing the drag of the air the Guibal would soon produce no air at all.

The author of the paper will probably remember that at the time the Lemielle Ventilator at Page Bank was under consideration, a Guibal Ventilator was offered to do the same work, viz.: - Under a 10-inch water-gauge to produce 120,000 cubic feet of air per minute - a result which it will probably be admitted would be a serious risk to attempt to attain with the Lemielle, as already at 16 revolutions per minute with water-gauge of 6.65 inches, and a volume of 97,338 cubic feet, the apparatus is strained to a dangerous extent, as an inspection of it will prove. The re-entering volume, if the apparatus did work satisfactorily, would be 6,064 cubic feet at a 10-inch water-gauge, hence $Vu = 11,029 - 6,064 = 4,965$ cubic feet, would be quantity of air per revolution of the ventilator drawn from the mine, requiring a speed of $120,000 / 4,965 = 24.17$ revolutions per minute.

It will probably be admitted that the Page Bank Lemielle Ventilator could not work long under such conditions; and it will shortly be proved that the Guibal Ventilator is equal to such a result.

The dimensions of a Guibal Ventilator to do the maximum work of this Lemielle, namely, 97,338 cubic feet per minute under a 6.65 inch water-gauge, are, diameter 36 feet 8 inches, breadth 10 feet, steam cylinder 36 inches diameter, 32 inches stroke, steam being supplied at an average pressure throughout the stroke of about 20 lbs. to the square inch, the ventilator making 75 to 80 revolutions per minute, that is the periphery travelling at the rate of 1.75 miles per minute. Some ventilators of these dimensions are in course of erection in this country, and one of 40 feet diameter is set to work abroad.

Some interesting experiments were made by Mr. Morison at Pelton Colliery, and are recorded in the last issue of our Proceedings.

In order to make an accurate comparison of these experiments conducted upon different mines, it is of great importance that the same conditions of mine be operated upon, that is, that each apparatus be doing similar work, exhausting a given volume of air under the same drag or depression of water-gauge.
To express this mechanically let \( Q \) be the volume exhausted in thousands of cubic feet per minute, and \( h \) the water-gauge in hundredths of inches at one mine, and \( Q_1 \) \( h_1 \) the respective volumes and water-gauges at another.

If \( \) this condition would be satisfied.

(141)

[Table of Experimental Results from Page Bank and Pelton]

Examining the Page Bank and Pelton tables of experiments it is found that No. 8 experiment of Page Bank, where \( \) and No. 9 of Pelton which is the medium one of the three, with shutters properly adjusted, where \( \) present sufficiently similar conditions of mine, and they are, therefore, taken for comparison.

In No. 8 of Page Bank the mine is not in its ordinary working condition; the separation doors were opened.

(142)

In No. 9 of Pelton the mine was in its ordinary working condition.

These two experiments, however, are as nearly as possible the same as if the two ventilators had been working side by side upon the same mine, as the Guibal and Waddle ventilators are arranged at Pelton.

The comparisons of the No. 8 Page Bank and No. 9 Pelton are these:

<table>
<thead>
<tr>
<th></th>
<th>LEMIELLE</th>
<th>GUIBAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-gauge</td>
<td>1.10</td>
<td>1.85</td>
</tr>
<tr>
<td>Volume in cubic feet per minute</td>
<td>62,983</td>
<td>81,495</td>
</tr>
<tr>
<td>Volume in cubic feet re-entering</td>
<td>28,560</td>
<td>Nil.</td>
</tr>
<tr>
<td>Per centage of useful effect</td>
<td>25.48</td>
<td>58.70</td>
</tr>
</tbody>
</table>
By increasing the speed of the Lemielle, a similar water-gauge to the Guibal could have been obtained, and consequently the same volume of air. In this case the useful effect would probably have been increased as the experiments show an improved useful effect as the speeds become higher. It is fair to assume, from the results of the other experiments, that it would be 35 per cent, to compare with the Guibal, 58 per cent, if either ventilator was working on a mine with a co-efficient of condition of \( \frac{Q^2}{h} = 36 \), that is each drawing the same volume of air at the same depression of water-gauge.

In the case of the Lemielle the useful volume of air drawn from a mine remaining constant, and the water-gauge increasing, by increasing the drag, the re-entering volume increases, and the apparatus must work so much more quickly to maintain the same current through the mine; a source of greatly increased loss of power in overcoming the friction of the apparatus, and, therefore, a still further decrease of useful effect.

In the case of the Guibal, if the same constant volume is maintained, and the water-gauge increased, the ventilator must also work at a higher speed, and an increase of friction is the result, also diminishing its useful effect, but it is not subject to the re-entering volume, and has, therefore, only one source of depreciation of useful effect instead of two.

The Lemielle experiment No. 5 (a medium result, see column V), the power in the air discharged from the mine is .5762 of the power due to the volume generated, that is of the volume which ought to be discharged from the mine if there were no re-entries, and the power corresponding to this volume generated is in this experiment .5450 of the power applied in the steam cylinder, therefore the product of these two \(.5450 \times .5762 = .3140 \) should be the useful effect, which is confirmed by the experiment, that is 31.431 per cent, utilized. If in this experiment the water-gauge had been increased to 8 inches by throttling the air-ways

and the same speed of the machine maintained, the useful volume from the mine would have been only .35 instead of .5762, and supposing the resistances of the apparatus to be overcome to be the same (in such case they would in reality be greater with the heavier strain on machinery), the useful effect in this case would be \(.35 \times .545 = .19 \) or 19 per cent., instead of 31.4 per cent. If in experiment 5 Page Bank the one nearest the average, instead of 3.35 inches, the ventilator had been working under 8 inches water-gauge, the speed of ventilator not being increased, but the air currents throttled, \( V_x \), which was 4673 would be [series of calculations] total volume drawn from mine
would be $3786 \times 11.95 = 45,242$ cubic feet per minute. What, under similar circumstances, would be the result of the Guibal? Take

No. 13 experiment, Page Bank, where the maximum water-gauge was 4.55, and volume 134,110 cubic feet, with a useful effect of 44.65 per cent., and No. 11 experiment, Pelton, where the water-gauge was 2.9 inches, volume 102,771 cubic feet, and useful effect 66.21 per cent. Now, let the Guibal be worked so as to produce 4.55 inches water-gauge, and the volume of 134,110 cubic feet, the speed necessary would be [calculation] 75.1 revolutions per minute.

The volume of air will be at this increased speed [calculation] 128,635 cubic feet, and the useful effect represented by [calculation] = 92.23 H.P.

Now, the Guibal ventilator, as will be seen from a comparison of the Pelton experiments, increases its useful effect as the speed increases, and it would be a fair inference to draw, that at 75 revolutions per minute the per centage would be higher than 66.21, which is the result at 60 revolutions, but so as not to raise any doubt let us suppose that this remains the same at the higher speed.

The power to be applied will, therefore, be $100 \times 99.23/66.21 = 139.3$ H.P., and as the volume of air in the above supposition is 134,100 - 128,635 = 5,475 cubic feet inferior to the Lemielle, there will be required at the same speed the additional power to be applied of [calculation] 6.9 H.P. to produce the exact results of the Lemielle. That is a useful effect of $99.23/146.2 = 63$ per cent., for which, as shown in the Page Bank ex-

(144 )

periments, 215.193 H.P. are required, with a useful effect of only 44.65 per cent. There is, no doubt, however, that the assumption made with respect to the useful effect of the Guibal at the increased speed is placing this ventilator at a disadvantage which is contradicted by the other experiments.

Considering now the extreme case of the eight inches water-gauge in which the Lemielle would yield only 19 per cent. of useful effect, the Pelton Guibal would require to be driven at a speed of 99.6 revolutions per minute [calculation] = 99.6, and the volume of air would be [calculation] 170,598 cubic feet. The horse-power in the air would be

[calculation] = 215.0 H.P., and at 66.21 per cent useful effect, the power to be applied would be 100 [calculation] = 324.8 H.P. But instead of the volume of 170,598 cubic feet the Lemielle would draw
only 45,242 cubic feet. Therefore, the useful effect at a speed of 99.6 has to be reduced to \[ \text{calculation} = 57.03 \text{ H.P.} \] instead of 215.06, that is, by 158.03 H.P.; hence the power applied would be \[ \text{calculation} = 34.2 \text{ per cent,} \] to compare with 19 per cent., or nearly twice as good results as the Lemielle.

The accompanying parabolic curves (see Plates 37, 38, and 39), constructed in reference to the power applied and the useful effect which are the true basis of comparison of any machine, show more distinctly than the schedule of experiments where the practical results of the Guibal ventilator surpass those of the Lemielle. In Plate 37 are shown two curves, constructed upon the results of No. 9 experiment, and in dotted lines two curves on No. 12 experiment; a comparison of the ordinates drawn through these curves at any point will show that the useful effect of the Guibal increases as the drag decreases. In Plate 38 are shown six curves constructed upon the results of Nos. 4 and 8 experiments at Page Bank. It will be seen from them that the horse-power of the re-entering volume, which is expressed by the length of ordinate intercepted between the curves of the horse-power in the air and of the horse-power of the volume generated increases in the case of the heavier drag and diminishes when the separation doors are opened. In Plate 39 are brought together the curves of horse-power applied in each case for the same useful effect produced, and from this it will be seen that a Guibal

\[ (145) \]

and a Lemielle working under the same conditions of mine, the Lemielle requires a much greater power applied, and as the speed increases, in order to produce a higher useful effect on the same mine, the divergence of the curves increases still more rapidly.

The comparative scale for the revolutions of each ventilator was found to be as 1 is to 4.648, as follows, viz.: \[ \text{[formulae]}, \] and upon these formulae the various curves are constructed.

\[ \text{[ Calculations for experiments 8 & 9 ]} \]

Mr. Steavenson's experiments give an average of 35.54 per cent, useful effect at various speeds in ordinary condition of mine, and with the separation doors in the mine open, that is, with a less drag than the ordinary working conditions, an average useful effect of \[ 2233.13/ 6 = 37.19 \text{ per cent,} \] slightly in excess of the ordinary conditions.
Comparing the Guibal experiments at Pelton, the average useful effect in the usual condition is \(172.99/3 = 57.66\) per cent., and with less drag \(207.56/3 = 69.19\) per cent., according to the experiments of the 15th. March, but in neither case was the shutter adjusted, which was at once detected in taking out the proportion \(h/h_1\); so that though each apparatus has in common the property of improving its useful effect under the circumstances of a reduced drag, the Guibal shows a considerably more rapid improvement than the Lemielle.

In a new series of experiments, on the 5th of April, the shutter was adjusted for the ordinary conditions of the mine when the average

\[
(146)
\]

useful effect was \(182.20/3 = 60.73\) per cent, for ordinary conditions, and with less drag \(193.37/3 = 64.45\) per cent.

This adjustment, which was effected by lowering the shutter, will be seen to have improved the percentage of useful effect in the ordinary conditions of the mine from 57.66 to 60.73, but, as was anticipated, injured the result for a less drag, reducing it from 61.19 to 64.45.

Mr. Steavenson, seeing in the Guibal experiments that under the ordinary conditions, at a speed of forty revolutions 61,063 cubic feet, and with a less drag at the same speed of forty revolutions, 83,876 cubic feet per minute were put into circulation, hazarded the opinion that by increasing the drag with the Guibal it would soon draw no air at all from the mine. Had this remark been made upon the Lemielle, it would, as already pointed out, have been strictly accurate, but with the Guibal it is not so. This diminution of volume of air, and also the diminished useful effect, are properties of all machines alike - the Lemielle as well as the Guibal. Only in the Lemielle system is the more serious principle peculiar to that arrangement superadded, that of the re-entries of air, and hence the greatly inferior useful effect.

[ Calculation for Lemielle ventilator ]

[ Calculation for Guibal ventilator ]
If the volume circulated is small, the utilized power can only be small, though the power applied may be large; for the power applied must equal to the utilized power, and that required to overcome the resistances of the apparatus \( P_a = P_a + P_x \). These resistances vary with the speed of the machine. If the speed is constant, the loss of power in overcoming the resistances remains constant, and, therefore, if the volume of air circulated, and, consequently, the utilized power be increased, it is clear the useful effect must increase also. For example, a ventilator is worked by 20 H.P. applied, and the volume of air displaced, multiplied by the depression produced, represents 10 H.P.; that is, the useful effect is 10/20 or 50 per cent, while 10 H.P. is absorbed in overcoming the resistances of all kinds of the apparatus at this particular speed.

At the same speed the same resistances will have to be overcome, viz., 10 H.P. But if double the volume of air be drawn by the ventilator, the useful effect will be 20 H.P. instead of 10 H.P., and the power applied will have to be increased by 10 H.P., making it 30 H.P. The useful effect, therefore, in this case, will be 20/30, or 66 per cent. Now, at the same speed let the volume of air be only one-half, the useful effect will be 5 H.P., the power to be applied \( 10 + 5 = 15 \), and the useful effect, therefore, is reduced to \( 5/15 = 33 \) per cent.

If the shutter had been properly regulated for the altered conditions of the mine, the value of \( h \) under column \( r \) of the Pelton experiments would have been maintained in each experiment at the same speed. For the water-gauge, being dependent on the speed only, can be maintained quite independently of volume. Thus a correspondingly larger volume of air would have been circulated, making the useful effect still higher than is shown.

The Guibal ventilator, at a given speed, will produce the highest useful effect under the conditions of the admission of air to it being the maximum that it can discharge. Increase the resistances of the air coming into the ventilator, and following a natural law, the useful effect decreases.
G. B. FORSTER, Esq., Vice-President of the Institute, in the Chair.

The meeting proceeded to the election of officers for the ensuing year, and Mr. S. C. Crone, Mr. Thos. Douglas, and Mr. A. L. Steavenson were appointed scrutineers.

The Secretary then read the reports of the Council, and the reports of the Treasurer and Finance Committee, and also the report of the Technical Education Committee.

The following gentlemen were elected,

Members -
Henry Johnson, Dudley, Worcestershire.
Edward Nicholson, Jun., Beamish Colliery, by Chester-le-Street, Fence Houses.
T. Crawford, Jun., Littletown Colliery, near Durham.
David Peacock, President of the Institute of South Staffordshire Mining Engineers.
Thomas Checkley, Mining Engineer, Walsall.
William Kirkwood, Larkhall Colliery, Hamilton.
Aymer Ainslie, Iron Ore Master, Ulverstone.
Frederick Walter Hall, 23, St. Thomas' Street, Newcastle-on-Tyne.
Thomas Johnson, Wigan Coal and Iron Company, Wigan, Lancashire.

Graduate -

The Chairman thought they would agree with him that the Technical Education Committee had presented a very satisfactory report, for considering the short time during which the scheme had been worked,

and the difficulty of introducing so great a novelty over such a large district, the results had been of the most gratifying character. He had great pleasure in bearing testimony to the ability, energy, industry, and perseverance of Mr. Rowden, and he hoped all the members who had the opportunity would impress upon the pupils the desirability of keeping up what had been so happily begun and so successfully carried out up to the present time. There had also been a difficulty with the pupils who at first thought the task of passing the examinations too great for them to accomplish. He trusted, however, that this would be avoided next year, and that the scheme would progress, and the good results flowing from it be increased to a much, greater extent. He would also congratulate them on the satisfactory state of their finances.

The following letter was read by the Secretary:

Institution of Mechanical Engineers,

81, Newhall Street, Birmingham,

6th August, 1889.

My dear Sir,- I have the pleasure of conveying to you, by the instructions of the Council of this Institution, the expression of their special thanks to the Council, the Reception Committee, and the members generally of the Institute of Mining Engineers, and to yourself as the Secretary, for the very cordial welcome that the members of this Institution have received on the occasion of the Newcastle Meeting, and for the important and valuable aid that has been so kindly rendered in the very successful arrangements for the meeting of this Institution in Newcastle. I remain, my dear Sir,

Yours, very truly,

Theo. Wood. Bunning, Esq.,

Secretary. Institute of Mining Engineers.

Mr. W. Waller said, as reference was made in the report of the Council to the visit of the Mechanical Engineers to this town, he might perhaps be allowed to mention that he had met with several of their late guests, who had unanimously expressed their belief that the meeting in Newcastle had been one of the most successful they had ever held, and they wished particularly to thank those gentlemen who had so kindly opened their works for the inspection of the members.
A paper by Mr. T. J. Bewick was read "On Mining in the Mountain Limestone of the North of England."

The Chairman was sure the meeting would be very much obliged to Mr. Bewick for his able paper. The subject was one that had been

very much neglected in their Transactions, but he hoped it would receive more attention in future than it had hitherto done. There was hardly time to enter upon a discussion of the paper to-day, as they had so much business to get through, but if any gentleman wished to make any remarks they would be glad to hear them.

Mr. E. F. Boyd drew attention to a remark made by Mr. Bewick in his paper that the centre of the Durham district was more prolific in lead ore than either the northern or southern district of the mountain limestone. He would like to know if there was any particular reason why there were so few veins in Northumberland, and, with the exception of one district belonging to the Duke of Devonshire, and another at Kettlewell, there were scarcely any in Yorkshire. Could any explanation be given as to the deposit being so remarkably confined to a particular local district of Durham?

Mr. Bewick suggested that one reason might be that the districts mentioned were as yet insufficiently developed; as, for instance, the district near Clitheroe, which until recently was not known to be productive of lead ore, had now become very important; lead ore was also found extending in other parts, and no doubt there were undeveloped districts in Northumberland, and other counties included in the map, that contained deposits of ore, but it must be remarked that much of the limestone formation in the north and west of Northumberland is composed of beds occurring beneath the Whin Sill; whereas, those in the county of Durham and southward rest on, or, at any rate, are in a relatively higher position than that rock.

The Chairman then proposed a vote of thanks to Mr. Bewick for his paper, which was carried unanimously.

A paper by Mr. Geo. Fowler, "On a method of Abstracting Explosive Gas from the Goaves of Coal Mines, and of assisting the drainage of gas from the solid coal," was then read.

The Chairman remarked that this was a paper on a subject of the very greatest importance to them as mining engineers, and he was sure that anything which tended to prevent or reduce the number of those calamities which unfortunately had lately so distracted some districts would meet with the greatest attention from the Institution.

Mr. W. Cochrane understood that Mr. Fowler proposed to exhaust the gas from the goaves of the mines, which could not be done except by isolating them by brick or other air-tight walls, and by carrying drifts from these goaves to the pump at the upcast shaft.
Mr. Fowler said, he would make the downcast shaft air-tight, and exhaust generally from the whole of the workings. The goaves would be exhausted with the rest, and filled with fresh air from the working part of the mine on the re-opening of the downcast shaft. The advisability of carrying special drifts to the goaves would very much depend on their position and on other circumstances.

Mr. J. J. Atkinson thought that a change in the barometer might counteract all the advantages contemplated, but his opinion was that the effect would be to foul the pit and fill it full of gas, it would then have to be drained afresh, and the same amount of gas would still be generated after the temporary exhaustion as before.

Mr. Fowler considered that the flow of gas from the goaf would be increased during the time the mine was exhausted, but that on the re-admission of air the gas would be held back.

Mr. J. J. Atkinson doubted this, because he had never known gas, if present, fail to come off.

Mr. Willis observed that, supposing a machine or pump could be made to reduce the pressure, after a time there would cease to be air, and only the gas out of the coal would be left to be abstracted, which would fill the workings and be pushed back into the goaves when the air was re-admitted; and thus the mine would be in precisely the same position as before.

Mr. J. J. Atkinson said, if the ventilation in a fiery pit was suspended, and this it was virtually proposed to do, the whole atmosphere of the mine would become charged with gas.

Mr. I. L. Bell - Understanding from the author of the paper that it was intended to put the entire workings of the coal mine under an exhaustion of from five to six inches of mercury, he considered that a physical impossibility would be involved; because, in order to exhaust any vessel it was necessary to have it air-tight. As it was, he thought some proof would be required to show that any mine could be regarded in the light of a vessel hermetically sealed; there were the dislocatures of the strata, every crevice of which would have to be filled up or it would destroy the vacuum which this pump was to cause. It would in fact be a physical impossibility to produce the exhaustion proposed by Mr. Fowler.

Mr. Fowler - If it is impossible to create a partial vacuum in a mine, how is it possible to keep water out of it? We know that water met with in sinking shafts may generally be kept back by tubbing, and does not find its way through the strata, though at great pressure. The small feeders which are often met with in mines, and which must find their way in under great pressure, are not likely to be sensibly increased by a diminution of 2 or 3 lbs. in the counter pressure of the atmosphere.
Mr. S. B. Coxon thought they would require machines of immense magnitude to place the mine in the condition required by Mr. Fowler.

Mr. J. J. Atkinson remarked that the idea was old. It had been thoroughly considered before, and it was his opinion that it would be attended with very much greater danger than the ordinary mode. He thought the effect would simply be to foul the pit once a-week.

Mr. D. P. Morison observed that the horses would have to be drawn out of the pit when the vacuum was produced, and that seeing the difficulty of keeping the stoppings tight under an ordinary pressure, it would be almost impossible to keep them tight under the extraordinary pressure contemplated by Mr. Fowler.

Mr. J. J. Atkinson said, as far as the horses were concerned the difficulty had been provided for in the paper, and he did not himself consider there could be much difficulty with the stoppings.

The Chairman understood that it was contemplated to effectively seal the downcast shaft, and when that was done the other stoppings would not present any difficulty. He said, they were much obliged to Mr. Fowler for his paper, and proposed a vote of thanks to that gentleman.

The resolution was passed unanimously.

The Scrutineers having announced the election of Mr. E. F. Boyd to the office of President, that gentleman, on taking the chair, said he felt a certain amount of diffidence in rising to address them, notwithstanding the handsome manner in which they had elected him, for he felt that he was now occupying the place which had been filled by such worthy men as Nicholas Wood, T. E. Forster, and George Elliot. He could, however, assure them that nothing should be wanting on his part or in his sincere desire to serve them to the utmost of his ability in any capacity, and as they had done him the honour to elect him as their President, he would endeavour, on all occasions, by every means in his power, to render himself available for the purposes for which the President of their Institution was elected. He thought they ought not to separate without looking generally at the past as well as the future. In the general report of their Council, they had all the data laid before them, showing that their Institute was in a flourishing condition for the purposes for which it was commenced. He had a pleasing recollection of his association with the late Mr. Nicholas Wood, a very early friend of the Institute, and knowing something of that gentleman's mind, and what his purposes were in the establishment of such an Institution, he need hardly say that it had gone quite up to the mark which Mr. Wood intended, if not far beyond it. He believed that the purpose, in the first instance, was to search for the causes producing accidents in mines; in the next place, the ventilation of works of large extent; and the third question was, that they should have a sort of record of each improvement as it took place. Then, again, they had to note, if possible, the transactions which took place in the mines, with plans of the mines themselves. He might, perhaps, be allowed to doubt if they had exactly followed out that last intention, for he believed there were cases in which the
proprietors of mines would feel a delicacy in recording all their workings to be deposited as public property; this was a matter that seemed to come within the range of argument; for if the public good was the object they had in view, it would require but little self-denial on their part to give up the idea of privacy, for the satisfaction of recording what had been done in the mines of the country generally. As to the future, he would say but little now. They knew the difficulty they had in obtaining a sufficient number of papers for discussion, and of a sufficiently high standard to make the expense of printing them come within the range of the intention of this Institute; and they had lately tried to overcome the difficulties they found by forming Committees. He felt sure they would all agree with him, it was a source of great gratification that the members of these Committees had given their labours with very great earnestness, and had brought their works to a high point of minuteness and distinctness. At the same time they could hardly expect those gentlemen would be constantly called upon for this purpose. Was it not the duty of the President, under such circumstances, to urge the young members not to be always listeners? He thought that, from a similar point of view, they should get over the difficulty - that papers should all be of the highest character - and content themselves with recording circumstances within their own observation, on geology, ventilation, engineering, or the mode of getting the coal, or the mode of draining the coal. Any one of these things might be made the subject of a paper that would attract attention. Was it not within the range of their younger members to devote a certain amount of time to these subjects? He believed the simplest contribution in that way would be very acceptable; and if the papers were not printed, what then? When a man knew that he had done his best to advance the cause which

( 155 )

they all had so sincerely at heart, he could not be otherwise than satisfied with the efforts he had put forth with that object in view. With regard to the funds of their Institution, he thought they would not be surprised at his coming to the conclusion, to ask them to appoint another gentleman to succeed him as Treasurer. He had done his best from the commencement up to the present time, and he thought he was not making an improper request in asking them to relieve him of his office.

The meeting then separated; the President and a large number of the members afterwards attended the annual dinner, when the following telegram was read from Mr. Elliot, the late President:

6th August, 7.20 p.m.

Elliot, Paris, to Forster, 7, Ellison Place, Newcastle.

Greatly regret cannot attend Engineers’ Banquet. Unexpectedly called to Paris by his Excellency Nubar Pasha on important Egyptian business. Please express to my successor my personal regard. Best wishes for prosperity of Institution.
ON A METHOD OF ABSTRACTING EXPLOSIVE GAS FROM THE GOAVES OF COAL MINES,
AND OF
ASSISTING THE DRAINAGE OF GAS FROM THE SOLID COAL.

By GEORGE FOWLER.

One of the great difficulties in modern Coal Mining is the question - How to deal with the goaves or places where the coal has been got? In every colliery which is removing the whole of the coal there is a yearly increasing area of wrought mine, through which it is impossible by the means of ventilation in present use, to keep a circulation of air sufficient to carry away the gas that lies in it. There is, in fact, a constantly increasing magazine of gas sufficiently diluted to be explosive, and ebbing and flowing with every change of atmospheric pressure. It is to this, whatever may have been the immediate cause, that the magnitude of some of the colliery explosions is due. After the occurrence of a heavy explosion there is generally some variety of opinion as to the immediate cause. There are sufficient known instances of the occurrences of blowers to make these a possible source of the accident. It is, however, a significant fact, which a reference to the Inspectors' Reports will verify, that most of the heavy explosions have been in mines, where there have been patches of goaf amongst pillars of solid coal, and it is submitted that it is to the gas lying in these goaves, that the magnitude of the accident is due. How this is brought out of the goaves suddenly by a vibration of the air, or gradually by change of barometrical pressure, is perfectly well known to every mining engineer. The nearest approach to goaf ventilation is the practice which obtains in some of the
mines where the coal is worked long-wall, of coursing the air freely up and down the roads packed through the goaf.

The diagram No. 1 of a small portion of a long-wall mine will illustrate this clearly. It will be seen that the air circulates freely up and down the broad gates, and across the faces in such a manner that it not only sweeps along the faces, but finds its way through any openings in the goaf far back from the face, until the superincumbent weight has closed everything tight. There is probably no method of working coal which leaves so little goaf-room as in those long-wall pits where the principle is fully carried out. It is astonishing where a large area of coal has been got out free from pillars and ribs how dense and solid the goaf becomes. In whatever way, however, the goaf may have been made, it is certain that there are, more or less, hollow spaces in which the gas can accumulate, and it appears to be a question worthy of consideration whether it is not possible to remove these accumulations and to prevent them forming.

There are two properties which atmospheric air, and explosive gas possess, which might be made useful in solving the problem. They are perfectly elastic, and have a very strong desire to mix together if they are brought in contact. Is it then possible, to expand the gas lying in the goaves? To bring it by this means into the open mine, to replace it by fresh air, and then by a series of expansions and contractions to dilute and draw away the explosive gas from the goaves, and indeed to a certain extent from the solid mine as well. It is to this theory that the writer is desirous of calling attention with a hope that it may have a useful practical application.

The atmospherical pressure is undergoing continual alterations, but of small amount. As the mercury falls the goaf gases expand and come off into the working places of the mine; as it rises, they retreat, and the fresh air follows them in, and it is owing to this continual ebbing and flowing which is constantly bringing, but to a small amount, gas and air into contact, that the goaves are never filled with pure gas, but with more or less explosive compounds of gas and air. There is very frequently a doubt expressed whether the law of the diffusion of gases, or the natural desire which different gases when in contact possess to intermingle, is found true in mining experience. It is submitted that careful examination will remove that doubt. It will be found that at every point of issue explosive gas rapidly becomes mixed with air, and that we conclude erroneously that, that is pure gas, which is probably but a mixture of one part of gas to four or five of air.

There is little doubt that the natural law is always in action, but that its action is not sufficiently energetic to keep the whole of a mine, in which the ventilation is stagnant, at the same degree of dilution.

To state the case then in a concrete form, is it possible to close up
the greater portion of a mine and to reduce the pressure to a sufficient amount, and with sufficient frequency to draw away the gases lying in the goaves, and by repeating the operations at certain intervals to prevent the re-accumulation of the gas and keep the normal condition of the mine one of perfect freedom from explosive gas?

The cubic contents of every mine bear some proportion to the amount of coal extracted. If no goaf is formed, and if no part of the mine heaves at the floor, it must be exactly equal to the cubic contents of the coal drawn. When, however, any general surface settlement has taken place this quantity is very materially reduced, and over large areas of goaf the open spaces are not one-tenth of the original bulk of the coal. In a case of a long-wall mine which was flooded, and the water subsequently drawn, it appeared that, including all the open pillar roads, the cubic contents of the mine were but one-sixth of the original bulk of the coal, and over large areas of long-wall goaf, as before-mentioned, it would not be more than one-tenth.

The great difficulty with the goaves appears to occur where there are small patches located here and there amongst pillar roads, and a reference to the plans attached to the Inspectors' Reports will confirm this statement.

In these cases the goaf does not become solid, but the goaf chambers up thus, and here the gas lodges.

[ Drawing ]

A mine working thirty years, and drawing 150,000 tons per annum, would extract about 120,000,000 cubic feet of coal.

Allowing for a very small amount of surface settlement, it may be assumed that there is a void of 80,000,000 cubic feet in the mine. As before instanced, by long-wall work, there would be about 20,000,000, but this method is still far from being general.

Assuming that the barometer stands at 30 inches, the power required to reduce it 1 inch in every 1,000,000 cubic feet of air, or in other words, to abstract one-thirtieth of the air is as follows: - The pressure against an exhausting pump would rise from 0 to 68 lbs. per square foot, the mean pressure being 34 lbs. At the commencement of the operation the exhausting cylinder would abstract an amount of air, at

atmospheric pressure, equal to the cubic contents of the cylinder, but at the close only 29/30 of the contents at atmospheric pressure. The calculation, therefore, stands as follows: (see original text)

It thus appears that a moderate amount of exhaustion is attainable with small engine power, but that anything approaching entire exhaustion is unattainable.
In an operation of this kind, primarily for the purpose of extracting the gas out of the goaves, but also with a view to drain the solid coal, it is clear that it is desirable, as much as possible, to draw as directly as possible from the goaf. Assume, for instance, a large patch of goaf equal in cubic contents to one-thirtieth of the mine. If the exhaustion could be made to take effect at the centre of the goaf, the major part of the gas would be replaced by the air of the mine when 1 inch of exhaustion was obtained. It is, of course, impossible to ensure that the exhaustion shall take effect wholly from the centre of the goaf; if it were so, a very small degree of exhaustion would avail, but it is possible to connect the neighbourhood of the goaf by the most direct route with the exhausting pumps, and so, that the expansion may take effect in the first instance in the neighbourhood of the goaf, and the flow of air from the pillar-work be towards the goaf. In the diagram No. 2, which is a plan of the Lundhill Colliery at the time of the accident, the headways are supposed to be connected with the exhausting apparatus, so that the drainage may take effect from the goaf, and the flow of air from the pillar roads be towards the goaf. In some cases it would be desirable to use certain pillar roads solely for this purpose of gas drainage, in others the ordinary returns would be applicable.

The practical application of the method would thus be somewhat...

(161)

after the following fashion. Strong air-tight doors must be made to close the mine and sever it from the furnace, stables, and pit bottom, and then in those mines provided with hauling engines, pumping cylinders of thirty or forty inches bore would be connected with them and effect the operation. Where there is no underground engine, a pipe, connected with an engine at the top, would effect the same end; but it will be seen that pumps will not work so effectively at the top as the bottom of the shaft column. In cases where the stables are far inbye it would, of course, be necessary to bring the horses for the time to the shaft bottom.

It will be admitted by most engineers that there are few mines in which this could not be done, and the real question about which there is room for variety of opinion is, first, if done would it be effective? and second, could the same result be more readily obtained? It is scarcely possible to answer the first query without some knowledge of the amount of gas which is given off hour by hour in a large mine, and there happens to be an excellent case on record. In Mr. Dickenson’s report on the Oaks Explosion, we find after the explosion, when the mine was shut up, and consequently no fresh faces of coal ever being exposed, but on the other hand when the mine was considerably heated by fire and thus more likely to give off gas, that the yield of gas was about 550 cubic feet per minute. From the gassy nature of that seam, and the immense area of coal exposed, there are, probably, few mines which give off more gas; the great majority even of those which are reckoned fiery give off much less, indeed measurably, an inconsiderable quantity. This gas is also rarely given off in the goaves, but in the facings and headings where the ordinary ventilation should remove the bulk of it. For the sake of argument, however, let it be assumed that one-half of the regular feeder of gas, say, 250 cubic feet per minute, finds its way back into the goaf, what proportion does this bear to a weekly exhaustion of one-sixth of the cubic contents of the mine?

[Calculation]
that is, that if the feeder of gas to the goaf be 250 feet per minute, the weekly drain is equivalent to about 1,350 feet per minute, so that after the goaves were once cleared, a weekly exhaustion would suffice to keep them so, or in other words, after a week's work, the mine could be shut off on Saturday night, the air be partially exhausted, and the ordinary

(162)

ventilation of the mine he restored ready for coal drawing on Monday morning. To empty the goaves in the first instance, much would depend upon the proportion which their cubic contents bore to the open mine, and to the greater or less facility with which the exhaustion might be made to take effect in the neighbourhood of the goaf. In certain cases, it might be desirable to maintain one or two packed roads through the goaf, so as to give freer egress for the gas contained, but an exhaustion of 4 or 5 inches of mercury giving a pressure of 50 or 60 inches water-gauge, is a powerful agent in finding a channel.

In the ordinary course of working, dealing with water-gauge pressures of 1 and 2 inches, it is difficult to realize the effect of so powerful an agency as this, and nothing but practical trial can make it thoroughly apprehended.

The quantity of gas which comes into the most fiery mine is really small in proportion to the air which an efficient ventilation will circulate.

There appears, however, to be little chance of reasonable safety, as long as stores of gas are harboured below.

It is almost unnecessary to add, in conclusion, that this system is suggested with no idea that it will in any way dispense with the need of ordinary ventilation.

When the pumping was discontinued and the mine re-opened, some little time would be occupied in clearing the mine; with a current of 2 miles, at an average speed of 200 feet per minute about an hour would be thus occupied.

(163)

ON MINING IN THE MOUNTAIN LIMESTONE

of the NORTH OF ENGLAND.

By T. J. BEWICK, C.E., F.G.S.

In the Transactions of this Institution, the district to which the following observations refer, has not had so much of the attention of the members, as the coal and iron fields of the East Coast, which are
more densely populated, more accessible from the hives of industry, and which afford employment to an amount of capital and labour in proportion largely in excess of the lead mining districts.

That this latter district has not been more generally treated of, or discussed by the members of this Institution, probably arises not from its want of interest or importance, but owing to its distance from the main highways of commerce and the quiet unobtrusive way in which the mining operations therein are conducted.

This almost total isolation is very vividly portrayed to the traveller, by the heaps of valuable pig lead, which he will find piled up, waiting transit, at road sides in romantic spots with no habitation visible.

In Vol. XIII. of the Transactions of the Institution is a short paper by Mr. Sopwith, on the subject, and the present may be considered a continuation or amplification of that paper, which is confined to the district in which the principal lead mines are situated; this essay extends the area, and comprises the not inconsiderable portion of the island occupied by the out-crop or bassett of the mountain or carboniferous limestone of the northern part of England, abutting at its northern extremity on the south east corner of Scotland, and extending southwards through the counties of Northumberland, Durham, Cumberland, Westmoreland, Yorkshire, and into Lancashire, terminating near Clitheroe, in which latter locality are the recently discovered and productive Whitewell Lead Mines.

This outcrop forms a range of hills, for the most part of considerable altitude, and represents the "back bone," as it has not inaptly been called, of this part of the island.

The maximum length north to south is 136 miles, and the breadth from east to west varies from about 45 to 16 miles, the total area being about 4,000 square miles.

The general line of direction is north and south, commencing at its south end near the Irish Sea, and terminating on the east coast at Berwick-on-Tweed, thus having a diagonal direction through that part of the island which it occupies.

Although a portion of the district at the extreme north and south ends is but little above sea level, yet taking it generally, the elevation of the ground varies from 500 to 1,500 feet, the greatest height being the summit of Cross Fell Mountain, which is 2,901 feet above the sea.

This territory is especially interesting to the geologist, from the position and contortions of the strata, and the intersection of, and dislocations affected by the numerous dykes and veins; to the paleontologist from the fossils which abound in the rocks; to the mineralogist from the variety and beauty of the minerals it contains; to the mining engineer and miner from the extent and the diversity of the workings, the intricacies of the lodes, and the ground yet undeveloped; to the man of commerce by reason of the richness and value of the products it yields; and to the agriculturist from the difference in altitude, and the diversity and economic value of its soils, the fertility of which is greatly augmented by the limestones which prevail.
In the area under consideration are extensively wrought mineral deposits of great value the circumstances and extraction of which it is the object of this paper to explain.

They consist of galena or lead ore; blende, the ore of zinc, the "black jack" of the miner; iron pyrites or sulphur; barytes; fluor spar; iron ores; and other minerals of less frequent occurrence, and little commercial value, all of which are found in veins, having a vertical or nearly vertical position, whilst there are also thin seams of coal, vast beds of limestone and sandstone, clay and other sedimentary deposits of more or less value.

The veins, or lodes and dykes, are numerous and of many varieties; they intersect and dislocate the strata, and are generally traceable in every bed or layer of rock, from the uppermost downwards to an unknown depth.

Could the various dislocations be shown on a map of the district, it

(165)

would appear a complete net-work of lines, the meshes would not however be uniform either in shape or size, nor yet would the cords themselves if laid down to scale be regular in thickness.

These dislocations, productive and unproductive, vary in direction, in thickness, and in importance. We have north and south or cross, east and west and quarter-point veins, and these are again distinguished according to their size as dykes, veins, strings, leads, threads, and joints, and some of these have local names, as in Yorkshire, a vein or string having a bearing at or near right angles to an east and west vein is called a crossing.

Then, again, there are fissures almost exclusively in the limestone which are occasionally productive of lead ore, and in this respect only do they resemble the ordinary dislocation.

Following up the net work in a large territory it would be void of regularity, inasmuch as the veins or dislocations are in nests; thus we have the important ore producing districts of Tynedale, Allendale, Alston Moor, Weardale, Derwent, and Teesdale, Arkindale and Swaledale, Pateley Bridge, Hebden Moor, Grassington, and Whitewell, these being again subdivided, whilst between two or more of these nests are vast areas of ground almost unproductive of ore, and others, so far as yet known, without veins.

Geologically, the rocks are known as part of the primary or palaeozoic formation, lying immediately above the old red sandstone and below the millstone-grit. These rocks are of three principal descriptions: limestones, sandstones, and shales, for the most part in alternating beds of various thicknesses, with occasional seams of coal.
It is not in these rocks we find the mineral, but they are intersected by veins in which the ores form the most valuable and important part.

That the rocks, although of prior formation to the veins, nevertheless influenced in some unknown way the deposition or formation of the mineral, is clear from the fact that veins are more productive when the sides are formed of limestone, than if they were of sandstone; and, again, the yield is greater when sandstone, rather than shale, forms the walls; in other words, veins in limestone, as a rule, are most productive, next those in sandstone, and least so those in shale, in fact veins in the latter rarely carry ore. The direction or line of bearing of a vein has also much to do with its productiveness; thus, in this district, veins having an easterly and westerly direction are richest in mineral, whilst those having a contrary bearing do not often yield minerals of value; and, as a rule, it may be assumed that lodes having a bearing west of north and east of south, are more productive than those pointing through the other half of the compass.

It must not, however, be supposed that there are not productive veins having the objectionable bearing; this sometimes happens in the district under consideration, and in Cornwall and other places the most productive lead lodes are those bearing north and south, whilst the east and west veins contain copper and tin.

Generally, in the North of England, the dykes bear north and south, and have great dislocations, being usually unproductive of mineral.

The matrix of the vein has much to do with its productiveness, and this again varies in different strata and localities. Thus, in the Tynedale mines the sulphate and carbonate of barytes prevail; in the Alston Moor, Allendale, Weardale, and Teesdale mines, fluor spar, carbonate of lime, and quartz are the principal; in Yorkshire, carbonate of lime; and further south, quartz and carbonate of lime are the predominating matrices.

Most veins have distinct sides or walls; these are known as cheeks, and sometimes there is a main or leading cheek in the body of the vein. Not unfrequently these cheeks are striated, and, occasionally, are highly polished with a thin coating of lead ore, and when in this state are called slickensides.

Lead ore is the most important of the minerals raised, but the veins often contain many others, such as iron, blende, pyrites, copper in small quantities, and all these minerals may be found together in the same vein.

The body of the veins and the adjacent rocks, for some distance on each side, are generally ferruginous in character, sometimes highly so; and the rock, when thus impregnated, is known as "rider."
It also not unfrequently happens that the veins contain a considerable proportion of stiff black clay or "dowke;" and it is in the discrimination of the value of these and other circumstances as indications of the productiveness of a vein, that the practical experience, knowledge, and skill of the mining engineer is of service.

There are also two other circumstances in connection with these veins which must not be overlooked; these are the throw or break; and the hade or underlay. The former being the amount of dislocation of the strata, and the latter the variation from the perpendicular which the lode assumes. These circumstances vary exceedingly even in the limits of this field. In some of the districts, a few feet throw is considered favourable; whilst in other places the throw of the most productive veins is reckoned by fathoms. The value of a throw, whatever it may be, is estimated by the strata which are brought opposite each other on contrary sides of the vein, as before explained.

There is an almost universal law in the throw and hade of veins; thus, a vein having downwards or underlying to the south, throws the south side down, and vice versa. The extent of throw and hade of a vein is extremely variable, and occasionally the same vein changes its throw and hade.

Sometimes the veins flat, that is, on one or both sides there is a horizontal deposit of mineral, occasionally several fathoms in width, and up to 6 or 8 feet high; but generally its height is only 2 to 4 feet.

These flats occur at about the middle of the principal bed of limestone, known in the more northern part of the district as the great limestone, and in Yorkshire and southwards as the main or twelve fathoms lime. There are three distinct flats in this stratum called the high, middle, and low flats, the first being the most general, and yielding large quantities of lead ore; sometimes the mass is nearly pure galena, but more frequently the ore is intermixed with fluor spar and other minerals, or interspersed throughout the rock, and in this latter state is difficult to extract.

Similar, but much less frequent flats, occur in the scar limestone.

Flats of ore are most common in Allendale, Weardale, and Alston Moor, and usually occur where two or more veins form a junction, or where there are strings or leads in connection with the vein, and they are always in the same relative position in the limestone, and thus have a throw or dislocation similar to the strata.

In almost every part of the district, as before briefly mentioned, the matrix of the veins, and not unfrequently the adjacent rocks, are more or less ferruginous; and at Alston Moor and Weardale so much so that separate leases of the ironstone are granted, and for many years past the Spathose and other iron ores occurring in the latter locality have been extensively wrought, and the ore manufactured at the Tow Law Iron Works, of the Weardale Iron Company, into a superior class of iron.
The Alston Moor iron ores have likewise been wrought, but to a much less extent than those of Weardale.

These ores are for the most part obtained by open workings on the backs of the lodes and at the outburst of the limestones where intersected by veins and strings, but not unfrequently the operations are entirely underground, and of a mining character.

Sometimes the beds of limestone are, owing to the multiplicity of

(168)

veins and strings, almost solid masses of ironstone over a considerable area.

The ores of lead and iron are in these localities much intermixed; this, in many instances, is an advantage, inasmuch as from the poverty of the iron ore, and the smallness of the quantity of lead ore, neither of them would be remunerative to extract separately, whilst the two together may yield a satisfactory return; large quantities of both ores have thus been obtained which would not otherwise have been realised.

Dykes and cross veins form an important feature in the net work before alluded to, and have much influence on the ore bearing veins, which frequently cease to be productive after being intersected by them. Of these dykes there are some which call for special notice, and the first, as the best known, is the 90 fathom, or Stublick Slip Dyke, which is not only supposed to pass from east to west through the mountain limestone formation, but is well known to intersect the coal measures from the east coast at Cullercoats to the outcrop of the lowest seams south of Mickley, throughout which district it throws the north side down 90 fathoms or upwards.

Westwards of the coal-field its course is less known, but is generally assumed to be a little south of Riding Mill, crossing the Devil's Water, near Linne's Bridge, thence having a pretty direct course to Stublick, near Haydon Bridge, crossing the river Allen, near Staward Peel, passing up Whitfield to Coanwood, and westwards to Tindale Fell, beyond which it has not been traced.

That great dislocations in the strata exist at or near all these places is certain, but doubts are entertained as to their forming a continuous dyke. It is not impossible there may be two dykes entirely unconnected with each other, being parallel or nearly so, having gradually less influence as they approach. It is, however, quite certain that the strata all along the line described are many fathoms lower on the north side than on the south side, and thus it is we have patches of the lower seams of the Newcastle Coal-field at Stublick, Coanwood, Tindale Fell, and other places.
This dyke, or dykes, does not appear to have any influence on the lead ore deposits, and in this respect differs from the Burtree or Burtree Ford Dyke, so well known in the dales of the Allen, the Wear, and the Tees.

The Burtree Dyke has a north and south bearing nearly at right angles with the Stublick Dyke, and throws the east side down in places 80 or more fathoms.

These two dykes intersect at Staward Peel, where this and other

(169)

described geological phenomena present a field of observation rarely to be met with.

To the north of the Stublick Dyke little is known of the Burtree dislocation, but that the two actually cross each other seems certain, for within a mile north of Stublick Dyke a break is observed throwing the Little Limestone on the west side to nearly the same level as the Fell Top Limestone on the east, equivalent to a throw of from fifty to sixty fathoms.

Southwards the Burtree Dyke is supposed to cross the East Allen River, about two miles north of Allendale Town, and is traceable at various places on the west side of that river to Allenheads, where mining operations have been carried on, on both sides of it.

In the Weardale Mines, too, it has been intersected, and is observable across that dale, especially at Burtree Ford, where in the bed of the stream a fine section of the strata from the four fathoms limestone to the whin sill can be seen, each successive bed being distinctly visible until the whin itself, in a stratified form, is reached.

Further south in Burnhope, and Ireshope, the course of this great upheaval is distinctly visible, as it is also in Teesdale, until it is lost in the mass of basalt which develops itself in the neighbourhood of High Force, and Cauldron Snout, in that dale.

[see Drawing in original text ]

Though this is spoken of as a dyke, it is not the opinion of the writer that it is a continuous dislocation. North of, and close to the Stublick Dyke, it doubtless is so; but in many places further south, on approaching

(170)
it from the east, the strata at from 200 to 500 fathoms distance assume a greater rise, which gradually increases until they are nearly vertical, when on reaching the line of the supposed dyke, the inclination of the beds suddenly changes, and they become level, or have a slight dip to the west for some distance, and then again take the regular rise of the measures, as is represented in the sketch-section on the preceding page.

Thus, in these places, the great difference of level amounting to 80 or 90 fathoms, assumes somewhat the form of an anticlinal line without any actual dislocation of the strata.

That this dyke or upheaval has had an important influence in the formation of some of the most productive veins of the district seems conclusive, from the difference in the characteristics of such veins on the east and west sides of the dyke respectively, and from the fact, that as yet no vein has been traced through, or found productive on both sides.

On the east side of this dyke most of the veins are wide and soft, the matrix consisting generally of fluor spar, whilst on the west side they are contracted, contain little spar, and the matrix and adjacent rock are of a more ferruginous character.

In addition to these two great dykes we have others, such as the Back-bone of the earth, and Carr's cross vein, in Alston Moor; the Wharmley Whin Dyke, in Tynedale; and numerous others well known in the coal-field.

The last do not seem to have any effect on the deposition of minerals, yet, in a commercial sense, they are not unimportant, from the fact that the material of which they are composed, is the best for paving and macadamizing streets and roads subject to heavy traffic, and in whin paving setts and road metalling there is an increasing trade from this field.

The dip and rise of the strata vary considerably both in direction and angle of inclination. As a rule, the dip is eastwards, sometimes northeast, and at other places south-east, but generally it ranges between these two points.

The veins and dykes, especially the latter, have much influence on the dip of the strata, and sometimes there are great changes without apparent cause.

On the north side of the Stublick Dyke, the beds rise quickly to the north, and this extends to the outcrop of the whin sill, which, for a considerable distance, is nearly parallel with the dyke.

This rapid rise of the beds, is not, however, continuous even to the whin sill, for north of Haydon Bridge, and about midway between that
place and the Roman Wall, the strata for some distance dip to the north, as is shown on sections Nos. 2 and 3.

The better to illustrate this, which, however, is only one of many instances that might be given, four sections of the strata have been prepared, and accompany this paper. These sections are taken nearly parallel to each other, extending across the valley of the South Tyne, from north to south, and represent the effect of the veins and dykes on the strata of this particular locality.

Owing to the irregularities in the rise and dip of the strata, and the various intersections and throws, there is sometimes much difficulty in tracing the beds, not unfrequently leading to mistakes in their identification.

That mines have been wrought and produced lead ore at a very remote period is evidenced by the pigs of lead which have from time to time been found at different places in the country. A valuable collection of these antiquities is in the British Museum. From these we gather, that as early as the year 44, pigs of lead were manufactured, but the earliest evidence bearing on this district dates from the reign of the Roman Emperor Domitian, A.D. 81.

In 1734, two pigs of lead were found on Hayshaw Moor, eight miles N.W. of Ripley, in the West Riding of Yorkshire, on which is an inscription as above indicated.

These pigs are supposed to have been made from ore raised at Greenhow Hill, in Yorkshire, not far from the spot where they were found.

It is remarkable that the shape of pigs of lead has varied little in the last 1800 years. The earliest example was found in Somersetshire; its weight is 163 lbs. (11 stones 9 lbs.) and length 24 inches, and so with all others deposited in the British Museum, they vary between 20 and 24 inches in length, and from 9 to 16 stones in weight.

How the mineral was extracted at these early periods can only be surmised. No doubt the ore was, at the outset, exclusively obtained by open-workings, quarry fashion, on the backs of the veins; gradually this method would give way to shallow shafts and short adits, and these again would be succeeded by more extended workings, until we have the pits of the present day hundreds of fathoms in depth; adits several miles in length; and galleries, sumps, rises, and all the other varieties of mining operations now common to important mining fields. The old miners displayed considerable sagacity in opening out the veins, and choosing those which seemed to afford the best prospect of yielding the greatest profit. This the modern miner finds to his disadvantage, when he comes upon the "old man," the local term for ancient workings.
great amount of labour which must have been expended in mining in earlier times before the invention of gunpowder, that most powerful of all the miner’s agents.

In examining the narrow adits and cross cuts of ancient times, rarely exceeding two feet in width, we see with what skill they have been projected and with what careful exactness and neatness they have been cut through the solid rock by the aid of the pick alone.

Locally and nationally these mines are of much consideration, they yield to a certainty large returns to the Lord of the Manor and not unfrequently, but with much less certainty, are equally remunerative to the adventurer; they are the means directly or indirectly of employing vast numbers of workmen, who in return have to be provided with all the necessaries of life. The mineral riches of a district bring about the cultivation of the land, the making of roads and railways, and thus it is that but for these valuable deposits, for which the enthusiastic miner delights to search and to develope, much of the large tract represented on the map, would be mere sheep walks uncultivated and untraversed by even a decent cart road.

Then, again, in a national point of view, the employment of labour and capital finds vent, money is circulated, trade and commerce benefitted, the earth yields up its riches at the point of the pick and jumper in the shape of raw material; this has to be separated from the dross, manufactured into merchantable goods, conveyed to market, exported, and thus it is we find the W.B. and our other superior brands of lead, and our equally excellent Weardale iron, in the uttermost corners of the earth, our national industries encouraged and our commerce improved.

The royalties of the district are for the most part held in extensive territories, the property of landowners or lords; thus, for instance, large tracts in Tynedale, including Alston Moor, form part of the Greenwich Hospital estate, others belong to the Duke of Northumberland; Allendale, to Wentworth Blackett Beaumont, Esq.; Weardale, to the Ecclesiastical Commissioners for England; Derwent, to the trustees of Lord Crewe's estate, Mr. Skottowe's heirs, Mr. Silvertop, and Messrs. Joicey; Teesdale, to the Duke of Cleveland; Arkindale, to Gilpin Brown, Esq.; Swaledale, to Sir George W. Denys and others, and to the Crown; Wensleydale, to Lord Bolton; Grassington and Cononley, to the Duke of Devonshire, and Whitewell, to Colonel Towneley.

Generally these royalties are not worked by the owners, but by lessees

holding an entire royalty, and sometimes two or more; in other cases, as in Alston Moor, the tract is subdivided, and lessees may have a "square lease" or a "vein lease." The former being a plot of ground defined by objects on the surface, such as a river, stream, or fence, or by special stones or marks fixed for the purpose, whilst the latter is a length of 1,200 yards on the line of the vein to be worked, and 40 yards on each side of that vein, these undefined side boundaries being known as the "Cords."
The latter mode of leasing mines is objectionable on account of its being indefinite, and as leading to litigation, for it not unfrequently happens that veins divide or form branches, and it is difficult, nay, sometimes impossible, as the workings advance to define which is the main or original vein.

The celebrated and costly law-suit between the Hudgill Burn and Galligill Syke Companies, which after well nigh 20 years of litigation terminated in 1844 in a sort of "give and take" decision, is perhaps the most striking instance in modern times.

To the leasing system there are two important exceptions, namely, Mr. Beaumont in Allendale, and the Duke of Devonshire at Grassington, who each work their own royalties, and the former is also the lessee of a very large tract in Weardale.

The leases are generally for long terms of years, with a fixed dead or certain rent merging in the dues or royalty, which vary from one-fifth to one-twentieth of the produce, and this royalty or rent is sometimes paid in money according to the market price of lead or lead-ore, in other instances it is a proportion of raw material, or dressed mineral, and occasionally it is a proportion of the manufactured article or lead.

It is common to bind the lessees to employ a fixed number of miners on "dead work," or exploration, in lieu of the dead or certain rent, and thus the development of the property is secured without cost to the lessor.

The working of mineral veins is extremely speculative, and speaking commercially accompanied by considerable risk. Veins not unfrequently suddenly cease to be productive, sometimes vertically, at other times horizontally, so that to develop a mine and work it as a current going and continuous concern requires much skill, constant watchfulness, and great forethought.

Experienced persons generally take care to have several distinct investments, or in the case of a large royalty several explorations in progress at the same time, and when this is judiciously done, lead mining seldom fails to be remunerative.

This district being stratified, the first step in the development of a royalty, is to ascertain the thickness and relative position of the rocks and their ore bearing quality, the number, direction, and characteristics of the veins and dykes, and how these affect the strata and each other. This may be done by an examination of the beds of rivers and streams, cliffs, quarries, and outbursts of the strata, and by shallow sinkings or trial holes.

After these preliminaries, adits are driven from favourable points as regards elevation, convenience for depositing the material, and for the supply of water for the cleansing or dressing of the ores, and for working machinery; the strata to be driven through, the veins to be intersected, and the means of working and ventilation are all matters which call for the exercise of skill and judgment on the part of the engineer.
The vein or veins having been discovered, the next step is to develope it or them, and in so doing, keep in view the future economical extraction of the mineral, the ventilation of the workings, and the probabilities of further discoveries.

On the first intersection of a vein, it is usual to drive a level in it, and from this at convenient and favourable points "rise" above, and if free from water sink below the level, and from these "rises" and "sumps" make other levels or drifts in the vein.

The operation is thus continued sometimes for a mile or more, driving horizontal levels at different elevations or "randoms," and making rises or sinking sumps so that the vertical workings in a vein bear a resemblance to the horizontal levels and bords of a coal mine, or in other words, an elevation or longitudinal section of the workings in a mineral vein is similar to the horizontal or ground plan of a coal seam.

If the vein is productive, the extraction of the ore is effected by these horizontal levels or galleries, which are usually from 8 to 12 or 15 fathoms apart, and by the sumps and rises connecting the galleries at regular intervals, varying according to the custom of the locality or the circumstances of the workings. These communications are generally in the vein, and thus serve the double purpose of exploration and ventilation, and are usually 10 to 25 fathoms apart.

For the purposes of communication, the rises and sumps have ladders or stemples fixed in them, and are not unfrequently partitioned, one half being used as a waygate or passage for the workmen, the other half being a hopper or receptacle for the discharge of the material from the upper to the lower levels, the bottom being provided with a door or slide in the roof or on the side of the lower level, which on being opened allows the material to fall into wagons placed in the level.

After the mine has been laid open by horizontal galleries and vertical communications, the ore is extracted by means of roof and sole workings.

On the roof being worked away for a few feet in height, and the material removed to the dressing floor, a bunding, or floor of timber, is fixed at the level roof, and from this the workings for ore are continued upwards, the material falling down on the bunding, and forming a continually rising floor on which the miner prosecutes his work, an additional bunding being added on the height of the working becoming too great to be reached by ladders. Sometimes it is convenient to leave the bouse or mineral which has been wrought, and is in its undressed state, in the mine for a considerable
period for the purpose of aiding the working, the miner being enabled by this means always to reach
the roof by standing on the bouse, a proportion only of disengaged mineral being drawn from below
equivalent to the difference between the material in the solid vein and the corresponding mass
when in the state of bouse.

Veins of great width, say from 30 to 60 feet, exist, and in such cases it is impossible to apply timber
for the support of the sides, and the method just described of leaving a large quantity of bouse in
the mine has sometimes been resorted to.

It not unfrequently happens that owing to a want of ore or to the unsoundness of the walls or
cheeks, pieces of the vein are left unwrought and are called middlings, and occasionally these
middlings or horizontal pillars are a necessary part of the system of working; at other times when
the vein contains sufficient ore to pay the expense, whilst it is necessary to secure the sides, timber
stemplies or horizontal props are used to support the walls, in other cases rough masonry is put in
and occasionally " deads " or rubbish is taken back into the mine to fill the vacancy made by the
extraction of the ore. Owing to the cost this last method, however, cannot be resorted to except
where the vein yields very much ore.

The main levels, waygates, and air and water passages of a mine which it is necessary to keep open,
if not drifted in sound rock, are either timbered or walled and arched. For permanent roads the
latter is preferable and generally resorted to, and although more costly at the outset is ultimately
more efficient and economical.

Timber underground not unfrequently rots quickly, and taking into account its cost and the expense
and inconvenience of setting it, its use is a matter of serious consideration. There are, however,
instances of

( 176 )

insecure foundations, by reason of lower workings, where walling and arching would collapse, and
where in fact it is impracticable.

The removal of the bouse from the place of working to the dressing floor or bouse teams at the
surface is sometimes costly; if under level it is raised mostly by manual labour in a kibble or jonkit
suspended to a rope wound on to a jack-roll or drum, from this it is emptied into wagons and taken
to the surface or "day" by horses or ponies, occasionally the operation of lifting and hauling has to be repeated before the material reaches the washing floors.

More frequently the ore is worked above level, in which case it is wagoned or harrowed by manual labour to a rise or hopper, and from the bottom of it emptied into the wagons in the lower level by a slide or door.

On being taken to the washing or dressing floors the bouse is emptied into teams or depots, and from them usually taken to the grate in barrows or wagons by boys. There it is put into a stream of water and passes through the process of grating, hotching, knocking, huddling, or crushing, according to the quality or description. Sometimes however the bouse is not grated, but put direct through the crushing mill without undergoing any previous manipulation.

When cleared of impurities it is put into a bingstead and there weighed and sent in bags, containing a hundredweight, by carts to the smelt mill.

Another method, and probably the better where the system of paying the miner for raising the ore admits, is to put all the bouse into one team and pass it direct on to the grate.

In lead mining, as in all other underground operations, it does not answer to have work done by the day, and the great object to be aimed at is that it be made equally the interest of the employed and the employer to get the greatest quantity with the least waste of ore and labour - this is secured by the bingtale plan. In a young mine, however, this is not always convenient to carry into execution, inasmuch as it necessitates the entire separation of each partnership's bouse, calls for more conveniences in the floors, and is attended with a little extra expense in the dressing operations; but on the whole, wherever practicable, it is preferable; and in the case of a large, well-developed mine its adoption is of much importance.

There are a variety of ways of paying the miner for getting the ore; the principle in all cases is almost exclusively one of contract, sometimes it is by a fixed price or rate per "bing" of 8 cwts. of clean dressed ore,

( 177 )
at other times so much in the pound for what the ore brings in the market is paid - this in Cornwall is called "tribute." It is also very common to pay the miner by the square fathom of vein or the cubic fathom, and in case of " dead work" or " tutwork" by the lineal fathom.

In the dressing operations there is always a little of the finely-powdered ore carried off in the water - this, before it leaves the floors, is conducted into a pool or catch pit, where the water has a very slight current, for the purpose of allowing the various orey and earthy matters to subside. The sediment is called " slime," and after being removed from the catch pit, is operated upon and the ore separated from the earth and objectionable minerals by various simple processes - the principle being the same throughout, of mixing the material with water (the quantity varying according to the condition as regards size, &c), and thus getting it into a state of partial suspension and bringing the natural laws of gravitation to bear upon it, the particles taking their position according to their specific gravity.

Comparing the underground operations of the mines of this district with the coal workings of Northumberland, Durham, and Lancashire, or with the tin, copper, and lead mines of Cornwall, they are shallow, rarely reaching sea-level. The deepest mines are in Alston Moor, Allendale, Weardale, and Derwent; but sinkings in these localities do not often exceed 150 yards, and the deepest may be taken at under 300 yards.

The gradual rise of the strata westwards from the sea, and the undulations of the surface, are favourable to the exploration and working of veins by adits, and it is an uncommon occurrence to sink below such adits until a vein has been proved to be productive and promising.

Adits or levels driven horizontally into a mountain in metallic mining serve a similar purpose to shaft sinking in coal mining; they each intersect the deposit, in search of which they are executed, at right angles.

Of the principal adits or levels in the district we have some fine examples - the Nent Force level in Alston Moor, designed and carried out by Smeaton, for unwatering and exploring a large territory, the property of the Commissioners of Greenwich Hospital, is one of great magnitude.

The mouth of this adit is close to the town of Alston, and commences underneath the scar limestone, on the edge of the river Nent, up which valley it continues to Nenthead, a distance of about five miles.
The first four miles to Nentsberry shaft is driven so nearly level that by damming the water at the mouth it is navigable by a shallow boat for a considerable distance, and the craft is propelled by taking hold of plugs fixed in the side at regular intervals and at a convenient elevation.

The dimensions of this level are about 6 to 8 feet square, and its continuation from Nentsberry to Nenthead, a distance of about a mile, is at a higher random than the first portion.

In Arkindale and Swaledale, Yorkshire, are several excellent adits, the drifting of the most of which has been attended with satisfactory results.

These adits are for the most part driven straight to the intersection of the vein, and are from 6 to 7 feet high, and 4 to 5 feet wide at the belly.

The most recent and perfect thing of the kind is the Blackett level, now in course of execution at the Allendale lead mines.

The length of this level from its commencement, near Allendale Town, to Allenheads, to which place it is designed to extend, is seven miles.

It is nearly straight from end to end, there being only two slight angles; its transverse section is of the usual form, that of an egg, having its major axis placed vertically, with one end cut off to rest upon.

The height is 8 feet, greatest width 5 feet, and the gradient 8 feet per mile.

To accelerate the driving of this level there are four shafts upon it, and its termination at Allenheads is at an old shaft about 80 fathoms in depth; by this arrangement, with all the shafts sunk to the proper depth, ten foreheads might be kept in operation.
To drive long levels is a most costly and tedious operation; a more speedy method than manual labour of accomplishing this description of work is much needed. Many attempts have from time to time been made to introduce mechanical appliances for the purpose, from what was known as the "iron man," some 40 or 50 years ago, to the more recent inventions of Sommellier, Penrice, Westmacott, Low, Doering, Haupt, Beaumont, and others.

None have, however, been entirely successful, as applied to the ordinary operations of metalliferous mining.

Sommellier’s patented machinery at the Mont Cenis Railway Tunnel has perhaps been most successful. Doering’s machine has been at work for some time past at the Tincroft Mine, in Cornwall, and is about to be introduced on a larger scale at some other Cornish mines. Haupt’s, or the American Borer, will shortly be put to work at the Old Gang Lead Mines in Yorkshire, and the Diamond Borer, for the introduction and practical application of which we are indebted to Captain Beaumont, R.E. (M.P. for South Durham), is working satisfactorily at some slate quarries in North Wales.

( 179 )

Except the last-mentioned, all these machines are percussive in principle; this causes great wear and tear of machinery, and thus, in a measure, prevents their application, but the great obstacle has been the difficulty in angling the borers, or, in other words, to adapt them to execute all the various operations of the miner; this the Diamond Borer accomplishes.

A most striking circumstance in the field under consideration is the almost entire absence of steam engines, several of the largest concerns not having either in the mining or smelting operations any such engine.

This absence of steam engines and smoke gives to the country around a quiet, unobtrusive aspect unusual to mining districts.

Water is the agent employed, and some of the machinery to which it is applied is of first-class character.
The overshot water-wheel is the commonest form of motive power, but there are several instances of the use of hydraulic machinery erected by Sir William Armstrong and others, as well as of the turbine.

The most notable instance of the application of hydraulic machinery is at the W.B. Lead Mines, where the utilization of the water is carried to great perfection. The high hills and deep valleys which prevail favour the application of water-power, and by the arrangements the same feeder is made to flow over several wheels or engines one above the other either at the same spot or at a considerable distance, and thus its power is made available at several successive places. In one instance in the vale of the Allen the water is used in driving no less than 18 different water wheels or hydraulic engines in a distance of less than eight miles.

Water thus applied is of great importance in a locality in which coal, considering the near proximity of the coal-field, is costly. This is owing to the distance from the pits, the existing means of conveying it by road, and the want of public railways.

In the collection and economic application of the water as a motive power the abilities of the engineer are brought into play. Channels or races have to be formed so as to make available the greatest number of springs and secure the largest and best gathering ground at the highest possible elevation; in these the water is collected and conveyed to storage reservoirs, from which it is taken by metal pipes in the case of hydraulic machinery, and in troughs or pipes to the first or highest water-wheel, and from the tail or bottom of it in another race, or by troughs or pipes to the second, and so on to each successive motor.

These races or channels are not unfrequently continued for long distances, bringing the water from the side of one mountain, many hundred

feet above the bottom of the valley beneath, by a coutour several miles in length to the slope on the opposite mountain, not, perhaps, a mile distant from the first commencement, there to be applied in the various operations of pumping, winding, crushing, dressing, and smelting.

The strata, except near the outcrop, does not generally contain large quantities of water, and thus, with the natural drainage of the upper beds by the adits, the pumping of the water does not form a serious item of cost in the working of lead mines in the North of England.
From the fact that the greatest quantity of water is tapped in the upper strata, adits, in addition to the exploration of the ground, have a most beneficial effect in the drainage of a mine.

Lead mines generally, and particularly those in this district, are remarkably free from accidents to the workmen; there are no explosive gases generated as in coal mines, and few falls from the roofs; the workings are for the most part carried on with a strict regard to safety to the miner, who is not limited in the quantity of timber or other means of support he may require in his operations, and thus it is that, in a measure, accidents are of rare occurrence.

The lead miners, however, are notoriously short lived, the average of life of grown-up men being under fifty years. This, in the opinion of the writer, arises partly from commencing to work at too early an age, and also from a want of proper attention to bodily cleanliness, if the use of the bath was more common we should have a longer lived race of miners.

Usually the lead miners are a well-grown athletic body of men, it is rare to find one who is not a native, and they have little inclination to remove from the place of their birth. Some few have, from time to time, when a mania occurs (such as that for gold digging, not many years ago), emigrated to Australia or America, where, from their experience in mining, if steady and industrious, they prosper.

They have an early training to their occupation; as boys at ten years of age, or soon afterwards, they are employed in the dressing of the ores, or in working air machines, driving underground ponies, and such like.

On the whole they are a steady, hard working, respectable body; drunkenness is not common, and crime very rare indeed - religious influences form a marked feature in their character, and the majority are members of the prevailing sects of Wesleyan or Primitive Methodists, or attend these places of worship.

The system of payment of wages is in some parts of the district peculiar. The workmen receive subsistence or lent money each lunar
month, and a settlement is made half-yearly. With a body of men who are not given to changes or to move about from one Works to another, this system is found to answer a good purpose. The principal reason for deferring the settlement six months, arises from the peculiarity of the work executed, this applies to the mode of working by bingtale, where the result is not known for some weeks or even months, when the bouse has been drawn out of the mine and dressed, and even this last operation is not unfrequently delayed in winter by the severe and long continued frosts, which often prevail at the high lying position of most of the mines, and in summer from the want of water during droughts.

The wages or earnings of the miners do not vary materially in different localities. When employed by the day the wages of an able-bodied labourer or miner may be taken at 2s. as a minimum, and 3s.. 6d. as a maximum. When working by contract it is usual to allow a little higher rate, say from 2s. 6d., to 4s., but the last only occurs under particular circumstances of danger or emergency. Including the value of candles, tools, &c, used, the annual average cost of a miner may be taken at from £50 to £60. Boys begin work at the washing floors at about ten years of age at sixpence per day, generally rising twopence per day per annum for six or eight years, according to circumstances, when they are drafted into the mines.

These wages are small, but it must not be forgotten that the occupation of the lead miner is unattended with the risk from explosive gases which accompanies that of the coal miner; it is regular, not interfered with by the weather like those employed on the surface, and the hours are short, enabling him to devote attention to his garden or a little farm, to the occupancy of which lead miners aspire.

Formerly women and girls were much employed in the dressing-operations, but now they are so at only a few places and in small numbers.

The hours of work vary according to the custom of different districts, the situation of the mines in respect to the homes of the bulk of the workmen, and also whether the occupation is at the surface or underground. At surface work nine to ten hours per day and five to eight hours on Saturdays, or from fifty to fifty-eight hours per week is usual, whilst a miner is rarely occupied over forty hours per week, in some districts working five eight-hour shifts, and at other places six days of six hours each.

According to the census of 1861 there were upwards of 8,000 miners.

( 182 )
and about 2,000 other workmen employed in raising the ores and manufacturing them into metals in the district to which this paper refers, adding those engaged in limestone and sandstone quarries, and in the removal of the material to market or port and otherwise occupied in connection therewith, it may be assumed that the products of the mountain limestone formation give employment to from 12,000 to 13,000 people, upwards of two-thirds of whom are engaged in the lead trade.

Hunt's Mineral Statistics, published annually under Government authority, give the quantity and value of the principal mineral products of the country, but do not include limestones and sandstones. Taking these statistics as a basis, the writer estimates the total annual yield of the tract under consideration, exclusive of coal, at, in round numbers, 200,000 tons, of the value of £550,000 at the place of work, and the following proportions are an approximation of the weight and value of each description of mineral, viz.: -

<table>
<thead>
<tr>
<th>Weight per Cent.</th>
<th>Value per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron ore</td>
<td>60.0 ...</td>
</tr>
<tr>
<td>Lead ore and silver</td>
<td>18.0 ...</td>
</tr>
<tr>
<td>Zinc ore</td>
<td>0.2</td>
</tr>
<tr>
<td>Barytes, &amp;c.</td>
<td>1.8</td>
</tr>
<tr>
<td>Limestone, &amp;c.</td>
<td>20.0</td>
</tr>
</tbody>
</table>

APPENDIX.

( 1 )

[ Title ]

( 2 )
A DESCRIPTION OF PATENTS connected WITH MINING OPERATIONS, Taken out between Dec. 31, 1866, and Oct. 1, 1868, BEING A CONTINUATION OF APPENDIX 2, VOL. XVII

By THEO. WOOD BUNNING.

The writer, at the desire of the Council, has continued the list published in Vol. XVII., which included all patents applied for up to Dec. 31, 1866, and extended it to Sept. 30, 1868.

The patents have been described more to afford a general view of the nature of the invention than to ensure accuracy. For all practical purposes, a very slight sketch will show the general principles involved, and the details, if required, can be readily obtained from the Blue Books. The words used are generally those employed by the patentee. The patents are classified thus: -

1. - Lifting and winding, including safety hooks, &c.
2. - Mining and sinking.
3. - Pumping, subdivided into new modes of raising water, rotary and centrifugal pumps, and miscellaneous inventions.
4. - Ventilation.
5. - Safety-lamps and lighting mines.
6. - Coal-cutting, getting, and breaking down.
7. - Explosive compounds.
8. - Miscellaneous mining patents.

(4)

FIRST DIVISION.

LIFTING AND WINDING, INCLUDING SAFETY HOOKS, &c.


1867. No. 573. Broadbent. 6d. A hook in two parts, with projecting horns which come against a fixture, and open the hook to liberate the cage or other article when it is at the proper height.

1867. No. 754. Harper.(Provl.) 4d. The winding rope becomes disconnected from the cage or other lift, by means of catches of peculiar fork-like construction.

1867. No. 1777. Fairley. 1Od. The cage in its ascent when nearing the top strikes a lever which shuts off the steam or puts the eccentric out of gear.

1867. No. 1781. Edwards. 8d. This invention consists in making both the horizontal and vertical framing of lifts or cages of iron or steel tubing.

1867. No. 2044. Bernier. 1Od. The catches are kept raised by means of levers or other similar mechanism so long as the tension on the draught cable or chain does not change.

1867. No. 2073. Wrigley. 1Od. Improvements in pulleys and chains.

1867. No. 2144. Marley.(Provl.)Is. 4d. To prevent the overwinding of the cage, independently of the detaching hook, when it is drawn beyond the safe point of the "settle-board" a catch is actuated which shuts off the steam from the engine and applies it to a steam-brake.

1867. No. 2350. Ormerod. 1Od. Releases the pin of the shackle connecting the rope and cage together.

1868. No. 1919. Johnson. 8d. Brings the arresting-levers or slides into action by the gravity of the counterweights of the cage or lift, in lieu of using springs.

(5)

SECOND DIVISION. MINING AND SINKING.

1867. No. 859. Davies. 10d. Improvements in rotary digging machines, and in teeth for the same.

1867. No. 1916. Chaudron. 10d. Improvements in digging wells, and in apparatus and tools employed for that purpose.

1867. No. 2981. Norton. 1s. A simple pipe or tube of metal is forced, screwed, or driven into the soil, without removing any earth, until sufficient water is reached.

1867. No. 3285. Tilley. 6d. Improvements in couplings for boring tools.

1867. No. 3572. Gwynne.(Provl.) 4d. Sinks tubes or cylinders, and excavates from their interior the accumulated soil by means of an internal screw or tool.

1868. No. 699. Norton. 10d. Horse hair or other filtering material is wound around the inner tube of the well pipe, or if an inner tube be not employed, the end of the outer tube where there are perforations is filled with horse hair or other filtering material.

1868. No. 2813. Warner. 8d. Bores into the ground, a lining tube being used to prevent the sides of the hole falling in. When the water stratum is arrived at, the suction pipe of the pump is put down inside the lining tube; this tube is then withdrawn and the earth rammed in around the suction pipe.

(6)

THIRD DIVISION. PUMPING - DIVIDED INTO FOUR SECTIONS.

1st, new methods; 2nd, rotary; 3rd, portable; 4th, sundry.

FIRST SECTION - NEW METHODS.
This invention consists in constructing pumps of a compressible elastic tubular passage or pipe, communicating at one end with the supply pipe for the fluid, and at the other end with the delivery pipe. Along the external surface of this passage two or more rollers or pressers are passed in succession in the direction from the supply end towards the delivery end, and so as to compress the passage and force the fluid contained therein towards the delivery end. The passage, by virtue of its elasticity, opens out again as soon as the roller has passed over it.

The power of compressed air is applied by a pipe to a jacket surrounding a receptacle placed at the bottom of a ship or mine, from which receptacle a main tube ascends to the desired height.

A new apparatus for raising or forcing water, applicable to ships, mines, and other purposes. According to this invention the power of compressed air is applied by a pipe to a jacket surrounding a receptacle placed at the bottom of a ship or mine, from which receptacle a main tube ascends to the desired height.

Consists in an arrangement of apparatus, whereby the reciprocating action of a hollow air-tight piston or plunger is unimpeded by the necessity of raising a column of water in the ordinary way.

Apparatus constructed with the view of realizing the effective power of steam issuing from a boiler, by allowing the steam to act gradually on the water, and gradually diminishing the velocity of the steam, and transferring the power gained out of each lessening of the velocity to the body of water to be set in motion; also, by
Effecting a gradual and thorough condensation of the steam by allowing it to act at intervals upon different separate lots of water, and thus obtaining several distinct and perfect times of direct contact between the steam and the water to be propelled.


Pumps, by the direct application of steam, first, by the vacuum resulting from its condensation causing the water to rush into the chamber or vessel, and then by the direct application of the steam pressure to the therein contained water, causing the same to be ejected therefrom.

SECOND SECTION - ROTARY PUMPS.

1867. No. 755. Lake. 6d.

This invention relates to that class of rotatory engines and pumps in which pistons on separate shafts connected with each other rotate together inside a casing formed by the intersection or junction of two cylinders.

1867. No. 833. Winder. (Provl.) 4d.

Consists in the use of a screw or parts of screws of one or more threads or wings applied upon an axis to work within a cylindrical case.

1867. No. 1181. Newton. 10d.

Constructing two rotating interlocking abutments, having concave and convex surfaces, so that in revolving together, the contact between them is preserved.

1867. No. 1529. Hughes and Head. 4d.

An annular cylinder is used in which rotates a piston made tight and carrying round with it on either side an induction and an eduction pipe; these pipes connect with the centre pipe, which also forms the axis and medium of motion.

1867. No. 1671. Bricknell. 8d.
A cylindrical chamber in which revolves a cylindrical centre piece fixed upon a suitable axis, with sliding pistons which are acted upon by cams at the times desired to enable them to pass an abutment or partition.

1867. No.1791. Hughes and Head. (Provl.) 4d.

An annular cylinder in which rotates one or more pistons and concentric, with which rotates a centre piece.

1867. No.1828. Wilson and Hall. 8d.

An eccentric cylinder, with sliding discs working in another.


The steam cylinder in which the piston works, is made of a circular figure, and has in its axis a vertical shaft to which rotary motion is to be given.

1867. No. 2246. Bewley. (Provl.) 4d.

In this invention the case in which the disc or impeller revolves is constructed with an annular groove or space adapted to receive a ring formed round the circumference of the revolving disc, the respective parts of the ring and case being turned and bored to fit cylindrically. The parts of the case between which the ring revolves, and in which are water passages leading into the ring at the centre and out of it at the circumference, have radial partitions to prevent rotary motion of the water.

1867. No. 2278. Marshall and Stewart. 8d.

A drum is made to revolve in a casing so constructed that part of its internal surface is concentric to the drum, but with a space left between the two, through which the fluid can be moved by the action of one or more sliding plungers or vanes carried round by the drum. The remaining part of the above-mentioned surface is eccentric with the drum, and at one place in contact with the same, while the ends of the drum are fitting mechanically to the insides of the ends of the casing.

1867. No. 2334. Leachman and Holroyd. 8d.
Consists in the use of a rotary cylinder to which vanes are connected, working upon a fixed shaft in a chamber of irregular cylindrical shape in accordance with the shape of the cam or eccentric by which the vanes are actuated.

1867. No. 2536. Hubner. (Provl.) 4d.

In the circumference of a wheel of large diameter is made a rectangular hollow groove turned on each face, within which is placed a heavy semi-circular metallic ring adjusted to slide easily within the groove. This semi-circular ring acts both as a piston and a cylinder bottom, and its object is to counterbalance, by its weight, the pressure of the steam introduced in the hollow groove.


Consists of two cylinders, one within and eccentric to the other, and sliding pistons arranged radially to the inner cylinder and connected together by links.

1867. No. 3304. Hughes. (Provl.) 4d.

This Provisional Specification describes a rotary engine and pump in which the fluid enters and escapes at the axis.

(9)

1868. No. 839. Naylor. Is. 4d.

A wheel, having curved blades projecting from its periphery, is mounted on a horizontal axis in a narrow channel of masonry. Water is supplied at the bottom of this channel from the lower level, and when the wheel is driven it raises the water to the higher level.

1868. No. 1279. Cooke. 1Od.

Relates to the construction of such rotary pumps and engines as have a cylindrical piston rotating eccentrically in a cylinder, and which have also a shutter constantly kept near to the same and passing in and out through a suitable part of the circumference of the cylinder so as to divide the inlet from the outlet.

Consists of a cylinder, the interior of which is made of a heart shape, which is provided with a hollow axis mounted in bearings at each end, in which axis is fitted a piston having a sliding motion combined with the rotary motion of the axis, so as to permit of its following the curve of the steam chamber.

1868. No. 2006. Austin and Austin. 8d.

Comprises a cylindrical drum fixed on a tubular shaft having two or more equidistant wings or pistons fixed on it and working concentrically in a cylindrical casing.

1868. No. 2185. Wright. 3s. 4d.


Relates, 1st, in constructing centrifugal pumps without side discs and forming them of cast steel. 2nd, in arranging parts of frictional gearing, by which the groove is formed of two discs capable of being drawn together by means of screws, upon the same shaft, and may be employed for the purpose of transmitting motion to other machinery. 3rd, a novel mode of utilizing the heat-abstracting power due to the flow of water through the suction or delivery pipe of a centrifugal pump and such-like hydraulic machinery; and in a novel arrangement of condensing apparatus formed by encasing the suction or delivery pipe of the centrifugal pump, into which casing or chamber steam to be condensed is exhausted.

1868. No. 2328. Smith. 2s. 10d.

Improvements in machinery for obtaining rotary motion, and for raising, forcing, and measuring fluids. Relates to that class of engines in which a number of blades working within a cylinder are caused to rotate around an axis at the centre of the said cylinder.

1868. No. 2651. Hall. 10d.

Improvements in patent No. 18, 1864.

( 10 )

THIRD SECTION - PORTABLE PUMPS.

1867. No. 1827. Holman. 8d. Secures the general arrangement.
1867. No. 3630. Walker and Holt. 4d. General arrangement.


1868. No. 1046. Holman. 1Od.

Forms the pump and steam cylinders in one piece and causes the pistons to force water from one side whilst being acted upon by the steam on the other.

1868. No. 1153. Moreland and Thomson. 1Od.

Improvements in pumping engines and steam boilers therefore, which steam boilers are also applicable to other purposes, and consists in connecting the steam cylinder rigidly and compactly to the pump cylinder.

1868. No. 1334. Hardick and Hardick. 8d.

The piston-rods of the water cylinder and the steam cylinder are connected together.

1868. No. 1655. Tijou. 8d.

Consists of a peculiar arrangement of direct-acting steam pump, wherein the working cylinder is provided with a cylindrical valve, which receives a partial rotatory motion in its valve case, from a scroll grooved rocking frame in connection with the valve spindle itself.


FOURTH SECTION - MISCELLANEOUS INVENTIONS.
1867. No.  69.  Hughes. 10d.

Consists in the arrangement and construction of pumps, called differential pumps, capable of being made to discharge at pleasure variable quantities of liquids.

1867. No.  485.  West and Darlington. 8d.

Consists in counterbalancing more effectually and cheaply the long and weighty pump-rods used in mining operations, and for various other purposes where counterbalancing weights are necessary.

(11)

1867. No.  860.  Matthews. (Provl.) 4d.

Consists substantially in providing a double-action force pump, which is placed in a proper position at the bottom of the shaft, and in placing the engine and boiler and all the apparatus which supplies the motive power below the surface, by preference at the bottom of the shaft.

1867.  No.  1026.  Matthews. (Provl.) 4d.

Consists in combining a ram with one or more pump buckets, and only one foot valve, by which a continuous stream of water may be thrown.

1867.  No.  1027.  Adair. 8d.

This pump is double-acting, but by removing the cover it becomes single-acting.

1867.  No.  1045.  Lake. 8d.

Is a combined water meter and force pump.

1867.  No.  1821.  Reddicliffe. Is. 2d.

Improvements in buckets for pumps, especially suited for pumps for mines.

1867.  No.  1898.  Zaroubine. 8d.

A sucking and forcing hydro-pneumatic pump with no piston.
1867. No. 2022. Holmes. 1s.

From the middle of an ordinary pump barrel having a double piston, a pipe is carried down which terminates at its lower end in the liquid to be raised, a pipe leads from the upper part of the barrel to deliver the liquid raised by the first-named pipe. From the bottom of the pump barrel a pipe is carried down which also terminates at its lower end in a box immersed in the liquid and filled therewith, such box being closed at all points, except that it is provided with inlet valves, and that a pipe is carried up from its lower part to deliver the liquid.

1867. No. 2289. Ludeke. (Provl.) 4d.

This Provisional Specification describes an apparatus consisting of two cones, each mounted on an axis turning in suitable bearings, and so arranged that the cones are in contact.

1867. No. 2408. Clark. 8d.

Consists of a stationary cylinder in which is a floating piston alternately depressed by steam for raising the water, and then again elevated by the water, the steam being condensed by the water as soon as the piston is down.

1867. No. 2716. Wilkinson. 1s. 4d.

The suction pipe is arranged to rise up in a chamber at the side of the pump cylinder. The cylinder communicates at its lower end with this chamber by a passage having a valve opening into the cylinder, and the cylinder contains a valved piston. The suction valve is mounted on the top of the suction pipe above the level of the piston. The water is delivered through the piston passing the valve therein, and it escapes by a spout at the upper end of the cylinder above the piston.

1867. No. 2809. Williams. (Provl.) 4d.

Consists in combining a ram with one or more pump buckets, and only one foot valve in the construction of a combined lift and force pump, by which a continuous stream of water may be thrown,
Is applicable to ships' and other pumps.

Employs a cam or eccentric wheel working on an axis within a cage or frame in the interior of the body of the pump, at the lower or bottom end of this cage or frame is the piston, one revolution of the axis causes the piston to be raised or lowered three times.

Casts on each side of the opening for the clack or bucket grooves into which the door slides, and gives such a slope or inclination to the inside face of the groove and the outside of the door which fits against it as shall have the effect, when the door is let down, of causing it to press against the face of the clack or bucket door piece, so as to make a tight joint.

The chief objects of this invention are to raise water from mines or wells, and to force water to a great height from a reservoir or water-race for driving a water-wheel.

Consists in an improved pump, constructed of a well bored cylinder, the piston of which is formed of a ring furnished with valves opening upwards, the rod of the piston being connected to a crank on a horizontal shaft worked by the gearing hereinbefore mentioned.

Uses pipes with valves at their bottoms. By inserting and alternately raising and lowering these pipes in water, it will rise in them over their tops and so escape.

The usual suction and delivery valves are dispensed with and their functions performed by means of a sliding action of the barrel.
1868. No. 484. Taunton. 4d.

An annular space is formed within the pump head, and a hollow cylindrical bucket, packed on one or both surfaces, and fitted with a valve on its upper end, to which the spear rod is attached, is caused to reciprocate therein.

1868. No. 1058. Jones. 2s. 1Od.

Describes working the pumps which raise the water by means of engines at the bottom of the mine worked by compressed air or water brought down by pipes from the mouth of the pit. Also a method of lessening the concussion of the valves of pumps.


Consists of a series of tubes joined together, a straight-fluted or rifle-grooved penetrator revolving easily in the bottom length, which has orifices for admission of water, and a valve to prevent its returning.

1868. No. 2258. Meldrum. (Provl.) 4d.

Consists of several chambers, the lower one being a condenser with a central tube through which a piston rod works a piston in the upper or steam chamber, and this has an inlet from a well, and an outlet or discharge passage. Proper valves and passages and a second piston are provided so as to ensure the machine effecting the desired result.

1868. No. 2457. Edwards. 2s. Consists in making force pumps with flexible rings instead of pistons, and flexible discs instead of valves.

1868. No. 2512. Winsborrow. Is. 4d.

The liquid is directed through valves to the opposite ends of cylinders in succession, such cylinders being placed by preference perpendicularly, and opening at their opposite ends into separate chambers.

1868. No. 2831. Benson. 1s. 2d.
Consists in constructing a steam engine with a cylinder and piston suited to each other, so that the piston will perform the functions of a valve in opening and closing the ports of steam passages.

1868. No. 2863. Newton. 1s.

A pair of cylinders, the pistons of which are on the same rod, are mounted horizontally above a water supply pipe provided with inlet valves to admit water to a chamber, from which it is expelled on the return stroke.

1868. No. 2933. Death and Ellwood. 4d. An arrangement of mechanism for driving a pair of horizontal pumps by means of spur gear combined with horse gear.

(14)

FOURTH DIVISION.

VENTILATION.

1867. No. 40. Pownall. (Provl.) 4d.

Consists of constructing in various parts of the underground workings air chambers capable of holding a number of men, which are to be supplied with fresh air by air pumps or fans conducted through pipes to the chambers. In these chambers the miners can seek refuge from the noxious gases till relief be afforded to them or till they can make their way to the bottom of the shaft by the help of air bags or belts, a number of which it is proposed to keep in such chambers, and which can be charged with fresh air from the supply pipe in each chamber.

1867. No. 117. James. (Provl.) 4d.

Consists in two distinct systems of pipes laid down the shafts and main passages of mines, with branches having regulating valves leading into the workings, through one of which systems of pipes the foul air is drawn out of the mine, while fresh air is forced into the mines through the other system of pipes.

1867. No. 235. Hopkinson. 4d.
Consists in the use of superheated steam, for causing the "up-cast" current employed in ventilating mines.

1867. No. 552. Pownall. (Provl.) 4d.
Consists in making recesses in the roof of the mine over those places where the noxious gases accumulate, and from these recesses pipes are laid communicating with exhausting air pumps or fans.

1867. No. 565. Harbert and Goodman. 1Od.
Gases are destroyed in the most distant workings of coal and other mines by exploding them by currents of electricity.

1867. No. 827. Haseltine. 6d.
Ventilates by utilising the exhaust steam from a steam engine.

1867. No. 1181. Newton. lOd.
Constructing two rotating interlocking abutments, having concave and convex surfaces, so that in revolving together the contact between them is preserved.

( 15 )

1867. No. 1194. Lemielle. (Provl. refused.) 8d.
As was shown in my first patent, No. 1031, in the year 1854, the ventilator consists of a cylinder receiving a rotatory movement round its axis. This cylinder is provided with doors of the same height (doing duty for pistons) and of rectangular form, of which one side is in the surface of the cylinder and parallel with its axis, which serves for an oscillating centre. The opposite side describes a circular movement which engenders another cylinder outside the other, but with a different centre. The surface engendered by this last mentioned movement is fixed and constitutes the casing of the ventilator; its axis is the iron beam of the ventilator, from which branch out the arms which conduct the generating of the second cylinder. These door pistons, which are called the wings of the ventilator, there describe a movement which refolds them by inclining by different degrees on the cylindrical surface, and which opens them by enlarging this inclination. When we have found the largest section comprised between two wings we fix on the other side of each of these limits, apertures in the casing for the exit and entrance of the maximum of air that the machine will supply.
But the most perfect way, and which in itself constitutes a new invention, consists in superseding the upper curves and lower curves in the beam, replacing them with a straight one, and making it take the place of the axis of the casing. In this case the upper pivot is done away with, and the cylinder of the ventilator is supported on the circumference of its lower base.

1867. No. 1678. Lloyd. 10d.

Describes the transmitting motion to the piston of an air pump from the driving shaft of a steam engine by gearing so arranged that whilst the driving shaft of the engine revolves at an even speed, the piston of the air pump moves faster at the commencement than at the end of each stroke.

1867. No. 2200. Jones. 4d.

For extinguishing fires and destroying explosive fire-damp in coal mines. The patentee takes oxides of manganese, iron, soda, potash, carbon, or any other oxides, muriatic or chloric acid, or such substances of which these are composed or produce, caustic liquor, iron, or any other caustic, ammonia, lime, or any other alkali, mixed in a suitable quantity of water.

1867. No. 2324. Sturtevant. 8d.

Improvements in blowers for furnaces and other purposes.

(16)

1867. No. 2677. Cooke. (Provl.) 4d.

A tube or shaft open at both ends, with openings at the sides and inner tubes, so arranged as to prevent the down draught and facilitate the up draught.

1867. No. 2684. Bevan. (Provl.) 4d.

Applies a fan to the break carriage for introducing a current of air in underground railways.

1867. No. 2964. Lemielle. (Provl.) 4d.

This invention consists essentially in rendering airtight the inner parts of ventilators of that class for which Letters Patent were granted to Theodore Lemielle, dated the 8th day of May, 1854, No. 1031.
1868. No. 898. Smith. (Provl.) 4d.

Consists in extracting foul air from mines, by pipes connected to the inlet valve or valves of one or more bellows.

1868. No. 915. Cretin-Borne. (Provl.) 4d.

A pipe from an exhausting fan leads down the mine shaft and along the main gallery; branch pipes lead along the other workings. The fan exhausts the air and fresh air is supplied down the shaft. Another set of pipes is carried to the same parts as the first set; this second set communicates with the open air and serves to keep up a current if a portion of the roof falls.

1868. No. 1058. Jones. 2s. 1Od.

For hauling minerals in mines by engines worked by compressed air at the ends of the roads.

1868. No. 1104. Davies. 8d.

Consists, firstly, in the addition to the circumference of the casing of an annular chamber serving as a receptacle for the air drawn to the centre of the apparatus, and which is compressed by the rapid movement of the wings or vanes; and, secondly, in the substitution for the vanes of a circular brush made of horse-hair, whalebone, or metallic wire.

1868. No. 1279. J. Cooke. 1Od.

Relates to the construction of such rotary engines as have a cylindrical piston rotating eccentrically in a cylinder, and which have also a shutter constantly kept near to the same, and passing in and out through a suitable part of the circumference of the cylinder, so as to divide the inlet from the outlet.

1868. No. 2496. Hughes. (Void.) 4d.

Describes a turbine with two discs, one close, the other open in the centre,
with a fixed ring round the opening, so that it can revolve air tight in an opening in the front end of the casing.

1868. No. 2608. Rammell. 1Od.

An improved form of machine obtained by reducing, according to certain rules, the collective transverse area of the internal ducts or passages, relatively to that of the central apertures by which the air is admitted.

1867. No. 137. Harding. 6d. The use of a soft and cheap rivet as a fastening for mining lamps.

1867. No. 252. Fanshawe. (Provl.) 4d.

Consists in the use of a new description of lamps hermetically sealed as to the air of the mine, and receiving their supplies of gas and air, and discharging the vitiated air without the mine, and consists further in the application of electricity for lighting the gas within the lanterns or lamps from the exterior thereof.

1867. No. 525. Young. 8d.

The construction of burners for lamps to be used for burning mineral oils. The body and wick spout of miners' lamps are constructed in one piece, so as to prevent the spout from being melted off when the miner is at work.

1867. No. 611. Macrae. (Provl.) 4d.

This invention consists in the admixture of camphor with the hydrocarbon oils for the purpose of enabling them to be consumed without giving off offensive odours. The proportion of camphor used is dependent upon the specific gravity of the oils.
1867. No. 617. Rowley. (Provl.) 4d.
Lamps to convey evidence within themselves of their having been opened.

1867. No. 992. Waldenstrom. (Provl.) 4d.
Consists in a lever and spring catch, which extinguishes the light when the gauze is unscrewed.

1867. No. 1597. Jones. 8d.
For extinguishing the flame, should the miner attempt to remove the protecting wire gauze.

1867. No. 1908. Dubrulle. (Provl.) 4d.
Consists in so forming the lamp, that on the removal of the safety wire gauze the lamp cannot be lighted until the said wire gauze has been replaced ; also in applying a lock, so that the wire gauze cannot be removed except with the aid of a particular key.

1867. No. 1938. Morison. 8d.
Placing a metal shield over the apertures through which air is admitted

( 19 )

to support combustion. Causing such air to pass through several rings and discs of wire gauze or perforated copper before reaching the flame of the lamp. Substituting a cylinder of brass or other metal in place of the wire gauze cylinder for the top of the lamp.

1867. No. 2230. Higgs. (Provl.) 4d
Describes a method of encasing ordinary safety lamps with a tube made partly of glass and partly of gauze.

1867. No. 2521. Gardner. 8d. '
Consists in adapting to the ordinary miner's safety lamp, a bolt fastener or lock, consisting of a tube through which the lamp is fed with oil, the said tube forming when in position, a lock or fastener that retains the oil in the lamp, and at the same time effectually prevents any tampering.

1867. No. 2818. Mays. (Refused.) 4d.

Extinguishing lights by cutting off the supply of fresh air which is necessary for the process of combustion.

1867. No. 3209. Lowther and Bennett. (Provl.) 4d.

Fixing the rods and wire gauze to the oil vessels of the said lamps, so that the protecting gauze cannot possibly be removed unless wilfully broken.

1867. No. 3376. Horn. (Provl.) 4d.

Consists in applying an air chamber above the old reservoir, such air chamber being perforated circumferentially, the said perforations being moreover guarded against gas blowers and draughts of air by a surrounding shield.

1867. No. 3427. Foster. (Provl.) 4d.

The application of an extinguisher in miners' lamps carried by a fusible spindle, so that should the temperature exceed a certain degree the spindle will fuse and the extinguisher fall. The construction of three concentric rings when used with Argand burners. These rings support or carry the glass and the double gauzes of the lamp.

1867. No. 3640. Rowe. 8d.

Consists in connecting the cap and the wick tube to the bottom of the lamp by studs fitting in grooves like a bayonet joint; also in applying an elastic and metal ring to make the joint air-tight; also in an improved lock and key to secure the cap to the bottom of the lamp, which lock cannot be opened except by the proper key.

1868. No. 203. Thomas. (Provl.) 4d. Consists in the construction of the miner's safety-lamp in such a manner as to enable petroleum and other mineral oils to be consumed.
therein in lieu of animal or vegetable oils as at present used, and the production thereby of an increased light to the miner with considerably less danger.

1868. No. 375. Desens. (Provl.) 4d.

In the lamp the light is extinguished when trying clandestinely to take off the gauze.

1868. No. 419. Hann. 8d.

This Provisional Specification describes forming safety-lamps with numerous tubes of small diameter, or with concentric cylinders with narrow spaces between them to carry off the products of combustion from the flame of the lamp.

1868. No. 1766. Horn. 8d.

Relates to a means of obtaining an increased amount of light and more perfect combustion in miners' safety-lamps; also to an improved lock for fastening all the parts of the improved lamp together.


Relates to an improved arrangement of safety-lamp by which the risk of explosion is diminished, the light from the flame of the lamp being transmitted through suitably arranged glass surfaces, and thus furnishing a less obscure light than is obtained from lamps where the light is transmitted through wire gauze.

1868. No. 2464. Hann and Hann. 8d.

Preventing any current passing between the wire gauze cylinder and the glass chimney; the means of admitting air to the burner, and the caps or tops of safety-lamps.

1868. No. 2891. Desens. (Provl.) 4d.

The wick holder (a small tube moving up and down in the interior of a cylindrical tube by means of three small teeth, gearing with an endless screw for regulating the wick) is put out of gear with the screw by means of a detent fixed at the side of the gallery surrounding the entrance to the body of the lamp.
SIXTH DIVISION.

COAL GETTING.

1867. No. 43. Doering. Is. 8d.

This consists primarily in distributing from one or more cylinders the steam or other fluid to one or more other cylinders, the pistons of the first cylinders being worked from a cross-head connected to the piston-rod of the engine. This applies where a distribution of the fluid is required to work different parts of the mechanism at different parts of the stroke of the engine, but it is specially intended for boring engines.


According to a former patent, No. 2624, 1863, the feed and exhaust ports of the piston valves were so arranged that the piston of the boring machine must go nearly the entire length of the stroke before the motive agent could act upon the piston valve. To obtain the rotary motion of the borer and feed motion of the machine, a ratchet brace is fitted to work loosely on the spindle which enters the back of the machine, the ratchet being fixed. The plug which has a spill on its lower end is dropped into a hole in a lever below the ratchet, and an opening is left in the lower end of the lever for a spiral spring forced up round the spill. The plug fitting into this lever, works in an opening in a rod connecting two pistons in a supplementary cylinder at the back of the boring machine. The fluid works as follows: - Either each end of this cylinder is connected by pipes to the ordinary steam passages of the main cylinder, or, as the chief power is required on one side of the cylinder, that end of the nearest ordinary steam passage is connected, thus securing the inlet and exhaust to that end, the other end of the supplementary cylinder being connected to the feed direct.

1867. No. 457. Walker. (Provl.) 4d.

Consists in the use of a horizontal wheel, provided with teeth on its periphery, to cut a channel at the lower part of a face of coal, which also propels itself along by self-acting means.

1867. No. 535. Howat. 1Od.

Relates to a machine for cutting longitudinal and vertical grooves in
coal to facilitate the getting- of coal, or for excavating- or tunnelling-. The grooves are cut by one or more cutters, which are propelled by steam or compressed air and drawn back by springs. The cutters and the apparatus for working them are mounted on a travelling frame running on rails in the mine or tunnel.

1867. No. 575. Berrens, 1s.
Consists in the use of an iron cylinder, carried on a central shaft, and having sets of boring tools on the outside of its fore end, the central shaft running backward and forward through the centre of a cog wheel actuated by an endless screw worked by ratchet wheels having hooks moving to and fro with the central shaft of the cylinder, which shaft is attached end to end with a wooden shaft carrying handles, by which workmen pulling all together draw back the shaft and cause the ring of drills or borers on the cylinder to strike the rock, breaking pieces which fall out on the backward motion of the tools.

1867. No. 733. Read. (Provl.) 4d.
Consists in boring and excavating coal by means of a boring instrument to make a small hole, and then inserting in this hole an instrument with expanding wedges which in being drawn out, brings with it a considerable quantity of the mineral.

1867. No. 864. Newton. 1s. 4d.
First —Sustaining the boiler, engine, feeding and other mechanism upon a rigid carriage. Second — Arranging toothed rails in combination with feed spur wheels. Third.—The use of solid chisel carrying stocks, and of removable chisels. Fourth.—Communicating a rectilinear reciprocating motion to a chisel stock.

1867. No. 886. Donisthorpe. 1s. 2d.
Describes connecting a bar carrying cutting tools to the exterior of a cylinder which slides to and fro, the piston being held fast. The frame which carries the cylinder and cutter is supported on a truck in such manner that the frame can incline in any direction; at the four corners of the frame are rollers which, when the machine is at work, are to be pressed upwards against the roof of the mine.

1867. No. 964. Jones. 1s. 8d.
Relates, first, to an arrangement of cutters for cutting grooves in coal; secondly, to an arrangement of apparatus for giving to coal cutting machines a slight backward movement after every forward stroke of the pick, and a greater forward movement after every backward stroke of the pick; thirdly, to coupling the axles of coal cutting machines by a chain and chain wheels; fourthly, to employing a chain wheel on the machine to gear with a chain, one end of which is fixed at a distance in front of the machine, and the other end in rear of the machine; lastly, to a mode of constructing the tramways used with coal cutting machines.

1867. No. 1123. Simpson. 1s.

Relates to machinery of the kind described in the Specification of Letters Patent granted to the present applicant, and dated 21st June, 1862 (No. 1831), and comprises various improvements in details, and in the combining of various parts.

1867. No. 1137. Cochrane. 10d.

Consists of two metal bars with another bar or piece in between them, and having a number of inclines upon it; on each side there are corresponding inclines on the inner sides of the outer bars. The inclines which are opposed the one to the other do not come absolutely into contact, small rollers slightly exceeding the height of the incline being interposed. The centre bar or piece has a screw stem at the front with a nut upon it, by turning which, the outer bars are pressed against the sides of the hole with sufficient force to break down the coal or mineral.

1867. No. 1311. Bunning and Cochrane. 10d.

Propose to cut grooves in the coal or other substance to any convenient width to a depth from the face adequate to the requirements of the case, and to sufficiently secure the machine by means of the groove when cut. The back of the tool holder is caused to slide on a bar guide or support, which is also made so as to enter the groove for some distance. This bar guide has one or more hydraulic rams so arranged, that when the pressure is applied they act against the top of the groove and jamb the bar against the bottom, whereby it is held fast, and when the pressure is removed, the bar, with the holder sliding on it, will be slack in the groove and in a position to be advanced for another cut.

1867. Jones. No. 1388. (Provl.) 4d.

Consists—Firstly, in an improvement on the rails described in the specification of an invention for which he obtained Letters Patent No. 2708, of date the 19th October, 1866, and in wheels to run thereon. Secondly, in making coal mining machines arranged to run on rails constructed according to
the above first part of his invention self-feeding. Thirdly, in employing with the rails described double or single acting screw or other jacks as means for jamping

(24)

the rails between the floor and roof of the mine. Fourthly, in novel means for carrying, holding down, and keeping up to their work, coal mining machines generally. Fifthly, in a novel arrangement of arms or levers and cutters to plane or pare away coal or other mineral so as to form deep shallow channels or grooves therein.

1867. No. 1566. Snell. Is. 4d.

Consists of two chisels, attached to the pistons of two cylinders worked either by steam or condensed air, which act on the coal or stone to be cut; the leading chisel cutting to a given depth, and the second increasing the depth of the cut; when the chisels arrive at the end of a cut they are reversed and work back again. The two pistons are connected by a beam, so that the recoil of each aids the momentum of the other.

1867. No. 1704. Doering. 2s. 4d.

A cushion of air is maintained on the small side of all the small pistons; this in the valve and rotary motion cylinders, is overcome as required by air from a port in the main cylinder, while the advance cylinder is not able to act until its larger side is exhausted by a port in the main cylinder being sufficiently opened by the forward stroke; or the piston of the advance may be operated by pressure on its larger side. (See No. 2922, 1866, and No. 43, 1867.)

1867. No. 1783. Jones. Is. 8d.

Describes a peculiar construction of frame to be used for supporting coal-cutting machines when driving headings in coal mines. By the arrangement described, the machine can readily be moved to one side of the heading whilst the coal is being removed after being wedged down. Also, modes of constructing hydraulic apparatus for wedging or breaking down coal and other minerals. Also, of attaching a lever pick to its axis, by which the depth of cut can be adjusted.


Dispenses with the aid of the usual rails or guides, using a portable engine, which may be readily moved from place to place, and to which the cutters are geared in such a manner as to be capable of
being traversed along their work for some distance without shifting the engine by which they are actuated. Various descriptions of cutters may be used, but the use of a cutter rocking to and fro on a centre after the manner of a pick is preferred.

1867. No. 2027. Newton. Is. 4d.

Comprises two principal parts, viz., a continuous rotating piercing machine and a kind of carriage to contain one or more of these machines, which may be employed for tunnelling or underground work. The piercing machine is composed of a metallic frame on which is placed one of Perret's engines worked by water pressure. This motive engine communicates motion to a hollow iron shaft which has its outside made hexagonal. At one end of this shaft is placed the piercing tool and at the other extremity is a piston to which the necessary pressure is applied for working the boring tools.

1867. No. 2451. Elliott. (Provl.) 4d. Consists in the use of machinery wherein the cutting discs revolve with, and advance on, a central axle, the inner end of which rests in a bearing fixed in or to the substance intended to be cut, the other end being suitably supported. The forward motion of the cutting discs on the central axle is produced by ropes or bands passed over friction rollers on an arm fixed to the inner end of the central axle, and carried back to a circular plate and connected with a rope or band, from which is suspended a suitable descending weight.

1867. No. 2503. Doering. Is. 6d.

An arrangement of boring engine in which the cylinder acts as a distributor. In addition to the ordinary ports and a supply port, the cylinder has two ports in communication respectively with the back end of the valve and the back end of the advance movement cylinder. The piston rod has three pistons, forming two chambers, the forward one of which communicates with the outer air through the rod. Constant pressure is maintained in front of the valve, which is of smaller area than the back; the valve rod has four pistons, the two outer being the piston proper, and the others acting to open and close the ordinary main ports.

1867. No. 2607. McKean. Is. 6d.

A cylinder of cast iron or other material is employed in which a piston is moved by any elastic or inelastic fluid, the drill or other cutting-tool being attached to the piston rod. A pivot is arranged at the top or bottom of the cylinder, by means of which, and by certain clamps and rods, the drilling apparatus is rapidly fixed and clamped in any desired position. The cylinder is provided with the
usual valve chamber, valve, and orifices for the admission and emission of the actuating fluid - air or steam being preferred.

Consists of a drill carried at one end of a long screw which works

( 26 )

through a nut carried by a post, which can be fixed between the floor and roof of the mine. The screw is turned by a crank handle or otherwise, and thus a forward motion, together with a rotary motion, is imparted to the drill. The nut through which the screw works can be raised or lowered, and can also turn on an axis at right angles to the post.

1867. No. 3076. Sturgeon. 6d.
Relates to "opening out" on driving headings, and consists in an improved arrangement of machinery described in a provisional specification filed by him on the 2nd July, 1867, No. 1927, by which improvement, the nicks are cut in a curvilinear or arched form. This is done by having the cutter on a frame capable of turning on a central axis. A feed motion is imparted to the frame, and causes the cutter to travel in a circular arc as it is elevated. In a pick action machine, the pick being worked as described in his provisional specification, 2nd July, 1867, and mounted as in a specification of patent granted to him and others on November 28th, 1864, No. 2962, the requisite rotary feed motion is imparted to the headstock on which the pick is mounted, and the cutter is thus caused to travel through a circular arc.

1867. No. 3311. Munro. 8d.
Forms boring tools of chilled cast iron, whereby the labour and expense hitherto attendant on the formation of such tools of steel is greatly reduced.

1867. No. 3386. Jordan and Darlington. 10d.
A cylinder fitted with a piston and rod, to which the boring bar is fixed, one side of the piston being open to the atmosphere, and the other subject to the pressure of water or other suitable fluid thrown into the cylinder by a force pump, and withdrawn again by the back stroke of the said pump. A driving plunger or force pump constructed for the above purpose; force pumps and pipes for transmitting power by an enclosed circuit of water or other suitable fluid, and of rendering this power active in any part of the aforesaid circuit without discharging the fluid.
1868. No. 116. Pittar. 8d.
Consists in the application and arrangement of various mechanical appliances for working the drill used in perforating rocks.

1868. No. 162. Hosking. 8d.
Consists in arranging the cutters upon the cutting head, in a curved line or lines (such curved line or lines not being portions of circles) having the centre of the cutting head for their centre.

1868. No. 458. Melling. Is. 6d.
Consists, first, in regulating the passage of air or other fluid from one side of the piston to the other; secondly, in bringing the piston back by a part of the air used to propel it; thirdly, in making the piston-rod eccentric to the piston, to bring the cutters near the lower surface of the coal to be cut; fourthly, in connecting the cutters to the piston-rod so that the cutters are rigid when cutting, and fall back from the coal when drawn back; four or other number of cutters are fixed to a rod. Fifthly, in supporting the apparatus on additional wheels placed at right angles to the propelling wheels for the convenience of transport.

1868. No. 600. Firth. 10d.
Describes arranging picks used in machines for cutting coal and other minerals so that any number of picks may be worked in the same breadth of roadway as is required for one pick.

1868. No. 813. Barlow. (Provl.) 4d.
Describes forming tunnels by forcing forwards a cylinder into the ground and removing the earth from within the cylinder to allow of an iron or other lining for the tunnel being fitted together within the rear end of the cylinder. The forward end of the cylinder is closed, with the exception of an opening at or below its centre, so that should water break into the end of the tunnel the upper part of the tunnel may always be kept full of air.

1868. No. 1183. Lake. 1s. 6d.
Consists in the novel construction of the valve which admits the steam or other fluid into the cylinder, and in the peculiar mode of, and devices for operating the said valve; in the novel construction and arrangement of the feeding mechanism; in the mode of securing the drill or cutting implement; in the feed screw or holder; in the means for more effectually supporting the frame
which carries the drill cylinders; and in the employment of a frame of peculiar construction for supporting the machinery to work in a vertical direction.

1868. No. 1219. Rothery. 3s.

Proposes to combine together end to end, two cylinders of different diameters open at their outer ends, and each having a piston working therein. These two pistons are both fitted on to the same rod which works through a stuffing-box in a stationary division or partition between the two cylinders; the object of the smaller cylinder and piston is to produce the return or back stroke of the pick or cutter, whilst the larger cylinder serves to give the cutting blow or stroke to the said pick or cutter. The connecting rod which transmits motion to the pick axis is partly contained within the actuating cylinder itself, thus economizing space. Two cylinders of the same or different diameters arranged as above described may be used as a motive power engine for various purposes.

1868. No. 1220. Ridley and Rothery. (Provl.) 4d.

Consists in the employment of a quadrant cylinder secured to the framing of a truck or carriage, within which quadrant or cylinder a diaphragm or piston reciprocates on an axis, such axis forming the axis of the vibrating pick or cutting tool itself, thereby dispensing with lever arms, connecting rods, and piston rods.

1868. No. 1223. Donisthorpe. (Provl.) 4d.

Describes using a lever pick in combination with a rectilinear reciprocating pick, the lever pick being used to make smooth and even the bottom of the groove formed by the rectilinear reciprocating pick, and also to undercut each slice or strip of coal before it is cut off by such reciprocating pick. The lever arm of the lever pick carries a plate which is to receive upon it the pieces of coal or mineral as they are cut away, and carry them back out of the groove, or the arm itself is caused to sweep back the pieces out of the groove.

1868. No. 1482. Chubb. 1s. 6d.

Minerals are obtained without "holing," "kirving," or "nicking" being necessary, by means of hydraulic apparatus with an elongated plunger, or with several plungers on one bar. The apparatus is inserted into a hole formed in the working face, and is then expanded so as to force the mineral out. Or sometimes a flexible bag is used with a rod passing through it, and on the rod, stops are fixed to restrain the bag from expanding endwise. The bag is enclosed in an expanding metal case.
The head of the machine is a strong disc, which is divided into four or other number of broad arms, with radial sides, by a corresponding number of spaces being left in it of sufficient size for a workman to pass from one side of the disc to the other when it is in the tunnel.

For securing or holding the stands or frames of rock, boring or excavating machines; the stands or frames are held by atmospheric pressure. A disc of rubber or other material is placed on the floor of the tunnel, and a vacuum is formed below it.

Mounts the chisels or tools in a cutter head, to which a rocking motion is imparted by a crank eccentric or toggle joint, so as to cause the tool to strike in succession a number of smart blows on the stone as the cutter travels along.

Introduces a socket at the end of each pick, so that the points, being made of cast steel to the full length required, can be put in and taken out at pleasure.

Relates in part, to means for giving rotary motion to cutters when using lever or other handles for them, so that the opposite sides of the cutting edges thereof, may be used alternately.

Comprises, firstly, a boring engine in which there is no valve to the cylinder. The piston rod has four pistons, forming between them three chambers; a constant supply of motive fluid is maintained in the central chamber. When the pistons are at the back of their stroke, a passage communicates between the central chamber and the back of the cylinder, so that the pistons are caused to make their forward stroke; when the forward stroke is completed, the central chamber communicates by
a passage with the front end of the cylinder, so that the pistons are caused to make their back stroke.

1868. No. 2198. Brunton. 10d.

Consists in a new form of tool for cutting slate and other rock; and, further, in a machine for the purpose of applying the chisel to cut grooves or slots.

1868. No. 2643. Gillott and Copley. 10d.

Propose to employ a horizontal revolving wheel or disc having a series of cutters mounted on the periphery thereof, such cutters being made to cut outwards or from the bottom of the groove, or undercut to the face of the working, whilst the body of the machine itself takes its bearing against the face, in order to resist the strain of the cut.

1868. No. 2965. Doering. 10d.

The forward movement of the engine, according to the progress of the work, is regulated by a valve or cock, which regulates the supply of water to, and the outlet of water from, a cylinder attached and adjacent to the main cylinder, the said valve being worked in a manner already known, by motive fluid distributed from the main cylinder to a small cylinder, the piston of which is connected to the valve.

SEVENTH DIVISION.

EXPLOSIVE COMPOUNDS.

1867. No. 52. Prentice. 10d.

Describes encasing a cartridge or other article in India-rubber; the India-rubber is blown out into a bubble-like form, the article is introduced into the interior and the bubble is allowed to collapse upon it.
1867. No. 989. Reeves. (Provl.) 4d.

Describes the making gun cotton from vegetable fibre.

1867. No. 1129. Prentice and Richardson. (Provl.) 4d.

Describes the treating gun cotton with paraffin dissolved in paraffin oil or other solvent.

1867. No. 1345. Newton. 4d.

Pulverized charcoal, silica, or other substance capable of absorbing liquids is impregnated with nitroglycerine, which is thereby rendered less dangerous to use.

1867. No. 1408. Neumeyer. 4d.

This invention has reference to patent No. 1636 of 1865. In place of preparing the ingredients for the powder as described in the specification to the said patent, about 72 parts by weight of saltpetre are mixed with about 18 parts by weight of ordinary charcoal, and then about 10 parts by weight of flowers of sulphur are added, the whole being gently stirred together in a vessel with revolving arms for about 15 minutes, and in the presence of water in the proportion of about 40 parts by weight to every 100 parts of the compound. The compound is then removed and dried without being subjected to the process of granulation.

1867. No. 3458. Johnson. 4d.

Consists substantially in mixing and diluting nitro-glycerine with porous combustible substances, and the employment of such material for blasting and other similar purposes.

1867. No. 3469. Designolle and Casthelaz. 6d.

Has for its object, to apply to the manufacture of powders, the easy combustion of the picrates of potash, of the salts formed by picric acid, of the derivatives of picric acid, and of their salts, and also of picric carbazotic or trinitrophenic acid, and the quantity of useful gas which is developed during the said combustion.

1867. No. 3652. Abel. 4d.
Relates to the preparation of improved explosive compounds. Consists in producing intimate mixtures of gun cotton in the filamentous condition or in the form of pulp with large proportions (from 30 to 60 per cent.) of an oxidizing salt, such as nitrate of potash or soda, or chlorate of potash, and with a small proportion (about one per cent.) of an alkali or an alkaline carbonate. Consists also in producing still more highly explosive compounds by impregnating either partly or completely with nitro-glycerine any one of the explosive mixtures above described, and in afterwards coating the impregnated grains, discs, or masses of other forms, with any known impervious material, such as paraffin, bees-wax, India-rubber, gutta-percha, collodion, shellac, or other resins.

Consists in taking carbonate of copper about 8 parts, graphite about 10 parts, prepared quicklime about 15 parts, prepared alum about 50 parts, nitrate of soda about 350 parts, soda-ash about 20 parts, ferro-cyanide of potassium about 300 parts, charcoal about 30 parts, prepared sugar about 350 parts, and carbonate of potash about 450 parts. One-half the graphite and one-half the charcoal are to be combined with the carbonate of copper, lime, nitrate of soda, soda-ash, and carbonate of potash, to constitute one part of the powder - the other halves of the graphite and charcoal being combined with the other ingredients to form another part of the powder; and in this partly combined but divided state each powder is inexplosive and consequently harmless, and when required for use the mixture of the two renders the whole highly and powerfully explosive.

1868. No. 1210. Clark. 10d.
Cleansing and purifying vegetable fibre in powder or particles, by extracting and separating from it foreign substances, by treating such powder or particles with high pressure steam solutions of alkalis and acids and animal charcoal in a close steam tight vessel.

1868. No. 1375. Nisser. 4d.
Consists in mixing a compound of nitrate of potassia or nitrate of soda, or both, with either chlorate or per-chlorate of potassia in the manufacture of an explosive compound for blasting. Also of a compound of saccharum album, or white lump sugar, and sub-

(33)
limate of sulphur mixed either with vegetable fibre, or charcoal, or both.

1868. No. 2542. Shaen. 4d.
Consists in combining nitro-glycerine or Schultze's wood powder, either alone or together, with other explosive substances.

1868. No. 2865. Lake. 4d.

Uses chlorate of potash, sulphur, and charcoal, for blasting purposes.

(34)

EIGHTH DIVISION.

MISCELLANEOUS.

1867. No. 1273. Lomax. 10d.

Wagons for collieries, &c. Consists in forming the corners of the wagon by welding together two pieces of angle iron for each corner, leaving between them a space sufficient to receive the ends of the timber or planks forming the ends and sides of the wagon.

1867. No. 1282. Dutton. 10d.

Consists in constructing revolving screens of two or more concentric cylinders, made of bars, wire gauze, or perforated metal, revolving within one another.


Transferring coal or minerals from railway wagons into barges.

1868. No. 728. Burton and Lawrence. 8d.

For screening coals, cinders, and other matters.

1867. No. 48. Claus. 8d.

Describes a mode of raising brine from bore-holes, by closing the top of the bore-hole with a "cover," and forcing air or water beneath the cover by a force-pump, causing the brine to rise up through a delivery pipe which passes to the surface.

1867. No. 87. Blagden. 4d.
Separating silver from lead by the application of electricity to the molten lead, with which a small quantity of zinc has been incorporated.

1867. No. 620. Breckon and Dixon. 1Od.

Consists in the use of an endless-chain of buckets to convey the coke or other material from the ovens or elsewhere, to a sloping spout mounted on wheels and turning on a pivot, to distribute the coke in the hopper. The distributor is made with a screen to allow small particles to escape, and the hopper has doors below which are openings to discharge the coke into the wagons.