NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS

TRANSACTIONS

VOL. XXVII.

1877-78.

NEWCASTLE-UPON-TYNE: A. REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

1878.

CONTENTS OF VOL. XXVII.

	PAGE.
Report of Council	vii.
Finance Report	ix.
Account of Subscriptions	xii.
Treasurer's Account	xiv.
General Account	xvi.
Patrons	xvii.
Honorary and Life Members	xviii.
Officers	xix.
Original Members	xx.
Ordinary Members	xxxvii.
Associate Members	xxxvii.
Students	xxxviii.

Subscribing Collieries	xlii.
Charter	xliii.
Bye-laws	xlix.
Barometer Readings	307
Index	315

GENERAL MEETINGS.

1877.	PAGE
Sept. 1-Paper by Messrs. T. Lindsay Galloway and C. Z. Bunning, "A description of an Instrument for Levelling Underground"	3
Discussed.	6
Discussion of Mr. Emerson Bainbridge's Paper "On different methods of Lubricating Coal-tubs or Corves"	8
Discussion of Mr. Shaw's Paper "On a new form of Marine Boiler"	9
Oct. 6.—Election of Members only	13
Oct. 19.—Visit to the Stonecroft and Greyside Lead-mines, the Prudham Quarries and the Settlingstones Lead-mines	15
Nov. 3.—Paper by Mr. J. B. Simpson, "An Account of the condition of the Mining Industries of Prussia, in the year 1875"	25
Discussed.	64
Discussion of Mr. A. L. Steavenson's Paper, "On an improved method of detecting small quantities of Inflammable Gas"	65
Dec. 1.—Paper by Mr. David Burns, "On the Intrusion of the Whin Sill"	73
Discussed.	78
Paper by Dr. Walter Saise, "Notes on the Geology of the Bristol Coal-field, with special reference to the Gloucestershire Basin"	87
1878.	
Feb. 2. Discussion of Mr. Wm. Cockburn's Paper, "On Cooke's Ventilating Machine," and Mr. Wm. Cochrane's Paper, "On the advantages of Centrifugal Action Machines for the Ventilation of Mines"	100

Paper by Mr. Henry Hall, "On the Telephonic Ventilation Tell-tale" 121

PAGE.

Mar. 2.—Paper by Mr. William Harle, "On increased economy in the Manufacture of Coke by Mechanical Means" 127

Discussion of Messrs. T. Lindsay Galloway and C. Z. Bunning's Paper, "A description of an Instrument for Levelling Underground" 128

Paper by Mr. Charles Parkin, "On the Perran Iron Lode in Cornwall and the Mines in the district" 131

April 13.—Paper by Mr. G. A. Lebour, "A Geological Sketch of the Northern Coal-field of France" 143

Paper by Mr. T. Lindsay Galloway, "On the present condition of Mining in some of the principal Coal-producing Districts of the Continent" 171

May 4.—Paper by Mr. Alexander Ross, "On Mechanical Stoking for Colliery Boilers" 205

Discussed 209

Paper by Mr. Edwin Gilpin, "On Canadian Coals—their composition and uses" 213

June 1.—Election of Members only 245

June 4, 5, 6, 7.—Visit to Douai and neighbourhood 245

Aug. 3.—Appointment of Scrutineers to examine the voting papers for the election of Officers 283

Paper by Mr. E. H. Liveing, "On a new method of detecting very small quantities of Inflammable Gas, and of estimating the proportion present" 287

Discussed 289

Discussion of Mr. J. B. Simpson's Paper, "An account of the condition of the Mining Industries in Prussia, in the year 1875" 294

Discussion of Mr. David Burns' Paper, "On the Intrusion of the Whin Sill" 297

REPORT

It was the duty of the Council in their report of last year to draw the attention of the members to the advantages that the acquisition of a Royal Charter would give their Institute, and to the revision of the Bye-laws which such acquisition necessitated; and it is now their pleasing task to have to state that these alterations have produced most desirable results.

The admission of a class of members who have duly served their time, and who have qualified themselves as engineers by having been engaged for some years in responsible positions, and by giving them, when admitted, a certificate showing that the Council have duly considered the status of the applicant, would, it was hoped, tend considerably to keep up the prestige of the Institute; and the Council have now the pleasure of being able to state that they were not mistaken in their predictions, and that the number of gentlemen who have aspired to be enrolled as members shows that the distinction is appreciated and sought for, and augurs well for the future position of the Institute.

The most pleasing feature in the proceedings of the last year has been the visit the members made to the Coal-fields of the North of France, in June last, where they were received most courteously by their professional brethren.

Thanks to the excellent papers of Mr. Henry Laporte and Mr. T. Lindsay Galloway, the members had an excellent opportunity of studying much that was interesting in this important coal-field, and were in a position the better to observe its peculiarities during their visit. These papers, together with a description of the collieries and works visited, which have been compiled by the Secretary and translated from various documents, and the plans and maps illustrating the same, will enable the members to find in the Transactions of the past year a complete history of the progress, present position, and modes of working pursued by our neighbours, and the interest attached to these details has been much enhanced by the very lucid discourse of Professor Gosselet on the probable extension of the field, and on some of the more prominent geological features of the district.

In addition to the above visit, a very pleasant and instructive visit was made last year to the Stonecroft and Settlingstone Lead Mines and the Prudham Quarries; and it is the intention to organise similar excursions in the neighbourhood of Newcastle from time to time.

It will be seen by the report of the Finance Committee that there has been a considerable increase of expenditure over income. This has been caused by the expenses attendant on publishing the following valuable works:—"Illustrations of Fossil Plants," the "Catalogue of the Hutton Collection," and the first volume of the "Borings made in Northumberland and Durham;" but it will be seen that the capital account has been increased to about the same amount.

These works have been paid for during the last year, and they have hardly been published long enough for the amount of sales to form an appreciable asset against the expenditure; but it is hoped the funds of the Institute will reap the benefit of this in future years, and that its income will thereby be materially benefitted.

The transactions of the past year are of unusual interest. Mr. Simpson's paper "On the Mining Industries of Prussia," and the two papers by Mr. Laporte and Mr. Galloway, already mentioned, will add greatly to our knowledge of the coal-fields of the Continent; whilst the paper by Dr. Saise, "On the Geology of the Bristol Coal-field," and that by Mr. Charles Parkin, "On the Perran Iron Lode in Cornwall," have given us much valuable information respecting interesting districts in our own island. The paper by Mr. Edwin Gilpin "On Canadian Coals: their Composition and Uses," with the large number of valuable analyses it contains, will enable members to arrive at a just appreciation of the value of the coal deposits in that country. These, with a paper by Mr. David Burns, "On the Intrusion of the Whin Sill," comprise the papers devoted more particularly to Geology and Mining; the only paper on a mechanical subject being that by Mr. Alex. Ross "On Mechanical Stoking for Colliery Boilers." The shorter papers "On Increased Economy in the Manufacture of Coke by Mechanical Means," by Mr. W. Harle; "The Telephonic Ventilation Tell-Tale," by Mr. Henry Hall; and "A Description of an Instrument for Levelling Underground," by Messrs. Galloway and C. Z. Bunning, close the list by adding a series of valuable hints whereby in many ways economy of time and money may be effected.

The number of deaths by explosions of gas in mines in the United Kingdom during the year has unfortunately been more than usually numerous, and include some valued members of the Institute. These misfortunes have occupied the serious attention of the Council; and they hope that the result of experiments now being carried on by some of the members will form the basis of a valuable paper, which it is proposed to read to the members at an early date.

[ix]

FINANCE REPORT

The Finance Committee have to report that the receipts for the past year show a decrease of £91 19s. 8d., having been from all sources in 1876-77 £2,108 16s. 4d., and this year £2,070 16s. 8d. This is due no doubt to the great depression which has existed in all departments of mineral and commercial enterprise, which has considerably increased the difficulty of collecting the subscriptions, and which has materially increased the amount of arrears.

The expenditure has amounted to £751 11s. 3d. more than the receipts. This has been caused by the outlay necessitated by the publication of several works of great importance. The great bulk of the copies of these works remain in stock, and increase the assets of the Institute £748 13s. 9d. beyond what they were last year, the amounts being respectively, £6,352 7s. and £5,603 13s. 3d.

The Institute continues to hold 134 shares in the Institute and Coal Trade Chambers' Company, Limited, of the value of £2,680 included in the above assets.

LINDSAY WOOD.

WILLIAM COCHRANE.

JOHN B. SIMPSON.

[x]

[blank page]

[xi]

[Disclaimer]

[xii]

[Account with subscriptions, 1877-78.]

(xiii)

[Account with subscriptions, 1877-78.]

[xiv]

[TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, for the year ending August, 1878]

[xv]

[TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, for the year ending August, 1878]

[xvi]

[General statement, August, 1878]

[xvii]

PATRONS

His Grace the DUKE OF NORTHUMBERLAND.

His Grace the DUKE OF CLEVELAND.

The Most Noble the MARQUESS OF LONDONDERRY.

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 OF RAVENSWORTH.

The Right Honourable the LORD WHARNCLIFFE.

The Right Reverend the LORD BISHOP OF DURHAM.

The Very Reverend the DEAN AND CHAPTER OF DURHAM.

WENTWORTH B. BEAUMONT, Esq., M.P.

HONORARY MEMBERS

	Elected. Ordy.	Hon.
The Right Honourable the EARL OF RAVENS WORTH		1877
WILLIAM ALEXANDER, Esq., Inspector of Mines, Glasgow		1863
* JAMES P. BAKER, Esq., Inspector of Mines, Wolverhampton	1853	1866
JOSEPH DICKINSON, Esq., Inspector of Mines, Manchester		1853
THOMAS EVANS, Esq., Inspector of Mines, Pen-y-Bryn, Duffield Road, Derby		1855
* HENRY HALL, Esq., Inspector of Mines, Rainhill, Prescott		1876
* RALPH MOORE, Esq., Inspector of Mines, Glasgow		1866
CHARLES MORTON, Esq., The Grange, St. Paul's, Southport		1853
* THOMAS E. WALES, Esq., Inspector of Mines, Swansea	1855	1866
* FRANK N. WARDELL, Esq., Inspector of Mines, Wath-on-Dearne, near Rotherham	1864	1868
* JAMES WILLIS, Esq., Inspector of Mines, 14, Portland Terrace, Newcastle-on-Tyne	1857	1871
THOMAS WYNNE, Esq., Inspector of Mines, Manor House, Gnosall, Stafford		1853
R. P. PHILLPSON, Esq., Newcastle-upon-Tyne		1874
WARINGTON W. SMYTH, Esq., 28, Jermyn Street, London		1869
The Very Rev. Dr. LAKE, Dean of Durham		1872
* Prof. W. S. ALDIS, M.A., College of Physical Science, Newcastle		1872
* „ G. S. BRADY, M.D., F.L.S. do. do.		1875
* „ A. FREIRE-MARRECO, M.A. do. do.		1872
* „ A. S. HERSCHEL, M.A., F.R.A.S. do. do.		1872
* Dr. DAVID PAGE, LL.D., do. do.		1872

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-an-Rhine, Prussia	1853
M. THEOPHILE GUIBAL, School of Mines, Mons, Belgium	1870
M. E. VUILLEMIN, Mines d'Aniche (Nord), France	1878

LIFE MEMBERS

	Ordy.	Life.
C. W. BARTHOLOMEW, Esq., Broxholme, Doncaster		1875
DAVID BURNS, Esq., C.E., Brookside, Haltwhistle		1877
E. B. COXE, Esq., Drifton, Jeddo, P.O., Luzerne Co., Penns., U.S .	1873	1874
ERNEST HAGUE, Esq., Castle Dyke, Sheffield	1872	1876
HENRY LAPORTE, Esq., M.E., Flenu, Mons, Belgium		1877
H. J. MORTON, Esq., 4, Royal Crescent, Scarborough	1856	1861
W. A. POTTER, Esq., Cramlington House, Northumberland	1853	1874
R. CLIFFORD SMITH, Esq., Parkfield, Swinton, Manchester	1874	1874

* Honorary Members during term of office only.

OFFICERS, 1878-79.

PRESIDENT

G. C. GREENWELL, Esq., F.G.S., Tynemouth.

VICE-PRESIDENTS

I. LOWTHIAN BELL, Esq., M.P., Rounton Grange, Northallerton.

WM. COCHRANE, Esq., St. John's Chambers, Grainger Street West, Newcastle-on-Tyne.

G. B. FORSTER, Esq., Backworth House, Newcastle-on-Tyne.

JOHN MARLEY, Esq., Mining Offices, Darlington.

CHARLES MITCHELL, Esq., Jesmond, Newcastle-on-Tyne

A. L. STEAVENSON, Esq., Durham.

COUNCIL

T. W. BENSON, Esq., 11, Newgate Street, Newcastle-on-Tyne.

CUTHBERT BERKLEY, Esq., Marley Hill Colliery, Gateshead.

WM. BOYD, Esq., 74, Jesmond Road, Newcastle-on-Tyne.

V. W. CORBETT, Esq., Seaton House, Seaham Harbour.

S. C. CRONE, Esq., Killingworth Hall, Newcastle-on-Tyne.

THOMAS DOUGLAS, Esq., Peases' West Collieries, Darlington.

W. H. HEDLEY, Esq., Medomsley, Newcastle-on-Tyne.

THOS. HEPPELL, Esq., Leafield House, Chester-le-Street.

T. G. HURST, Esq., F.G.S., Lauder Grange, Corbridge.

WM. LISHMAN, Esq., Bunker Hill, Fence Houses.

GEO. MAY, Esq., Harton Colliery Offices, Tyne Docks, South Shields.

JAMES NELSON, Esq., Marine and Stationary Engine Works, Gateshead.

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

A. M. POTTER, Esq., Shire Moor Colliery, Newcastle-on-Tyne.

J. T. RAMSAY. Esq., Walbottle Hall, Blaydon-on-Tyne.

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

J. G. WEEKS, Esq., Bedlington Colliery, Bedlington.

JAMES WILLIS, Esq., 14. Portland Terrace, Newcastle-on-Tyne.

Ex-officio

Past presidents

Sir W. G. ARMSTRONG, C. B., LL.D., F.R.S., Jesmond, Newcastle-on-Tyne.
E. F. BOYD, Esq., Moor House, Fence Houses.
Sir GEO. ELLIOT, Bart., M.P., Houghton Hall, Fence Houses

LINDSAY WOOD, Esq., Southill, Chester-le-Street.

Retiring Vice Presidents

T. J. BEWICK, Esq., Haydon Bridge, Northumberland

JOHN DAGLISH, Esq., Tynemouth

SECRETARY AND TREASURER

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

LIST OF MEMBERS

AUGUST, 1878.

ORIGINAL MEMBERS

Marked (*) are Life Members.	elected.
1 Adams, G. F., Guild Hall Chambers, Cardiff	Dec. 6, 1873
2 Adams, W., Cardiff	1854
3 Adamson, Daniel, Engineering Works, Hyde Junction, Manchester	Aug. 7, 1875
4 Addy, W. F., Dronfield, near Sheffield	May 6, 1876
5 Ainslie, Aymer, Hall Garth, Carnforth	Aug. 7, 1869
6 Aitkin, Henry, Falkirk, N.B.	Mar. 2, 1865
7 Allison, T., Belmont Mines, Guisbro'	Feb. 1, 1868
8 Anderson, C. W., Kirk Hammerton Hall, York	Aug. 21, 1852
9 Anderson, William, Rainton Colliery, Fence Houses	Aug. 21, 1852
10 Andrews, Hugh, Felton Park, Felton, Northumberland	Oct. 5, 1872
11 Appleby, C. E., 20, Great George Street, Westminster, London, S.W.	Aug. 1, 1861
12 Archer, T., Dunston Engine Works, Gateshead	July 2, 1872
13 Arkless, John, Tantoby, Burnopfield	Nov. 7, 1868
14 Armstrong, Sir W. G., C.B., LL.D., F.R.S., Jesmond, Newcastle-upon-Tyne (Past President, *Member of Council*)	May 3, 1866

15	Armstrong, Wm., Sen., Pelaw House, Chester-le-Street	Aug. 21, 1852
16	Armstrong, W., Junior, Wingate, Co. Durham	April 7, 1867
17	Armstrong, W. L., Leighs Wood Colliery Co. Ld., Aldridge, nr. Walsall	Mar. 3, 1864
18	Arthur, David M. E., Accrington, near Manchester	Aug. 4, 1877
19	Ashwell, H., Anchor Colliery, Longton, North Staffordshire	Mar. 6, 1862
20	Ashworth, James, Bank Top Colliery, Burslem	Feb. 5, 1876
21	Ashworth, John, Jun., 81, Bridge Street, Manchester	Sept. 2, 1876
22	Asquith, T. W., Seaton Delaval Colliery, Northumberland	Feb. 2, 1867
23	Atkinson, J. B., Ridley Mill, Stocksfield-on-Tyne	Mar. 5, 1870
24	Atkinson, W. N., Chilton Moor, Fence Houses	June 6, 1868
25	Aubrey, R. C., Astley House, Woodlesford, near Leeds	Feb. 5, 1870
26	Austine, John, Cadzow Coal Co., Glasgow	Nov. 4, 1876
27	Aynsley, Wm., Birtley, Chester-le-Street	Mar. 3, 1873

28	Bachke, A. S.	Mar. 5, 1870
29	Bagley, Chas. John, Tees Bridge Iron Co., Stockton	June 5, 1875
30	Bailes, George, Murton Colliery, Sunderland	Feb. 3, 1877
31	Bailes, John, Wingate Colliery, Ferryhill	Sept. 5, 1868
32	Bailes, T., Junior, 41, Lovaine Place, Newcastle-on-Tyne	Oct. 7, 1858

		ELECTED.
33	Bailes, W., Murton Colliery, Sunderland	April 7, 1877
34	Bailey, G., St. John's Colliery, Wakefield	June 5, 1869
35	Bailey, Samuel, Perry Barr, Birmingham	June 2, 1859
36	Bailey, W. W., Kilburne, near Derby	May 13, 1858
37	Bain, R. Donald, Newport, Monmouthshire	Mar. 3, 1873

38 Bainbridge, E., Nunnery Colliery Offices, Sheffield	Dec 3, 1863
39 Banks, Thomas, Leigh, near Manchester	Aug. 4, 1877
40 Barclay, A., Caledonia Foundry, Kilmarnock	Dec. 6, 1866
41 Barkus, Wm., 1, St. Nicholas' Buildings, Newcastle-on-Tyne	Aug. 21, 1852
42 Barnes, R. J., Atherton Collieries, near Manchester	Sept. 13, 1873
43 Barnes, T., Seaton Delaval Office, Quay, Newcastle-on-Tyne	Oct. 7, 1871
44 Barrat, A. J., Ruabon Coal Co., Ruabon	Sept. 11, 1875
45 Bartholomew, C., Castle Hill House, Ealing, London, W.	Aug. 5, 1853
46* Bartholomew, C. W., Broxholme, Doncaster	1875
47 Bassett, A., Tredegar Mineral Estate Office, Cardiff	1854
48 Bates, Matthew, Bews Hill, Blaydon-on-Tyne	Mar. 3, 1873
49 Bates, Thomas, Heddon, Wylam, Northumberland	Mar. 3, 1873
50 Bates, W. J., Bews Hill, Blaydon-on-Tyne	Mar. 3, 1873
51 Batey, John, Newbury Collieries, Coleford, Bath	Dec. 5, 1868
52 Beanlands, A., M.A., North Bailey, Durham	Mar. 7, 1867
53 Beaumont, James, M.E., Oughtbridge, near Sheffield	Nov. 7, 1874
54 Bell, I. L., M.P., Routon Grange, Northallerton (Vice-President)	July 6, 1854
55 Bell, John (Messrs. Bell Brothers), Middlesbro'-on-Tees	Oct. 1, 1857
56 Bell, Thomas, Crosby Court, Northallerton	Sept. 3, 1870
57 Bell, T., Jun. (Messrs. Bell Brothers), Middlesbro'-on-Tees	Mar. 7, 1867
58 Benson, J. G., Accountant, Newcastle-on-Tyne	Nov. 7, 1874
59 Benson, T. W., 11, Newgate Street, Newcastle (*Member of Council*)	Aug. 2, 1866
60 Berkley, C., Marley Hill Colliery, Gateshead (*Member of Council*)	Aug. 21, 1852
61 Berryman, Robert, Howick Villa, Pershon Road, Birmingham	Aug. 5, 1876
62 Beswicke, Wm., South Parade, Rochdale	Sept. 11, 1875
63 Bewick, T. J., M. Inst. C.E., F.G.S., Haydon Bridge, Northumberland (*Member of Council*)	April 5, 1860
64 Bidder, B. P., Duffryn Collieries, Neath, Glamorganshire	May 2, 1867

65 Bigland, J., Bedford Lodge, Bishop Auckland — June 4, 1857

66 Binns, C., Claycross, Derbyshire — July 6, 1854

67 Biram, B., Peaseley Cross Collieries, St. Helen's, Lancashire — 1856

68 Black, James, Jun., Portobello Foundry, Sunderland — Sept. 2, 1871

69 Black, W., Hedworth Villa, South Shields — April 2, 1870

70 Bladen, W. Wells, Wolstanton, No. Staffordshire — April 7, 1877

71 Blagburn, C., King Street, Quay, Newcastle-on-Tyne — Sept. 2, 1871

72 Bolam, H. G., Little Ingestre, Stafford — Mar. 6, 1875

73 Bolton, H. H., Newchurch Collieries, near Manchester — Dec. 5, 1868

74 Boole, Charles, Rainford Colliery, St. Helen's, Lancashire — Dec. 4, 1875

75 Boot, J. T., M.E., The Orchards, Hucknall, near Mansfield — April 1, 1871

76 Booth, R. L., Ashington Colliery, near Morpeth — 1864

77 Borries, Theo., Lombard Street, Quay, Newcastle-on-Tyne — April 11, 1874

78 Bourne, Peter, 39, Rodney Street, Liverpool — 1854

ELECTED.

79 Bourne, Thos. W., Broseley, Salop — Sept. 11, 1875

80 Boyd, E. F., Moor House, Fence Houses (Past Pres., *Mem. of Council*) — Aug. 21, 1852

81 Boyd, R. F., Moor House, Fence Houses — Nov. 6, 1869

82 Boyd, Wm., 74, Jesmond Road, Newcastle-on-Tyne (*Mem. of Council*) — Feb. 2, 1867

83 Bradford, Geo., Etherley, Bishop Auckland — Oct. 11, 1873

34 Breckon, J. R., Park Place, Sunderland — Sept. 3, 1864

85 Brettell, T., Mine Agent, Dudley, Worcestershire — Nov. 3, 1866

86 Brogden, J. — 1861

87 Bromilow, Wm., Queen's Road, Southport, Lancashire — Sept. 2, 1876

88 Brown, E., 79, Clayton Street, Newcastle-on-Tyne — Mar. 7, 1874

89 Brown, J. N., 56, Union Passage, New Street, Birmingham 1861

90 Brown, Thos. Forster, Guild Hall Chambers, Cardiff 1861

91 Browne, B. C., Asso. M.I.C.E., No. Granville Road, Jesmond, N'castle Oct. 1, 1870

92 Bruton, W., Whitwood, Normanton, Streethouse Colls., nr. Normanton Feb. 6, 1869

93 Bryham, William, Rosebridge Colliery, Wigan Aug. 1, 1861

94 Bryham, W., Jun., Douglas Bank Collieries, Wigan Aug. 3, 1865

95 Bunning, Theo. Wood, Neville Hall, Newcastle-on-Tyne (Secretary and Treasurer) 1864

96 Burn, James, The Avenue, Sunderland Aug. 2, 1866

97 *Burns, David, C.E., Brookside, Haltwhistle 1877

98 Burrows, James, Douglas Bank, Wigan, Lancashire May 2, 1867

99 Burrows, J. S., Green Hall, Atherton, Manchester Oct. 11, 1873

100 Cabry, J., N.E. Railway, B. and T. Section, Newcastle-on-Tyne Sept. 4, 1869

101 Caldwell, George, Moss Hall Colliery, near Wigan Mar. 6, 1869

102 Campbell, W. B., Consulting Engineer, Grey Street, Newcastle Oct. 7, 1876

103 Carr, Wm. Cochran, South Benwell, Newcastle-on-Tyne Dec. 3, 1857

104 Carrington, T., Jun., High Hazels, Darnal, near Sheffield Aug. 1, 1861

105 Catron, J., Brotton Hall, Saltburn-by-the-Sea Nov. 3, 1866

106 Chadborn, B. T., Pinxton Collieries, Alfreton, Derbyshire 1864

107 Chadwick, W. H., Bank Colliery, Little Hulton, nr. Bolton, Lancashire Dec. 4, 1875

108 Chambers, A. M., Thorncliffe Iron Works, near Sheffield Mar. 6, 1869

109 Chambers, W. Hoole, Silkstone Main Colliery, near Barnsley Feb. 5, 1876

110 Chapman, M., Plashetts Colliery, Northumberland Aug. 1, 1868

111 Charlton, E., Evenwood Colliery, Bishop Auckland Sept. 5, 1868

112 Charlton, F., C.E., Moot Hall, Newcastle-on-Tyne Sept. 2, 1871

113 Charlton, George, Washington Colliery, Co. Durham Feb. 6, 1875

114 Checkley, Thomas, M.E., Lichfield Street, Walsall Aug. 7, 1869

115	Cheesman, I., Throckley Colliery, Newcastle-on-Tyne	Feb. 1, 1873
116	Cheesman, W. T., Wire Rope Manufacturer, Hartlepool	Feb. 5, 1876
117	Childe, Rowland, Wakefield, Yorkshire	May 5, 1862
118	Cizancourt, M. De, St. Etienne, France	Sept. 1, 1877
119	Clarence, Thomas, Elswick Colliery, Newcastle-on-Tyne	Dec. 4, 1875
120	Clark, C. F., Garswood Coal and Iron Co., near Wigan	Aug. 2, 1866
121	Clark, G., Chesterton Coal & Iron Co. Ld., Chesterton, No. Staffords.	Dec. 7, 1867
122	Clark, G., Jun., Monkwearmouth Engine Works, Sunderland	Dec. 6, 1873
123	Clark, R. B., Marley Hill, near Gateshead	May 3, 1873

		ELECTED
124	Clark, W., M.E., The Grange, Teversall, near Mansfield	April 7, 1866
125	Clarke, William, Victoria Engine Works, Gateshead	Dec. 7, 1867
126	Clifft, J. H., 26, Devonshire Street, High Broughton, Manchester	May 6, 1876
127	Cochrane, B., Aldin Grange, Durham	Dec. 6, 1866
128	Cochrane, C., The Grange, Stourbridge	June 3, 1857
129	Cochrane, W., St. John's Chambers, Grainger Street West, Newcastle (Vice-President)	1859
130	Cockburn, G., 8, Summerhill Grove, Newcastle-on-Tyne	Dec. 6, 1866
131	Cockburn, W., Upleatham Mines, Upleatham, Marske	Oct. 1, 1859
132	Coe, W. S., Newchapel Colliery, Tunstall	Feb. 5, 1876
133	Coke, R. G., Tapton Grove, Chesterfield, Derbyshire	May 5, 1856
134	Cole, Richard, Walker Colliery, near Newcastle-on-Tyne	April 5, 1873
135	Cole, Robert Heath, Cobridge, Stoke-upon-Trent	Feb. 5, 1876
136	Cole, W. R., Broomfield, Jesmond, Newcastle-on-Tyne	Oct. 1, 1857
137	Collis, W. B., Swinford House, Stourbridge, Worcestershire	June 6, 1861
138	Cook, John, Wigan Coal and Iron Co., Wigan	Nov. 7, 1874

139	Cook, J., Jun., Washington Iron Works, Gateshead	May 8, 1869
140	Cooke, John, North Brancepeth Colliery, near Durham	Nov. 1, 1860
141	Cooksey, Joseph, West Bromwich, Staffordshire	Aug. 3, 1865
142	Cooper, P., Thornley Colliery Office, Ferryhill	Dec. 3, 1857
143	Cooper, R. E., C.E., 1, Westminster Chambers, Victoria Street, London	Mar. 4, 1871
144	Cooper, T., Rosehill, Rotherham, Yorkshire	April 2, 1863
145	Cope, James, Port Vale, Longport, Staffordshire	Oct. 5, 1872
146	Corbett, V. W., Seaton House, Seaham Harbour (*Mem. of Council*)	Sept. 3, 1870
147	Corbitt, M., Wire Rope Manufacturer, Teams, Gateshead	Dec. 4, 1875
148	Coulson, F., Shamrock House, Durham	Aug. 1, 1868
149	Coulson, W., Shamrock House, Durham	Oct. 1, 1852
150	Cowen, Jos., M.P., Blaydon Burn, Newcastle-on-Tyne	Oct. 5, 1854
151	Cowey, John, Wearmouth Colliery, Sunderland	Nov. 2, 1872
152	Cowlishaw, J., Thorncliffe, &c, Collieries, near Sheffield	Mar. 7, 1867
153	Cox, John H., 10, St. George's Square, Sunderland	Feb. 6, 1875
154	Cox, S. H. F., Lower Carloggas, St. Columb, Cornwall	Dec. 2, 1876
155	*Coxe, E. B., Drifton. Jeddo, P. O. Luzerne Co., Penns., U.S.	1874
156	Coxon, Henry, Quay, Newcastle-on-Tyne	Sept. 2, 1871
157	Coxon, S. B., Usworth Colliery, Washington Station, Co. Durham	June 5, 1856
158	Craig, W. Y., 2, Cambridge Gate, Regent's Park, London, N.W.	Nov. 3, 1866
159	Crawford, T., Littletown Colliery, near Durham	Aug. 21, 1852
160	Crawford, T, Burnhope Colliery, by Lanchester, Co. Durham	Sept. 3, 1864
161	Crawford, T., Jun., Littletown Colliery, near Durham	Aug 7, 1869
162	Crawshay, E., Gateshead-on-Tyne	Dec. 4, 1869
163	Crawshay, G., Gateshead-on-Tyne	Dec. 4, 1869
164	Crofton, J. G., Esh Colliery, Durham	Feb. 7, 1861
165	Crone, E. W., Killingworth Hall, near Newcastle-on-Tyne	Mar. 5, 1870

166	Crone, J. R., Tow Law, via Darlington	Feb. 1, 1868
167	Crone, S. C., Killingworth Colliery, Newcastle (*Member of Council*)	1853
168	Cross, John, 78, Cross Street, Manchester	June 5, 1869
169	Croudace, C. J., Brayton Domain, &c. Colliery Office, Maryport	Nov. 2, 1872

		ELECTED.
170	Croudace, John, West House, Haltwhistle	June 7, 1873
171	Croudace, Thomas, Lambton Lodge, New South Wales	1862
172	Cuthbert, W., Beaufront Castle, Northumberland	Aug. 1, 1874
173	Daburon, Mons., Ingenieur aux Mines de Lens, Pas de Calais	May 1, 1875
174	Daglish, John, Tynemouth (*Member of Council*)	Aug. 21, 1852
175	Daglish, W. S., Solicitor, Newcastle-on-Tyne	July 2, 1872
176	Dakers, J., Chilton Colliery, Ferryhill	April 11, 1874
177	Dale, David, West Lodge, Darlington	Feb. 5, 1870
178	D'Andrimont, T., Liege, Belgium	Sept.3, 1870
179	Daniel, W., 37, Camp Road, Leeds	June 4, 1870
180	Darling, Fenwick, South Durham Colliery, Darlington	Nov. 6, 1875
181	Darlington, John, 2, Coleman Street Buildings, Moorgate Street, Great Swan Alley, London	April 1, 1865
182	Darlington, J., Black Park Colliery Co. Limited, Ruabon	Nov. 7, 1874
183	Davey, Henry, C.E., Leeds	Oct. 11, 1873
184	Davidson, James, Newbattle Colliery, Dalkeith	1854
185	Davis, David, Coal Owner, Maesyffynon, Aberdare	Nov. 7, 1874
186	Davison, George	Mar. 4, 1876
187	Day, W. H, Eversley Garth, So. Milford	Mar. 6, 1869
188	Deacon, Maurice	Sept. 11, 1875

189	Dees, R. R., Solicitor, Newcastle-on-Tyne	Oct. 7, 1871
190	Devillaine, M., St. Etienne, France	Sept. 1, 1877
191	Dickinson, G. T., Wheelbirks. Northumberland	July 2, 1872
192	Dickinson, R., Coal Owner, Shotley Bridge, Co. Durham	Mar. 4, 1871
193	Dickinson, W. R., Priestfield Lodge, Lintz Green, Co. Durham	Aug. 7, 1862
194	Dinning, Joseph, Langley Smelt Mills, Northumberland	April 5, 1873
195	Dixon, D. W., Brotton Mines, Saltburn-by-the-Sea	Nov. 2, 1872
196	Dixon, Nich., Dudley Colliery, Dudley, Northumberland	Sept. 1, 1877
197	Dixon, R., Wire Rope Manufacturer, Teams, Gateshead	June 5, 1875
198	Dobson, W., 14, Ashfield Terrace West, Newcastle-on-Tyne	Sept. 4, 1869
199	Dodd, B., Bearpark Colliery, near Durham	May 3, 1866
200	Dodds, J., M.P., Stockton-on-Tees	Mar. 7, 1874
201	Douglas, C. P., Consett House, Consett, Co. Durham	Mar. 6, 1869
202	Douglas, T., Peases' West Collieries, Darlington (*Mem. of Council*)	Aug. 21, 1852
203	Douthwaite, T., Merthyr Vale Colliery, Merthyr Tydvil	June 5, 1869
204	Dove, G., Viewfield, Stanwix, Carlisle	July 2, 1872
205	Dowdeswell, H., Butterknowle Colliery, via Darlington	April 5, 1873
206	Dyson, George, Middlesborough	June 2, 1866
207	Dyson, O., Houghton Main Colliery, Darfield, near Barnsley	Mar. 2, 1872

208	Easton, J., Nest House, Gateshead	1853
209	Eckersley, Nathaniel, Standish Hall, Wigan	Sept. 2, 1876
210	Eddison, Robert W., Steam Plough Works, Leeds	Mar. 4, 1876
211	Eland, J. S., Accountant, Newcastle-on Tyne	Nov. 7, 1874
212	Elliot, Sir G, Bart., M.P., Houghton Hall, Fence Houses (Past President, *Member of Council*)	Aug. 21, 1852

213 Elliot, W. S., Windlestone Colliery, near Ferryhill Station Sept. 13, 1873

214 Elliott, W., Tudhoe House, Durham 1854

215 Elliott, W. D., Pemberton Street, Hull Oct. 11, 1873

216 Elsdon, Robert, 76, Manor Road, Upper New Cross, London Nov. 4, 1876

217 Embleton, T. W., The Cedars, Methley, Leeds Sept. 6, 1855

218 Embleton, T. W., Jun., The Cedars, Methley, Leeds Sept. 2, 1865

219 Eminson, J. B., Londonderry Offices, Seaham Harbour Mar. 2, 1872

220 Everard, I. B., M.E., 6, Millstone Lane, Leicester Mar. 6, 1869

221 Farmer, A., Westbrook, Darlington Mar. 2, 1872

222 Farrar, James, Old Foundry, Barnsley July 2, 1872

223 Favell, Thomas M., 14, Saville Street, North Shields April 5, 1873

224 Fearn, John Wilmot, Chesterfield Mar. 6, 1869

225 Fenwick, Barnabas, Team Colliery, Gateshead Aug. 2, 1866

226 Fenwick, George, Banker, Newcastle-on-Tyne Sept. 2, 1871

227 Fenwick, Thomas, East Pontop Colliery, by Lintz Green April 5, 1873

228 Ferens, Robinson, Oswald Hall, near Durham April 7, 1877

229 Fidler, E., Platt Lane Colliery, Wigan, Lancashire Sept. 1, 1866

230 Firth, S., M. A., 16, York Place, Leeds 1865

231 Firth, William, Burley Woods, Leeds Nov. 7, 1863

232 Fisher, R. C, The Wern, Ystalyfera, Swansea July 2, 1872

233 Fletcher, G., Trimdon Colliery, Trimdon Grange April 4, 1868

234 Fletcher, Geo., Hamsteels Colliery, near Durham Aug. 1, 1874

235 Fletcher, H., Ladyshore Coll., Little Lever, Bolton, Lancashire Aug. 3, 1865

236 Fletcher, I., M.P., Clifton Colliery, Workington Nov. 7, 1863

237 Fletcher, Jas., Manager Co-operative Collieries, Wallsend, near Newcastle, New South Wales Sept. 11, 1875

238 Fletcher, J., Kelton House, Dumfries July 2, 1872

239 Fletcher, W., Waterhead, Ambleside Feb. 4, 1871

240 Foggin, William, Pensher Colliery, Fence Houses Mar.6, 1875

241 Forrest, J., Assoc. Inst. C.E., Pentrehobin Hall, Mold, Flintshire Mar. 5, 1870

242 Forster, G. B., M.A., Backworth House, near Newcastle-upon-Tyne (Vice-President) Nov. 5, 1852

243 Forster, J. R., Water Co.'s Office, Newcastle-on-Tyne July 2, 1872

244 Forster, J. T., Waldridge Colliery, Chester-le-Street Aug. 1, 1868

245 Forster, Richard, White House, Gateshead Oct. 5, 1872

246 Forster, R., South Hetton, Fence Houses Sept. 5, 1868

247 Foster, George, Osmondthorpe Colliery, near Leeds Mar. 7, 1874

248 Fothergill, J., King Street, Quay, Newcastle-on-Tyne Aug. 7, 1862

249 Fothergill, Robt. T. Mar. 3, 1877

250 France, Francis, St. Helen's Colliery Co., St. Helen's, Lancashire Sept. 1, 1877

251 France, W., Lofthouse Mines, Saltburn-by-the-Sea April 6, 1867

252 Franks, George, Victoria Garesfield, Lintz Green Feb. 6, 1875

253 Frazier, Prof. B. W., Lehigh University, Bethlehem, Penns., U.S Nov. 2, 1872

254 Furness, H. D., Close House, Ravensworth, Gateshead-on-Tyne Dec. 2, 1871

255 Galloway, R. L., Ryton-on-Tyne Dec. 6, 1873

256 Galloway, T. Lindsay, M.A., Ryton-on-Tyne Sept. 2, 1876

257 Gardner, Walter, M.E., The Stone House, Rugeley Feb. 14, 1874

258 Gerrard, John, Westgate, Wakefield Mar. 5, 1870

259 Gibson, John, Ryhope Colliery, near Sunderland Dec. 4, 1875

260 Gill, Harry, Consulting Engineer, Newcastle-on-Tyne May 2, 1874

261 Gillett, F. C., Midland Road, Derby July 4, 1861

262 Gilmour, D., Portland Colliery, Kilmarnock Feb. 3, 1872

263	Gilpin, Edwin, 26, Spring Gardens, Halifax, Nova Scotia	April 5, 1873
264	Gilroy, G., Ince Hall Colliery, Wigan, Lancashire	Aug. 7, 1856
265	Gilroy, S. B., Assistant Gov. Inspector of Mines, Stone	Sept. 5, 1868
266	Gjers, John, Southfield Villas, Middlesbro'	June 7, 1873
267	Goddard, D. H., Chester-le-Street	July 2, 1872
268	Goddard, F. R., Accountant, Newcastle-on-Tyne	Nov. 7, 1874
269	Gooch, G. H., Lintz Colliery, Burnopfield, Gateshead	Oct. 3, 1856
270	Goodman, A., Walker Iron Works, Newcastle-on-Tyne	Sept. 5, 1868
271	Gordon, James N., 49, George Street, Portman Square, London, W.	Nov. 6, 1875
272	Gott, William L.	Sept. 3, 1864
273	Grace, E. N., Dhadka, Assensole, Bengal, India	Feb. 1, 1868
274	Grant, J. H., care of C. Grant, 69, Lower Circular Street, Calcutta	Sept. 4, 1869
275	Gray, Thomas, Underhill, Taibach, South Wales	June 5, 1869
276	Greaves, J. O., M.E., St. John's, Wakefield	Aug. 7, 1862
277	Green, J. T., Abercarn Fach, near Newport, Monmouthshire	Dec. 3, 1870
278	Green, W., Jun., Thornelly House, Blayd on-on-Tyne	Feb. 4, 1853
279	Greener, John, General Manager, Vale Coll., Pictou, Nova Scotia	Feb. 6, 1875
280	Greener, T., 71, Kellett Road, Brixton, London, S.W.	Aug. 3, 1865
281	Greenwell, G. C, Tynemouth (President)	Aug. 21, 1852
282	Greenwell, G. C., Jun., Poynton, near Stockport	Mar. 6, 1869
283	Greig, D., Leeds	Aug. 2, 1866
284	Grey, C. G., 55, Parliament Street, London	May 4, 1872
285	Grieves, D., Brancepeth Colliery, Willington, County Durham	Nov. 7, 1874
286	Griffith, N. R., Wrexham	1866
287	Grimshaw, E. J., Cowley Hill, St. Helen's, Lancashire	Sept. 5, 1868
288	Grimshaw, W. J., Stand Lane Colliery, Radcliffe, Manchester	Nov. 1, 1873
289	Ground, H. N., Redheugh Colliery, Gateshead-on-Tyne	July 2, 1872

290 Guinotte, Lucien, Directeur des Charbonnages de Mariemont et de Bascoup, Mons, Belgium Sept. 2, 1871

291 Haggie, D. H., Hendon Patent Ropery, Sunderland Mar. 4, 1876

292 Haggie, P., Gateshead 1854

293 *Hague, Ernest, Castle Dyke, Sheffield 1876

294 Haines, J. Richard, Adderley Green Colliery, near Longton Nov. 7, 1874

295 Hales, C., Nerquis Cottage, Nerquis, near Mold, Flintshire 1865

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

297 Hall, George, South Garesfield Colliery, Lintz Green Mar. 6, 1875

298 Hall, M., Lofthouse Station Collieries, near Wakefield Sept. 5, 1868

299 Hall, M. S., M.E., Westerton, near Bishop Auckland Feb. 14, 1874

300 Hall, W., Spring Hill Mines, Cumberland County, Nova Scotia Sept. 13, 1873

301 Hall, Wm., Thornley Colliery, County Durham Dec. 4, 1875

302 Hall, William F., Haswell Colliery, Fence Houses May 13, 1858

303 Hann, Edmund, Glanmoor Villa, Uplands, Swansea Sept. 5, 1868

304 Harbottle, W. H., Orrell Colliery, near Wigan Dec. 4, 1875

305 Hardy, Jos., Preston Colliery, North Shields June 2, 1877

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

307 Harle, Richard, Browney Colliery, Durham April 7, 1877

308 Harle, William, Pagebank Colliery, near Durham Oct. 7, 1876

309 Harrison, R. W., Eastwood, near Nottingham 1861

310 Harrison, T., Great Western Colliery, Pontypridd, Glamorganshire Aug. 2, 1873

311 Harrison, T. E., C.E., Central Station, Newcastle-on-Tyne May 6, 1853

312 Harrison, W. B., Brownhills Collieries, near Walsall April 6, 1867

313 Haswell, G. H., 11, South Preston Terrace, North Shields Mar. 2, 1872

314	Hawthorn, T., 98, Rye Hill, Newcastle-on-Tyne	Dec. 6, 1866
315	Hay, J., Jun., Widdrington Colliery, Acklington	Sept. 4, 1869
316	Heckels, Matthew, Boldon Colliery, Durham	April 11, 1874
317	Heckels, W. J.	May 2, 1868
318	Hedley, Edw., 2, Church Street, London Road, Derby	Dec. 2, 1858
319	Hedley, J. J., Consett Collieries, Leadgate, County Durham	April 6, 1872
320	Hedley, J. L., 3, Elm Vale, Fairfield, Liverpool	Feb. 5, 1870
321	Hedley, T. F., Valuer, Sunderland	Mar. 4, 1871
322	Hedley, W. H., Consett Collieries, Medomsley, Newcastle-on-Tyne (*Member of Council*)	1864
323	Henderson, H., Pelton Colliery, Chester-le-Street	Feb. 14, 1874
324	Henderson, John, Leazes House, Durham	Mar. 5, 1870
325	Heppell, T., Leafield House, Birtley, Fence Houses (*Mem. of Council*)	Aug. 6, 1863
326	Heppell, W., Brancepeth Colliery, Willington, County Durham	Mar. 2, 1872
327	Herdman, J., Park Crescent, Bridgend, Glamorganshire	Oct. 4, 1860
328	Heslop, C., Lingdale Mines, via Guisborough	Feb. 1, 1868
329	Heslop, Grainger, Whitwell Colliery, Sunderland	Oct. 5, 1872
330	Heslop, J., Hucknall Torkard Colliery, near Nottingham	Feb. 6, 1864
331	Hetherington, D., Coxlodge Colliery, Newcastle-on-Tyne	1859
332	Hetherington, Robert, Coanwood, Haltwhistle	Nov. 1, 1873
333	Hewitt, G. C., Coal Pit Heath Colliery, near Bristol	June 3, 1871
334	Hewlett, A., Haigh Colliery, Wigan, Lancashire	Mar. 7, 1861
335	Hick, G. W., 14, Blenheim Terrace, Leeds	May 4, 1872
336	Higson, Jacob, 94, Cross Street, Manchester	1861
337	Higson, P., Crown Chambers, 18, Booth Street, Manchester	Aug. 3, 1865
338	Hill, Leslie C., Bartholomew House, London, EC	Nov. 6, 1875
339	Hilton, J., Standish and Shevington Collieries, near Wigan	Dec. 7, 1867
340	Hilton, T. W., Wigan Coal and Iron Co., Limited, Wigan	Aug. 3, 1865

341 Hindmarsh, Thomas, Cowpen Lodge, Blyth, Northumberland Sept. 2, 1876

342 Hodgson, J. W., Dipton Colliery, via Lintz Green Station Feb. 5, 1870

343 Holding, W., Brensop Hall Coal Co., Wigan Mar. 3, 1877

344 Holliday, Martin, M.E., Peases' West Collieries, Crook May 1, 1875

345 Holmes, C., Grange Hill, near Bishop Auckland April 11, 1874

346 Homer, Charles J., Caverswall Castle, Stoke-on-Trent Aug. 3, 1865

ELECTED.

347 Hood, A., 6, Bute Crescent, Cardiff April 18, 1861

348 Hope, George, Newbottle Colliery, Fence Houses Feb. 3, 1877

349 Hornsby, H., Whitworth Terrace, via Spennymoor, Co. Durham Aug. 1, 1874

350 Horsley, W., Whitehill Point, Percy Main Mar. 5, 1857

351 Hoskold, H. D., C. and M.E., F.R.G.S., F.G.S., M. Soc. A., &c, 11, Rue Lauriston, Champs Elysees, Paris April 1, 1871

352 Howard, W. F., 13, Cavendish Street, Chesterfield Aug. 1, 1861

353 Hoyt, J., Acadia Coal Mines, Pictou, Nova Scotia May 8, 1869

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

355 Hughes, H. E., Old Durham Colliery, Durham Nov. 6, 1869

356 Humble, John, West Pelton, Chester-le-Street Mar. 4, 1871

357 Humble, Jos., Staveley Works, near Chesterfield June 2, 1866

358 Hunter, J., Jun., Silkstone and Worsbro' Park Colls., nr. Barnsley Mar. 6, 1869

359 Hunter, W., Monk Bretton Colliery, near Barnsley Oct. 3, 1861

360 Hunter, Wm., Charlaw Colliery Office, Quay, Newcastle Aug. 21, 1852

361 Hunter, W. S., Moor Lodge, Newcastle-upon-Tyne Feb. 1, 1868

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

363 Hurst, T. G., F.G.S., Lauder Grange, Corbridge-on-Tyne (*Member of Council*) Aug. 21, 1852

364 Hutchinson, G., Quarry House, Howden-le-Wear July 2, 1872

365	Hyslop, J. S., Guisbro'	April 1, 1871
366	Jackson, C. G., Wigan Coal and Iron Co., Limited, Wigan	June 4, 1870
367	Jackson, W., Cannock Chase Collieries, Walsall	Feb. 14, 1874
368	Jackson, W. G., Hazel Farm, Methley, near Leeds	June 7, 1873
369	Jarratt, J., Broomside Colliery Office, Durham	Nov. 2, 1867
370	Jeffcock, T. W., 18, Bank Street, Sheffield	Sept. 4, 1869
371	Jenkins, W., M.E., Ocean S.C. Colls., Ystrad, nr. Pontypridd, So. Wales	Dec. 6, 1862
372	Jenkins, Wm., Consett Iron Works, Consett, Durham	May 2, 1874
373	Johnasson, J., Leadenhall Street, London, E.C.	July 2, 1872
374	Johnson, Henry, Dudley, Worcestershire	Aug. 7, 1869
375	Johnson, John, M. Inst. C.E., F.G.S., 21, Victoria Square, Newcastle	Aug. 21, 1852
376	Johnson, J., Witley Colliery Co. Ld., Halesowen, nr. Birmingham	Mar. 7, 1874
377	Johnson, R. S., Sherburn Hall, Durham	Aug. 21, 1852
378	Johnston, T., Deanmoor Colliery Co., by Cockermouth	April 6,1872
379	Joicey, E., Coal Owner, Newcastle-on-Tyne	April 6, 1872
380	Joicey, John, Newton Hall, Stocksfield-on-Tyne	Sept. 3, 1852
381	Joicey, J. G., Forth Banks West Factory, Newcastle-on-Tyne	April 10, 186 9
382	Joicey, W. J., Tanfield Lea Colliery, Burnopfield	Mar. 6, 1869
383	Jordan, Robert, Ebbw Vale, South Wales	Nov. 7, 1874
384	Joseph, D. Davis, Ty Draw, Pontypridd, South Wales	April 6, 1872
385	Joseph, T., Ty Draw, near Pontypridd, South Wales	April 6, 1872
386	Kasalousky, Josef, 11, Kaiser Josefs Strasse, Vienna	Aug. 1, 1874
387	Kelsey, W., 41, Fawcett Street, Sunderland	Mar. 7, 1874
388	Kendall, John D., Roper Street, Whitehaven	Oct. 3, 1874
389	Kennedy, Myles, M.E., Hill Foot, Ulverstone	June 6, 1868

		ELECTED.
390	Kimpton, J. G., 40, St. Mary's Gate, Derby	Oct. 5, 1872
391	Kirkby, J. W., Ashgrove, Leven, Fife	Feb. 1, 1873
392	Kirkwood, William, Larkhall Colliery, Hamilton	Aug. 7, 1869
393	Kirsopp, John, Team Colliery, Gateshead	April 5, 1873
394	Knowles, A., High Bank, Pendlebury, Manchester	Dec. 5, 1856
395	Knowles, John, Westwood, Pendlebury, Manchester	Dec. 5, 1856
396	Knowles, Kay, Swinton Old Hall, Pendlebury, Manchester	Aug. 3, 1865
397	Knowles, Thomas, Ince Hall, Wigan	Aug. 1, 1861
398	Kyrke, R. H. V., Westminster Chambers, Wrexham	Feb. 5, 1870
399	Lackland, J. J., care of M. Stainton, 24, Winchester St., South Shields	Mar. 7, 1874
400	Laidler, W. J.	Mar. 4, 1876
401	Lamb, R., Cleator Moor Colliery, near Whitehaven	Sept. 2, 1865
402	Lamb, R. O., Gibside, Lintz Green, Newcastle-on-Tyne	Aug. 2, 1866
403	Lamb, Richard W., Coal Owner, Newcastle-on-Tyne	Nov. 2, 1872
404	Lambert, M. W., 9, Queen Street, Newcastle-on-Tyne	July 2, 1872
405	Lancaster, John, Bilton Grange, Rugby	July 4, 1861
406	Lancaster, J., Jun., Bilton Grange, Rugby	Mar. 2, 1865
407	Lancaster, S., Nantyglo & Blaina Steam Coal Collieries, Blaina, Mon.	Aug. 3, 1865
408	Landale, A., Lochgelly Iron Works, Fifeshire, N.B.	Dec. 2, 1858
409	*Laporte, Henry, M.E., Flenu, Mons, Belgium	1877
410	Laverick, J., Castle Eden Colliery, Castle Eden, County Durham	July 2, 1872
411	Laverick, Robt., West Rainton, Fence Houses	Sept. 2, 1876
412	Lawrence, Henry, Grange Iron Works, Durham	Aug. 1, 1868
413	Laws, H., Grainger Street West, Newcastle-on-Tyne	Feb. 6, 1869

414 Laws, John, Blyth, Northumberland 1854

415 Lawson, Rev. E., Longhirst Hall, Morpeth Dec. 3, 1870

416 Lawson, J. P., Port Hood, Cape Breton, Nova Scotia Dec. 3, 1870

417 Laycock, Joseph, Low Gosforth, Northumberland Sept. 4, 1869

418 Leather, J. T., Middleton Hall, Belford, Northumberland Aug. 6, 1870

419 Lebour, G. A., College of Physical Science, Newcastle-on-Tyne Feb. 1, 1873

420 Lee, George, Loftus-in-Cleveland June 4, 1870

421 Leslie, Andrew, Hebburn, Gateshead-on-Tyne Sept. 7, 1867

422 Lever, Ellis, Bowdon, Cheshire 1861

423 Lewis, Heney, Annesley Colliery, near Nottingham Aug. 2, 1866

424 Lewis, W. H., 3, Bute Crescent, Cardiff Aug. 4, 1877

425 Lewis, William Thomas, Mardy, Aberdare 1864

426 Liddell, G. H., Somerset House, Whitehaven Sept.4, 1869

427 Liddell, M., Prudhoe Hall, Prudhoe-on-Tyne Oct. 1, 1852

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

429 Linsley, R., Cramlington Colliery, Northumberland July 2, 1872

430 Linsley, S. W., Whitburn Colliery, Sunderland Sept. 4, 1869

431 Lishman, T., Jun., Hetton Colliery, Fence Houses Nov. 5, 1870

432 Lishman, Wm., Witton-le-Wear 1857

433 Lishman, Wm., Bunker Hill, Fence Houses (Member of Council) Mar. 7, 1861

434 Livesey, C., Bredbury Colliery, Bredbury, Stockport Aug. 3, 1865

435 Livesey, T., Jun., Hatherlow House, Romiley, Cheshire Nov. 7, 1874

ELECTED.

436 Llewellin, D., Glanwern Offices, Pontypool, Monmouthshire Aug. 4, 1864

437 Llewelyn, L., Aheraman, Aberdare, South Wales May 4, 1872

438	Lloyd, John F., Saltburn-by-the-Sea	Sept. 11, 1875
439	Logan, William, Langley Park Colliery, Durham	Sept. 7, 1867
440	Longbotham, J., Norley Collieries, near Wigan	May 2, 1868
441	Longridge, J. A., 3, Westminster Chambers, Victoria St., London, S.W.	Aug. 21, 1852
442	Low, W., Vron Colliery, Wrexham, Denbighshire	Sept. 6, 1855
443	Lupton, A., F.G.S., 3, Eldon Terrace, Leeds	Nov. 6, 1869
444	Mackenzie, J., 1, Royal Terrace, Crosshill, Glasgow	Mar. 5, 1870
445	Maddison, Henry, The Lindens, Darlington	Nov. 6, 1875
446	Maling, C. T., Ford Pottery, Newcastle-on-Tyne	Oct. 5, 1872
447	Mammatt, J. E., C.E., Beechwood, Bramley, near Leeds	1864
448	Marley, John, Mining Offices, Darlington (Vice-President)	Aug. 21, 1852
449	Marley, J. W., Mining Offices, Darlington	Aug. 1, 1868
450	Marshall, F. C., Messrs. Hawthorn & Co., Newcastle	Aug. 2, 1866
451	Marshall, J.	1864
452	Marston, W. B., Leeswood Vale Oil Works, Mold	Oct. 3, 1868
453	Marten, E. B., C.E., Pedmore, near Stourbridge	July 2, 1872
454	Martin, R. F., Mount Sorrel, Loughborough	April 11, 1874
455	Matthews, R. F., Seaton Carew, West Hartlepool	Mar. 5, 1857
456	Maughan, J. A., Nerbudda Coal and Iron Co. Limited, Garrawarra, Central Provinces, India	Nov. 7, 1863
457	Maughan, J. D., Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876
458	May, George, Harton Colliery Offices, Tyne Docks, South Shields (*Mem. of Council*)	Mar. 6, 1862
459	McCreath, J., 138, West George Street, Glasgow	Mar. 5, 1870
460	McCulloch, David, Beech Grove, Kilmarnock, N.B.	Dec. 4, 1875
461	McCulloch, H. J., Moat House, Wood Green, London, N.	Oct. 1, 1863
462	McCulloch, W., 178, Gresham House, Old Broad Street, London, E.C.	Nov. 7, 1874
463	McGhie, T., Cannock, Staffordshire	Oct. 1, 1857

464	McMurtrie, J., Radstock Colliery, Bath	Nov. 7, 1863
465	Meadows, J. M., 11, Eustace Street, Dublin	Dec. 4, 1875
466	Meik, Thomas, C.E., 6, York Place, Edinburgh	June 4, 1870
467	Menzies, W., King Street, Newcastle-on-Tyne	Sept. 13, 1873
468	Merivale, J. H., Nedderton, R.S.O., Northumberland	May 5, 1877
469	Miller, Robert, Strafford Collieries, near Barnsley	Mar. 2, 1865
470	Mills, M. H., Duckmanton Lodge, Chesterfield	Feb. 4, 1871
471	Mitchell, Chas., Jesmond, Newcastle-on-Tyne (Vice-President)	April 11, 1874
472	Mitchell, Joseph, Jun., Worsbro' Dale, near Barnsley	Feb, 14, 1874
473	Mitchinson, R., Jun., Pontop Coll., Lintz Green Station, Co. Durham	Feb. 4, 1865
474	Moffatt, T., Montreal Iron Ore Works, Whitehaven	Sept. 4, 1869
475	Monkhouse, Jos., Yeat House, Frizington, Whitehaven	June 4, 1863
476	Moor, T., North Seaton Colliery, Morpeth	Oct. 3, 1868
477	Moor, W., Engineer, Hetton Colliery, Fence Houses	Oct. 3, 1874
478	Moor, Wm., Jun., Engelholm, Sweden	July 2, 1872
479	Moore, R. W., Colliery Office, Whitehaven	Nov. 5, 1870

		ELECTED
480	Moore, T. H., Smeaton Park, Inveresk, Edinburgh	Feb. 2, 1867
481	Morison, D. P., 21, Collingwood Street, Newcastle-on-Tyne	1861
482	Morrell, John, Darlington	Oct. 7,1876
483	Morris, W., Waldridge Colliery, Chester-le-Street, Fence Houses	1858
484	Morrison, Martin, Royal Exchange, Middlesbro'	Sept. 2, 1876
485	*Morton, H. J., 4, Royal Crescent, Scarborough	1861
486	Morton, H. T., Lambton, Fence Houses	Aug. 21, 1852
487	Moses, Wm., Lumley Colliery, Fence Houses	Mar. 2,1872

488	Muckle, John, Monk Bretton, Barnsley	Mar.7, 1861
489	Mulcaster, W., Jun., M.E., Croft House, Aspatria, near Carlisle	Dec. 3, 1870
490	Mulvany, W. T., Pempelfort, Dusseldorf-on-the-Rhine	Dec. 3,1857
491	Mundle, Arthur, 1, Belle Grove Square, Newcastle-on-Tyne	June 5, 1875
492	Mundle, W., Redesdale Mines, Bellingham	Aug. 2, 1873
493	Nanson, J., 4, Queen Street, Newcastle-on-Tyne	Dec. 4, 1869
494	Nasse, Herr Bergassessor, Louisenthal, Saarbrucken, Prussia	Sept. 4, 1869
495	Naylor, J. T., 10, West Clayton Street, Newcastle-on-Tyne	Dec. 6, 1866
496	Nelson, J., C.E., Marine and Stationary Engine Works, Gateshead (*Mem. of Council*)	Oct. 4. 1866
497	Neville, Samuel, Jun., Engineer, Newcastle-on-Tyne	May 5, 1877
498	Nevin, John, Mirfield, Yorkshire	May 2, 1868
499	Newall, R. S., Ferndene, Gateshead (*Member of Council*)	May 2, 1863
500	Nicholson, E., jun., Beamish Colliery, Chester-le-Street	Aug. 7, 1869
501	Nicholson, J. W., Greenside Colliery, Milton, Carlisle	Oct. 11, 1873
502	Nicholson, Marshall, Middleton Hall, Leeds	Nov. 7, 1863
503	Noble, Captain, Jesmond, Newcastle-upon-Tyne	Feb. 3, 1866
504	North, F. W., F.G.S., Rowley Hall Colliery, Dudley, Staffordshire	Oct. 6, 1864
505	Nuttall, Thomas, Broad Street, Bury, Lancashire	Sept. 11, 1875
506	Ogden, John M., Solicitor, Sunderland	Mar. 5, 1857
507	Ogilvie, A. Graeme, 4, Great George Street, Westminster, London	Mar. 3, 1877
508	Oliver, Robert, Charlaw Colliery, near Durham	Nov. 6, 1875
509	Owen, J. H., 18, Prudhoe Terrace, Tynemouth	Aug. 4, 1877
510	Pacey, T., Bishop Auckland	April 10, 1869
511	Page, William, Merryweather & Co., York St., Lambeth, London, S.E.	Mar. 6, 1875

512 Palmer, A. S., Wardley Hall, near Newcastle-on-Tyne July 2, 1872

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

514 Pamely, C., Radstock Coal Works, near Bath Sept. 5, 1868

515 Panton, F. S., Silksworth Colliery, Sunderland Oct. 5, 1867

516 Parkin, C., Deer Park Mines, Newlyn East, Grampound Rd., Cornwall June 5, 1875

517 Parkin, John, Westbourne Grove, Redcar, Yorkshire April 11, 1874

518 Parington, M. W., Wearmouth Colliery, Sunderland Dec. 1, 1864

519 Parton, T., F.G.S., Ash Cottage, Birmingham Road, West Bromwich Oct. 2, 1869

520 Pattinson, J., Analytical Chemist, Newcastle-upon-Tyne May 2, 1868

521 Pattison, John, Engineer, Naples Nov. 7, 1874

522 Pattison, W., Ruabon and North Wales Colliery, Prysgwyn, Chirk Oct. 11, 1873

523 Pattison, W., Jun. Oct. 11, 1873

ELECTED.

524 Peace, M. W. Wigan, Lancashire July 2, 1872

525 Peacock, David, Westbromwich Aug. 7, 1869

526 Pearce, F. H., Bowling Iron Works, Bradford Oct. 1, 1857

527 Pearson, J. E., Golborne Park, near Newton-le-Willows Feb. 3, 1872

528 Pease, J. W., M.P., Hutton Hall, Guisbro', Yorkshire Mar. 5, 1857

529 Peel, John, Wharncliffe and Silkstone Coll., Wortley, near Sheffield Nov. 1, 1860

530 Peel, John, Horsley Colliery, Wylam-on-Tyne Mar. 3,1877

531 Peile, William, Rosemount, Roath, Cardiff Oct. 1, 1863

532 Penman, J. H., 2, Clarence Buildings, Booth Street, Manchester Mar. 7, 1874

533 Perrot, S. W., 39, Kronprinzen Strasse, Dusseldorf June 2, 1866

534 Philipson, H., 8, Queen Street, Newcastle-upon-Tyne Oct. 7, 1871

535 Pickersgill, T.,Waterloo Main Colliery, near Leeds June 5,1869

536	Pickup, P. W., Dunkenhalgh Collieries, Accrington, Lancashire	Feb. 6, 1875
537	Pinching, Archd. E., Kruisrivier, Middleburg, Transvaal, So. Africa	May 5, 1877
538	Potter, Addison, Heaton Hall, Newcastle-on-Tyne	Mar. 6, 1869
539	Potter, A. M., Shiremoor Coll., Northumberland (Member of Council)	Feb. 3, 1872
540	Potter, C. J., Heaton Hall, Newcastle-on-Tyne	Oct. 3, 1874
541	*Potter, W. A., Cramlington House, Northumberland	1874
542	Price, John, Messrs. Palmer Brothers & Co., Jarrow-on-Tyne	Mar. 3, 1877
543	Price, J. R., Standish, near Wigan	Aug. 7, 1869
544	Priestman, Jon., Coal Owner, Newcastle-on-Tyne	Sept. 2, 1871
545	Pringle, Edward, Choppington Colliery, Northumberland	Aug. 4, 1877
546	Railston, C. A., Framlington Place, Newcastle-on-Tyne	Feb. 3, 1877
547	Ramsay, J. A., Washington Colliery, near Durham	Mar. 6, 1869
548	Ramsay, J. T., Walbottle Hall, nr. Blaydon-on-Tyne (*Mem. of Council*)	Aug. 3, 1853
549	Ramsay, T. D.	Mar. 1, 1866
550	Ramsay, Wm,, Tursdale Colliery, County Durham	Sept. 11, 1875
551	Reed, Robert, Felling Colliery, Gateshead	Dec. 3, 1863
552	Rees, Daniel, Glandare, Aberdare	1862
553	Refeen, Wm., Teplitz, Bohemia	Oct. 5, 1872
554	Reid, Andrew, Newcastle-on-Tyne	April 2 , 1870
555	Reynolds, J. J., M.E., Leigh Road, Atherton, near Manchester	April 3, 1875
556	Richards, Charles	Mar. 3, 1877
557	Richards, E. W., Messrs. Bolckow, Vaughan, & Co., Middlesbro'	Aug. 5, 1876
558	Richards, G. C., M.E., Woodhouse, near Sheffield	June 5, 1875
559	Richardson, H., Backworth Colliery, Newcastle-on-Tyne	Mar. 2, 1865
560	Richardson, J. W., Iron Shipbuilder, Newcastle-on-Tyne	Sept. 3, 1870
561	Ridley, G., Trinity Chambers, Newcastle-on-Tyne	Feb. 4, 1865

562	Ridley, J. H., R. & W. Hawthorn's, Newcastle-on-Tyne	April 6, 1872
563	Ridyard, John, Bolton, Lancashire	Nov. 7, 1874
564	Rigby, John, Ash Villa, Alsager, Stoke-upon-Trent	Feb. 5, 1876
565	Ritson, U. A., 6, Queen Street, Newcastle-on-Tyne	Oct. 7, 1871
566	Ritson, W. A., Shilbottle Colliery, near Alnwick	April 2, 1870
567	Robertson, W., M.E., 123, St. Vincent Street, Glasgow	Mar. 5, 1870
568	Robinson, G. C., Brereton and Hayes Colls., Rugeley, Staffordshire	Nov. 5, 1870
569	Robinson, H., C.E., 7, Westminster Chambers, London	Sept. 3, 1870

		ELECTED.
570	Robinson, John, Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876
571	Robinson, R., Howlish Hall, near Bishop Auckland	Feb. 1, 1868
572	Robinson, R. H., Whittington, near Chesterfield	Sept. 5, 1868
573	Robson, E., Middlesbro'-on-Tees	April 2, 1870
574	Robson, J. M., 11, Belhaven Terrace, Glasgow	Dec. 5, 1868
575	Robson, J. S., Butterknowle Colliery, via Darlington	1853
576	Robson, J. T., Cambuslang, Glasgow	Sept. 4, 1869
577	Robson, M., Coppa Colliery, near Mold, Flintshire	May 4, 1872
578	Robson, Thomas, Lumley Colliery, Fence Houses	Oct. 4, 1860
570	Rogerson, J., Croxdale Hall, Durham	Mar. 6, 1869
580	Roscamp, J., Rosedale Lodge, near Pickering, Yorkshire	Feb. 2, 1867
581	Roseby, John, Haverholme House, Brigg, Lincolnshire	Nov. 2, 1872
582	Ross, A., Shipcote Colliery, Gateshead	Oct. 1, 1857
583	Ross, J. A. G., Consulting Engineer, 34, Collingwood Street, Newcastle	July 2, 1872
584	Rosser, W., Mineral Surveyor, Llanelly, Carmarthenshire	1856
585	Rothwell, R. P., 27, Park Place, New York	Mar. 5, 1870

586 Routledge, Jos., Ryhope Colliery, Sunderland Sept. 11, 1875

587 Routledge, J. L., Ryhope Colliery, Sunderland Oct. 7, 1876

588 Routledge, Wm., Sydney, Cape Breton Aug. 6, 1857

589 Rowley, J. O., Shagpoint Colliery, Otago, New Zealand Dec. 4, 1875

590 Rutherford, J., Halifax, Nova Scotia 1866

591 Rutherford, W., Marden House, Whitley, Newcastle-on-Tyne Oct. 3, 1874

592 Rutter, Thos., Blaydon Main Colliery, Blaydon-on-Tyne May 1, 1875

593 Ryder, W. J. H., Forth Street Brass Works, Newcastle-on-Tyne Nov. 4, 1876

594 Saint, George, Vauxhall Collieries, Ruabon, North Wales April 11, 1874

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

596 Scott, Andrew, Broomhill Colliery, Acklington Dec. 7, 1867

597 Scott, C. F., Hall Royal Collieries, Silkstone Common, Barnsley April 11, 1874

598 Scoular, G., Parkside, Frizington, Cumberland July 2, 1872

599 Seddon, J. F., Great Harwood Collieries, near Accrington June 1, 1867

600 Seddon, W., Dunkirk Collieries, Dukinfield Oct. 5, 1865

601 Shallis, F. W., M. and J. Pritchard, 9, Gracechurch Street, London April 6, 1872

602 Shaw, John, Neptune Engine Works, Low Walker, Newcastle Nov. 6, 1875

603 Shaw, W., Jun., Wolsingham, via Darlington June 3, 1871

604 Shelford, W., 35a, Great George Street, Westminster, London Feb. 5, 1876

605 Shiel, John, Framwellgate Colliery, County Durham May 6, 1871

606 Shone, Isaac, Pentrefelin House, Wrexham 1858

607 Shortrede, T., Park House, Winstanley, Wigan April 3, 1856

608 Shute, C. A., Westoe, South Shields April 11, 1874

609 Simpson, J., Heworth Colliery, near Gateshead-on-Tyne Dec. 6, 1866

610 Simpson, John, West Stanley Colliery, Chester-le-Street April 3, 1875

611 Simpson, Jos., Catchgate, near Annfield Plain Mar. 3, 1873

612 Simpson, J. B., Hedgefield House, Blaydon-on-Tyne (*Mem. of Council*) Oct. 4, 1860

613 Simpson, J. C., Bankhead Colliery, Muirkirk April 7, 1877

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

615 Simpson, Robt., Drummond Colliery, Westville, Pictou, N.S. Dec. 4, 1875

616 Sinclair, James, 48, Blackfriars Street, Manchester May 6, 1876

ELECTED.

617 Slinn, T., 2, Choppington Street, Westmorland Road, Newcastle July 2, 1872

618 Small, G., Duffield Road, Derby June 4, 1870

619 Smallshaw, J., Westleigh Colliery, Leigh, near Manchester Nov. 7, 1874

620 Smith, E. J., 16, Whitehall Place, Westminster, London Oct. 7, 1858

621 Smith, G. F., Grovehurst, Tunbridge Wells Aug. 5, 1853

622 Smith, J., Bickershaw Colliery, Wigan Mar.7, 1874

623 *Smith, R. Clifford, Parkfield, Swinton, Manchester 1874

624 Smith, T., Sen., M.E., Cinderford Villas, nr. Newnham, Gloucester May 5, 1877

625 Smith, T. E., M.P., Gosforth House, Dudley, Northumberland Feb. 5, 1870

626 Smith, T. E., Phoenix Foundry, Newgate Street, Newcastle-on-Tyne Dec. 5, 1874

627 Snowdon, T., Jun., West Bitchburn Coll., nr. Towlaw, via Darlington Sept. 4, 1869

628 Sopwith, A., Cannock Chase Collieries, near Walsall Aug. 1, 1868

629 Sopwith, T., Jun., South Derwent Coll., nr. Annfield Plain, Co. Durham Nov. 2, 1867

680 Sopwith, Thos., Jun., 6, Gt. George St., Westminster, London, S.W. Mar. 3, 1877

631 Southall, P., Park Hall Colliery, Cheadle, Stoke-upon-Trent Feb. 5, 1876

632 Southern, R., Burleigh House, The Parade, Tredegarville, Cardiff Aug. 3, 1865

633 Southworth, Thos., Hindley Green Collieries, near Wigan May 2, 1874

634 Spark, H. K., Startforth House, Barnard Castle 1856

635 Sparkes, O., care of J. Dunning, Southfield Villas, Middlesbro' Sept, 5, 1868

636 Spence, G., Southern States Coal, Iron, and Land Co., South Pittsburg, Tennessee, U.S. June 7, 1873

637 Spence, James, Clifton and Millgramfitz Collieries, Workington Nov. 7, 1874

638 Spencer, John, Westgate Road, Newcastle-on-Tyne Sept. 4, 1869

639 Spencer, John P., Borough Surveyor, Tynemouth Dec. 5, 1874

640 Spencer, M., Newburn, near Newcastle-on-Tyne Sept. 4, 1869

641 Spencer, T., Ryton, Newcastle-on-Tyne Dec. 6, 1866

642 Spencer, W., Cross House Chambers, Westgate Road, Newcastle Aug. 21, 1852

643 Spours, J. L. April 11, 1874

644 Stainton, Matthew, Ironfounder, South Shields May 6, 1876

645 Steavenson, A. L., Durham (Vice-President) Dec. 6, 1855

646 Steavenson, D. P., B.A., LL.B., Barrister-at-Law, Cross House, Westgate Road, Newcastle-on-Tyne April 1, 1871

647 Steele, Chas., Bolton Colliery, Mealsgate, Cumberland June 7, 1873

648 Steele, Charles R., 28, Wood Street, Maryport Mar. 3, 1864

649 Stephenson, G. R., 24, Great George St., Westminster, London, S.W. Oct. 4, 1860

650 Stephenson, W. H., Elswick House, Newcastle-on-Tyne Mar. 7, 1867

651 Stevenson, R., Crewe Coal & Iron Co. Ld, Newcastle-under-Lyme Feb. 5, 1876

652 Stobart, H. S., Witton-le-Wear, Darlington Feb. 2, 1854

653 Stobart, W., Wearmouth Colliery, Sunderland July 2, 1872

654 Stokoe, Joseph, Houghton-le-Spring, Fence Houses April 11, 1874

655 Storey, Thos. E., Clough Hall Iron Works, Kidsgrove, Staffordshire Feb. 5, 1876

656 Straker, John, Stagshaw House, Corbridge-on-Tyne May 2, 1867

657 Straker, J. H., Willington House, Co. Durham Oct. 3, 1874

658 Stratton, T. H. M., Seaham Colliery, Sunderland Dec. 3, 1870

659 Sutherst, Thomas Nov. 7, 1874

660 Swallow, J., Pontop Hall, Lintz Green May 2, 1874

661 Swallow, R. T., Springwell, Gateshead 1862

662 Swan, H. F., Shipbuilder, Newcastle-on-Tyne Sept. 2, 1871

		ELECTED.
663	Swan, J. G., Upsall Hall, near Middlesbro'	Sept. 2, 1871
664	Swann, C. G., Secretary, General Mining Association Limited, 6, New Broad Street, London	Aug. 7, 1875
665	Tate, Simon, Kimblesworth Colliery, Co. Durham	Sept. 11, 1875
666	Taylor, George, Brotton Mines, Saltburn-by-the-Sea	June 5, 1875
667	Taylor, H., King Street, Quay, Newcastle-on-Tyne	Sept. 5, 1856
668	Taylor, John, Earsdon, Newcastle-on-Tyne	Aug. 21, 1852
669	Taylor, John B., The Mount, Clent, Stourbridge	May 3, 1873
670	Taylor, T., King Street, Quay, Newcastle-on-Tyne	July 2, 1872
671	Taylor-Smith, Thomas, Urpeth Hall, Chester-le-Street	Aug. 2, 1866
672	Thomas, A., Bilson House, near Newnham, Gloucestershire	Mar. 2, 1872
673	Thompson, James, Hurworth, Darlington	June 2, 1866
674	Thompson, John, Boughton Hall, Chester	Sept. 2, 1865
675	Thompson, J., Hilton House, Blackrod, near Chorley	April 6, 1867
676	Thompson, R., Jun., Rodridge House, Wingate, Co. Durham	Sept. 7, 1867
677	Thompson, T. C., Milton Hall, Carlisle	May 4, 1854
678	Thomson, John, South Skelton Mines, via Guisbro	April 7, 1877
679	Thomson, Jos. F., Manvers Main Colliery, Rotherham	Feb. 6, 1875
680	Thorpe, R. S., 17, Picton Place, Newcastle-on-Tyne	Sept. 5, 1868
681	Thubron, N., Broadoak Colliery, Longhor, near Swansea	Oct. 3, 1874
682	Tinn, J., C.E., Ashton Iron Rolling Mills, Bower Ashton, Bristol	Sept. 7, 1867
683	Tone, J. F., C.E., Pilgrim Street, Newcastle-on-Tyne	Feb. 7, 1856
684	Turner, W. B., C. and M.E., Sella Park, via Carnforth	Dec. 7, 1867
685	Tylden-Wright, C., Shireoaks Colliery, Worksop, Notts	1862

686	Tylor, Alfred, E., 123, Bute Street, Cardiff	April 1, 1876
687	Tyson, Wm. John, 1, Lowther Street, Whitehaven	Mar. 3, 1877
688	Tyzack, D., Kelung, Formosa Island, c/o Com. of Customs, Amoy, China	Feb. 14, 1874
689	Tyzack, Wilfred, Tanfield Lea Coll., Lintz Green Station, Newcastle	Oct. 7, 1876
690	Ure, J. F., Engineer, Tyne Commissioners, Newcastle	May 8, 1869
691	Urwin, Robert, Neville Hall, Newcastle-on-Tyne	Sept. 1, 1877
692	Vaughan, Cedric, Hodbarrow Mines, Leyfield House, Millom, Cumb.	Aug. 5, 1876
693	Vivian, John, Diamond Boring Company, Whitehaven	Mar. 3, 1877
694	Vondracek, Vladimir	Aug. 1, 1874
695	Wadham, E., C. and M.E., Millwood, Dalton-in-Furness	Dec. 7, 1867
696	Wake, H. H., River Wear Commissioners, Sunderland	Feb. 3, 1872
697	Walker, G. B., Wharncliffe Silkstone Collieries, Wortley, nr. Sheffield	Dec. 2, 1871
698	Walker, J. S., 15, Wallgate, Wigan, Lancashire	Dec. 4, 1869
699	Walker, T. F., 58, Oxford Street, Birmingham	April 11, 1874
700	Walker, W., Saltburn-by-the-Sea	Mar. 5, 1870
701	Wallace, Henry, Trench Hall, Gateshead	Nov. 2, 1872
702	Walton, W., Upleatham Mines, Marske-by-the-Sea	Feb. 1, 1867
703	Wand, B. W.	Dec. 5, 1874
704	Ward, H., Rodbaston Hall, near Penkridge, Stafford	Mar. 6, 1862
705	Wardale, John D., M.E., Redheugh Engine Works, Gateshead	May 1, 1875

706	Wardell, S. C., Doe Hill House, Alfreton	April 1, 1865

707	Warrington, J., Worsborough Hall, near Barnsley	Oct. 6, 1859
708	Watson, H., High Bridge, Newcastle-on-Tyne	Mar. 7, 1868
709	Watson, H. B., High Bridge Works, Newcastle-on-Tyne	Mar. 3, 1877
710	Watson, M., Flimby and Broughton Moor Collieries, near Maryport.	Mar. 7, 1868
711	Webster, R. C., Bangor Isycoed, near Wrexham, North Wales	Sept. 6, 1855
712	Weeks, J. G., Bedlington Colliery, Bedlington (*Member of Council*)	Feb. 4, 1865
713	Westmacott, P. G. B., Elswick Iron Works, Newcastle	June 2, 1866
714	Whaley, John, Coanwood Colliery, Haltwhistle	Feb. 1, 1873
715	Whately, W. L., Kirkleatham Mines, Guisbro'	Dec. 4, 1875
716	White, H., Weardale Coal Company, Towlaw, near Darlington	1866
717	White, J. F., M.E., Wakefield	July 2, 1872
718	White, J. W. H., St. Andrew's Chambers, Park Row, Leeds	Sept. 2, 1876
719	Whitehead, James, Brindle Lodge, near Preston, Lancashire	Dec. 4, 1875
720	Whitelaw, A., 168, West George Street, Glasgow	Mar. 5, 1870
721	Whitelaw, John, 118, George Street, Edinburgh	Feb. 5, 1870
722	Whitelaw, T., Shields and Dalzell Collieries, Motherwell	April 6, 1872
723	Whittem, Thos. S., Wyken Colliery, near Coventry	Dec. 5, 1874
724	Widdas, C., North Bitchburn Colliery, Howden, Darlington	Dec. 5, 1868
725	Wight, W. H., Cowpen Colliery, Blyth	Feb. 3, 1877
726	Wild, H. F., Stockport, Columbia County, New York, U.S.	Oct. 3, 1874
727	Wild, J. G., Ellistown Colliery, Ellistown, near Leicester	Oct. 5, 1867
728	Williams, E., Cleveland Lodge, Middlesbro'	Sept. 2, 1865
729	Williams, J. J., Pantgwyn House, Holywell, Flintshire	Nov. 2, 1872
730	Williamson, John., Chemical Manufacturer, South Shields	Sept. 2, 1871
731	Williamson, John, Cannock, &c, Collieries, Hednesford	Nov. 2, 1872
732	Willis, J., 14, Portland Terrace, Newcastle-on-Tyne (*Mem. of Council*)	Mar. 5, 1857
733	Wilson, J., 69, Great Clyde Street, Glasgow	July 2, 1872

734	Wilson, J. B., Wingfield Iron Works and Colliery, Alfreton	Nov. 5, 1852
735	Wilson, J. S., Moorfield, Coxlodge, Newcastle-on-Tyne	Dec. 2, 1858
736	Wilson, Robert, Flimby Colliery, Maryport	Aug. 1, 1874
737	Wilson, T. H.	Mar. 6, 1869
738	Wilson, W. B., Kippax and Allerton Collieries, Leeds	Feb. 6, 1869
739	Winter, T. B., Grey Street, Newcastle-on-Tyne	Oct. 7, 1871
740	Wood, C. L., Freeland, Bridge of Earn, Perthshire	1853
741	Wood, Lindsay, Southill, Chester-le-Street (Past President, *Member of Council*)	Oct. 1, 1857
742	Wood, Thomas, Rainton House, Fence Houses	Sept. 3, 1870
743	Wood, W. H., West Hetton, Ferryhill	1856
744	Wood, W. O., East Hetton Colliery, Coxhoe, Co. Durham	Nov. 7, 1863
745	Woodhouse, J. T., Midland Road, Derby	Dec. 13, 1852
746	Woolcock, Henry, St. Bees, Cumberland	Mar. 3, 1873
747	Wright, G. H., 22, Low Pavement, Nottingham	July 2, 1872
748	Wright, J. M., 20, Summerhill Terrace, Newcastle-on-Tyne	Aug. 5, 1876
749	Wrightson, T., Stockton-on-Tees	Sept. 13, 1873
750	Young, Philip, Cae-pen-ty Colliery, Frood, near Wrexham	Oct. 11, 1873

[xxxvii]

ORDINARY MEMBERS

		ELECTED.
1	Brown, M. W., Leamside Station, Fence Houses	Oct. 7, 1871
2	Chambers, W. Henry, Birch wood Colliery, near Alfreton	Dec. 2, 1871
3	Clough, James, Bedlington Collieries, near Morpeth	April 5, 1873
4	Dacres, Thomas, Dearham Colliery, Maryport	May 4, 1878
5	Ellis, W. R., F.G.S., Wigan	June 1, 1878

6 Gilchrist, Thomas, Ovington Cottage, Prudhoe-on-Tyne May 4, 1878

7 Harden, John Henry, Towne Scientific School, University of Pennsylvania, Philadelphia June 1, 1878

8 Jones, Samuel Taylor, Whitelea Colliery, County Durham June 1, 1878

9 Kellett, William, Wigan June 1, 1878

10 Lisle, J., Washington Colliery, County Durham July 2, 1872

11 Lyon, James, Vale View, Whitehaven Mar. 3, 1877

12 Pease, J., West Cannock Colliery, Hednesford, Staffordshire Mar. 2, 1878

13 Sawyer, A. R., Ass. R.S.M., Poynton and Worth Collieries, near Stockport, Cheshire Dec. 6, 1873

14 Seymour, T. M., Lambton Colls.,Waratah, nr. Newcastle, New S.Wales Dec. 4, 1875

15 Spencer, John W., Newburn, near Newcastle-on-Tyne May 4, 1878

16 Stone, T. H.. Wigan Coal and Iron Co., Wigan Nov. 7, 1874

17 Topping, Walter, Messrs. Cross, Tetley, & Co., Platt Bridge, Wigan Mar. 2, 1878

ASSOCIATE MEMBERS

1 Bacon, Arthur H., Murton Colliery, Sunderland Nov. 3, 1877

2 Brown, W. B., Springfield, Victoria Park, Wavertree, Liverpool Mar. 2, 1878

3 Cabrera, Fidel, c/o H. Kendall & Son, 12, Gt. Winchester St., London Oct. 6, 1877

4 Cochrane, Ralph D., Hetton Colliery Offices, Fence Houses June 1, 1878

5 Fennell, Corry S., Bjuf Colliery, Helsingborg, Sweden Mar. 2, 1878

6 Greener, W. J., Pemberton Colliery, Wigan Mar. 2, 1878

7 Hughes, E. G., Solway View, Whitehaven June 1, 1878

8 Humble, Stephen, Uttoxeter Road, Derby Oct. 6, 1877

9 Rylands, Richard A., Haford Las, Minera, Wrexham June 1, 1878

10 Saise, Walt. D. Sc., c/o R. Little, Esq., Oakley House, L. Slough, Bucks. Nov. 3, 1877

11 Sutherst, John, Cleveland Foundry, Guisbro' Dec. 1, 1877

12 Winter, Thomas, Messrs. Tangye Brothers & Steel, Swansea Mar. 2, 1878

STUDENTS

		ELECTED.
1	Arkless, Thos. W., Coxhoe Colliery, Coxhoe, Co. Durham	June 2, 1877
2	Armitage, Matthew, Birtley, near Chester-le-Street	Oct. 6, 1877
3	Atkinson, E. E., Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876
4	Atkinson, F. R., Haswell Colliery, Fence Houses	Feb. 14, 1874
5	Ayton, E. F., Lumley Colliery, Fence Houses	Feb. 5, 1876
6	Ayton, Henry, Seaton Delaval Colliery, Dudley, Northumberland	Mar.6, 1875
7	Barnes, A. W., Grassmore Colliery, near Chesterfield	Oct. 5, 1872
8	Barrett, Charles, Harton Colliery, South Shields	Nov. 7, 1874
9	Bell, C. E., Park House, Durham	Dec. 3, 1870
10	Berkley, R. W., Marley Hill Colliery, Gateshead	Feb. 14, 1874
11	Bewick, T. B., Haydon Bridge, Northumberland	Mar. 7, 1874
12	Bird, Harry, Haydon Bridge, Northumberland	April 7, 1877
13	Bird, W. J., Wingate Colliery, Durham	Nov. 6, 1875
14	Blackett, W. C., 6, Old Elvet, Durham	Nov. 4, 1876
15	Bowlker, T. J., Heddon Vicarage, Wylam-on-Tyne	May 5, 1877
16	Bragge, G. S., New Hucknall Colliery, near Mansfield	July 2, 1872
17	Brough, Thomas, Seaham Colliery, Seaham Harbour	Feb. 1, 1873
18	Brown, C. Gilpin, Hetton Colliery, Fence Houses	Nov. 4, 1876
19	Bruce, John, 2, Framlington Place, Newcastle-on-Tyne	Feb. 14, 1874
20	Bulman, G. H., Ryhope Colliery, Sunderland	April 11, 1874
21	Bulman, H. F., 10, Framlington Place, Newcastle-on-Tyne	May 2, 1874
22	Bunning, C. Z., Ryton-on-Tyne	Dec. 6, 1873
23	Burnley, E. F., Whitwood Collieries, Normanton	April 11, 1874

24	Caldwell, John S., The Grove, Westhoughton, near Bolton, Lan.	Nov. 7, 1874
25	Candler, T. E., East Lodge, Crook, Darlington	May 1, 1875
26	Carr, Charles B., Harton Colliery Office, South Shields	May 6, 1876
27	Clark, Robert, Garnant Collieries, Cwmaman, nr. Llanelly, So. Wales	Sept. 11, 1875
28	Cobbold, C. H., San Valentino, Abruzzo, Citenone, Italy	May 3, 1873
29	Cockburn, W. C, 8, Summerhill Grove, Newcastle-on-Tyne	July 2, 1872
30	Cockin, G. M., Medomsley, Newcastle-on-Tyne	Nov. 2, 1872
31	Cox, L. Clifford, Ravenstone, near Ashby-de-la-Zouch	April 1, 1876
32	Craig, Ernest, Mining Offices, Tynemouth	Nov. 3, 1877
33	Crawford, T. W., Lofthouse Station Collieries, near Wakefield	Dec. 4, 1875
34	Crone, F. E., Killingworth House, near Newcastle	Sept. 2, 1876
35	Davidson, C. C., Hetton Colliery, Fence Houses	Nov. 4, 1876
36	Depledge, M. F., Brancepeth, near Durham	April 7, 1877
37	Dodd, Michael, Jun., Morton Grange, Fence Houses	Dec. 4, 1875
38	Donkin, Wm., Usworth Colliery, Washington Station, Co. Durham	Sept. 2, 1876
39	Dorman, Frank, Ellistown Colliery, Ellistown, near Leicester	May 1, 1875
40	Douglas, Arthur Stanley, West Lodge, Crook	June 1, 1878
41	Dowson, W. C., Belle Vue House, Escomb, near Bishop Auckland	Mar. 2, 1878

		ELECTED.
42	Dumford, H. St. John, Wharncliffe Silkstone Coll., Wortley, Sheffield	June 2, 1877
43	Dunn, A. F., Towneley Colliery, Ryton-on-Tyne	June 2, 1877
44	Eden, C. H., Sedgefield, Ferryhill	Sept. 13, 1873
45	Edge, J. C., Ince Hall Coal and Cannel Company, Limited, Wigan	Dec. 5, 1874

46	Evans, David L., Goldtops, Newport, Monmouthshire	May 4, 1878
47	Fenwick, J. W., Bebside Colliery, Cowpen Lane, Northumberland	Oct. 7, 1876
48	Fletcher, John E., Esh Collieries, near Durham	Dec. 1, 1877
49	Forster, Thomas E., Backworth, Newcastle-on-Tyne	Oct. 7, 1876
50	Forsyth, Frank W., Lofthouse Station Colliery, Wakefield	Dec. 2, 1876
51	Fowler, Robert, Wearmouth Colliery, Sunderland	Dec. 2, 1876
52	Fry, Charles, Lofthouse Mines, Saltburn-by-the-Sea	Sept. 1, 1877
53	Fryar, Mark, Walker Colliery, Newcastle-on-Tyne	Oct. 7, 1876
54	Gerrard, James, Ince Hall Coal and Cannel Company, Wigan	Mar. 3, 1873
55	Gibson, W. F., 100, Bedford Street, North Shields	April 7, 1877
56	Gilchrist, J. R., Newbottle Colliery Offices, Fence Houses	Feb. 3, 1877
57	Gould, Alex., North Seaton Colliery, near Morpeth	Dec. 1, 1877
58	Gordon, Chas., St. Chad's, Lichfield, Staffordshire	May 5, 1877
59	Greener, T. Y., Rainford Collieries, St. Helen's	July 2, 1872
60	Haddock, W. T., Jun., Ryhope Colliery, Sunderland	Oct. 7, 1876
61	Hallas, G. H., Hindley Green Colliery, near Wigan	Oct. 7, 1876
62	Hallimond, W. T., 9, Sutton Street, Durham	May 2, 1874
63	Hamilton, E., Rig Wood, Saltburn-by-the-Sea	Nov. 1, 1873
64	Harris, W. S., Sheep Hill, Burnopfield, near Lintz Green	Feb. 14, 1874
65	Harrison, Robert J., Mining Offices, Tynemouth	May 1, 1875
66	Harrison, R. W., Eastwood, near Nottingham	Mar. 3, 1877
67	Hedley, E., Rainham Lodge, The Avenue, Beckenham, Kent	Dec. 2, 1871
68	Hedley, Ernest H, Choppington Colliery, Northumberland	Oct. 7, 1876
69	Hendy, J. C. B., Usworth Colliery, Washington Station, Co. Durham	Sept. 2, 1876

70	Hill, Leonard, No. 4 Brancepeth, Durham	Oct. 6, 1877
71	Holme, James, Grove Terrace, Wolstanton, Stoke-on-Trent	Sept. 11, 1875
72	Howard, Walter, 13, Cavendish Street, Chesterfield	April 13, 1878
73	Hudson, Joseph S., Cambois Colliery, Blyth	Mar. 2, 1878
74	Humble, Joicey, 17, Westmorland Terrace, Newcastle-on-Tyne	Mar. 3, 1877
75	Humble, Robert, 17, Westmorland Terrace, Newcastle-on-Tyne	Sept. 2, 1876
76	Hunter, John P., Backworth Colliery, near Newcastle-on-Tyne	Oct. 6, 1877
77	Ironside, John C, Ryhope Colliery, near Sunderland	Dec. 4, 1875
78	Jepson, H, Durham	July 2, 1872
79	Jobling, Thos. E., Coxlodge Colliery, by Kenton, Newcastle-on-Tyne	Oct. 7, 1876
80	Johnson, W., Abram Colliery, Wigan	Feb. 14, 1874
81	Jordan, J. J., South Derwent Colliery, via Lintz Green	Mar. 3, 1873

		ELECTED
82	Kayll, A. C., Felling Colliery, Gateshead	Oct. 7, 1876
83	Kirkup, Philip, Esh Colliery, Durham	Mar. 2, 1878
84	Kirton, Hugh, Oxclose, Brancepeth, Durham	April 7, 1877
85	Leach, C. C., Bedlington Collieries, Bedlington	Mar. 7, 1874
86	Liddell, J. M., Somerset House, Whitehaven	Mar. 6, 1875
87	Lindsay, Clarence S., 5, Park Place West, Sunderland	Mar. 4, 1876
88	Liveing, E. H., Browney Colliery, Durham	Sept. 1, 1877
89	Locke, Ernest G., Pemberton Colliery, Wigan, Lancashire	Dec. 2, 1876
90	Longbotham, R. H., Framwellgate Colliery, near Durham	Sept. 2, 1876

91	Maddison, Thos. R., Thornhill Collieries, near Dewsbury	Mar. 3, 1877
92	Makepeace, H. R., Heworth Colliery Offices, Heworth,near Newcastle	Mar. 3, 1877
93	Markham, G. E., Howlish Offices, Bishop Auckland	Dec. 4, 1875
94	Marsh, T. G., c/o W. Fisher, Burnt Tree House, Tipton, Staffordshire	Sept. 13, 1873
95	Miller, D. S., Wearmouth Colliery, Sunderland	Nov. 7, 1874
96	Moore, Wm, Colliery Office, Whitehaven	Mar. 3, 1877
97	Moreing, C. A., 37, Spring Gardens, London	Nov. 7, 1874
98	Morrison, Robert, Lofthouse Mines, Saltburn-by-the-Sea	Sept. 1, 1877
99	Mundle, Robert, 1, Bolton Terrace, Newcastle-on-Tyne	Mar. 6, 1875
100	Nelson, James B., Seaton Delaval Colliery, Northumberland	April 13, 1878
101	Nicholson, Jos. C., Newbottle Colliery, Fence Houses	Feb. 3, 1877
102	Noble, J. C., Penshaw Colliery, Fence Houses	May 5, 1877
103	Oldham, Alfred R., Westfield House, Flimby, near Maryport	Mar. 2, 1878
104	Oliver, Septimus, East Hetton Colliery, Coxhoe, County Durham	Mar. 4, 1876
105	Ornsby, R. E., Seaton Delaval Colliery, Dudley, Northumberland	Mar. 6, 1875
106	Peake, Charles Edwd., Cwmaman Collieries, Aberdare, So. Wales	Nov. 3, 1877
107	Peart, A. W., Cwmaman Colliery Offices, Aberdare	Nov. 4, 1876
108	Pickering, W. H., Pemberton Colliery, Wigan	Mar. 2, 1878
109	Pickstone, Wm., Oak Bank, Black Lane, near Manchester	Sept. 11, 1875
110	Pocock, Francis A., Plawsworth Gate, Chester-le-Street	Mar. 6, 1875
111	Potter, E. A., Cramlington House, Northumberland	Feb. 6, 1875
112	Powell, Samuel, Westminster Chambers, Wrexham	June 1, 1878
113	Prest, J. J., Browney Colliery, Durham	May 1, 1875
114	Price, Stephen Richard, Mining Offices, Tynemouth	Nov. 3, 1877

115	Proctor, C. P., Killingworth Colliery, Newcastle	Oct. 7, 1876
116	Rathbone, Edgar P., Nunnery Colliery Offices, Sheffield	Mar. 7, 1874
117	Reed, R., Cowpen Colliery, Blyth	Feb. 3, 1877
118	Rees, Ernest P., Langley Park Colliery, Durham	Mar. 4, 1876
119	Richardson, R. W. P., Langley Park Colliery, Durham	Mar. 4, 1876
120	Robinson, Frank, No. 4 Brancepeth, Durham	Sept. 2, 1876
121	Robinson, Geo., Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876
122	Robson, Harry N., 3, North Bailey, Durham	Dec. 4, 1875

		ELECTED.
123	Robson, Thos. O., Cowpen Colliery, Blyth	Sept. 11, 1875
124	Routledge, W. H., Ryhope Colliery, near Sunderland	Oct. 7, 1876
125	Scarth, R, W., Browney Colliery, Durham	Dec. 4, 1875
126	Schier, H. C., East Hetton Colliery Offices, Coxhoe, Co. Durham	Dec. 4, 1875
127	Scott, Alex., Peases' West Collieries, by Darlington	Mar. 2, 1878
128	Scott, Wm, Brancepeth Colliery Offices, Willington, Co. Durham	Mar. 4, 1876
129	Short, James T., Assoc. Coll. of P.S., Bedlington Coll., Bedlington	Dec. 5, 1874
130	Smith, T. F., Jun., Cinderford Villas, near Newnham, Gloucestershire	May 5, 1877
131	Southern, E. O., 5, Fenwick Terrace, Jesmond, Newcastle	Dec. 5, 1874
132	Southern, W. J., 17, Portland Terrace, Newcastle-on-Tyne	Aug. 1, 1874
133	Southworth, Charles, Hindley Green Colliery, near Wigan	Oct. 7, 1876
134	Stobart, F., Blue House, Washington, Co. Durham	Aug. 2, 1873
135	Stoker, Arthur P., Birtley, near Chester-le-Street	Oct. 6, 1877
136	Swinney, A. J.	Feb. 5, 1876

137	Telford, W. H., Cramlington Colliery, Northumberland	Oct. 3, 1874
138	Thompson, William, Washington Colliery, Co, Durham	May 2, 1874
139	Todd, John T., Hetton-le-Hole, Fence Houses	Nov. 4, 1876
140	Topham, Edward C., Silksworth Colliery, Sunderland	Nov. 3, 1877
141	Tucker, A. W., Tanfield Lea Colliery, Lintz Green Station, Newcastle	Dec. 2, 1876
142	Vernes, Amidee, 8, Claremont Place, Gateshead	May 4, 1878
143	Walker, F. W., Harton Colliery, South Shields	Sept. 2, 1876
144	Walker, Smart, Ryhope Colliery, near Sunderland	Dec. 4, 1875
145	Walton, J. C., Heworth Colliery, near Newcastle-on-Tyne	Nov. 7, 1874
146	White, C. E., Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876
147	Williamson, J. E., Harton Colliery Offices, Tyne Docks, South Shields	Nov. 7, 1874
148	Wilson, John, Jun., The Priory, Whitehaven	Dec. 2, 1876
149	Wilson, J. D., 8, Walker Terrace, Gateshead-on-Tyne	Sept. 11, 1875
150	Wilson, J. T. Thornton Fields, Guisbro'	Nov. 7, 1874
151	Wood, A. E., Teversall Collieries, Mansfield, Notts.	Dec. 2, 1876

[xlii]

SUBSCRIBING COLLIERIES

1 Ashington Colliery, Newcastle-on-Tyne.

2 East Holywell Colliery, Earsdon, Northumberland.

3 Haswell Colliery, Fence Houses.

4 Hetton Collieries, Fence Houses.

5 Lambton Collieries, Fence Houses (Earl Durham).

6 North Hetton Colliery, Fence Houses.

7 Rainton Collieries (Marquess of Londonderry).

8 Ryhope Colliery, near Sunderland.

9 Seghill Colliery, Northumberland.

10 South Hetton and Murton Collieries.

11 Stella Colliery, Hedgefield, Blaydon-on-Tyne.

12 Throckley Colliery, Newcastle-on-Tyne.

13 Wearmouth Colliery, Sunderland.

14 Whitworth Colliery, Ferryhill.

CHARTER OF THE NORTH OF ENGLAND

INSTITUTE OF MINING AND MECHANICAL ENGINEERS

FOUNDED 1852.

INCORPORATED NOVEMBER 28th, 1876.

VICTORIA, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, to all to whom these Presents shall come, Greeting:

Whereas it has been represented to us that Nicholas Wood, of Hetton, in the County of Durham, Esquire (since deceased); Thomas Emerson Forster, of Newcastle-upon-Tyne, Esquire (since deceased); Sie George Elliot, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and Edward Fenwick Boyd, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty-two, form themselves into a Society, which is known by the name of The North of England Institute of Mining and Mechanical Engineers, having for its objects the Prevention of Accidents in Mines and the Advancement of the Sciences of Mining and Engineering generally, of which Society Lindsay Wood, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. And whereas it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community; that the Society has since its establishment diligently pursued its aforesaid objects, and in so doing has made costly experiments and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life; that the Society has held meetings at stated periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life ; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. And whereas in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of our Kingdom, we have been besought to grant to the said Lindsay Wood, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. Now know ye that we, being desirous of encouraging a design so laudable and salutary, of our especial grace, certain

knowledge, and mere motion, have willed, granted, and declared, and do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said Lindsay Wood, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "The North of England Institute of Mining and Mechanical Engineers," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of us, our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the statutes of mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectively at the rack rent which might have been had or gotten for the same respectively at the time of the purchase or acquisition thereof. And we do hereby grant our especial license and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments not exceeding with the lands, tenements or hereditaments so purchased or previously acquired such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements, or hereditaments not exceeding the like annual value. And we further will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. And our will

and pleasure is, and we further grant and declare that for the better rule and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all ex-officio Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. And we do hereby further will and declare that the said Lindsay Wood shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectively shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. And we do hereby further will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. And we do further will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the

Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say: for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held,

and for convening the same and regulating the proceedings thereat, and for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. And we do further will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, provided always that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. In witness whereof we have caused these our Letters to be made Patent.

Witness Ourself at our Palace, at Westminster, this 28th day of November, in the fortieth year of our reign.

By Her Majesty's Command.

CARDEW.

THE NORTH OF ENGLAND INSTITUTE of MINING AND MECHANICAL ENGINEERS.

BYE-LAWS

PASSED AT A GENERAL MEETING ON THE 16th JUNE, 1877.

1.—The members of the North of England Institute of Mining and Mechanical Engineers shall consist of four classes, viz.:—Original Members, Ordinary Members, Associate Members, and Honorary Members, with a class of Students attached.

2.—Original Members shall be those who were Ordinary Members on the 1st of August, 1877.

3.—Ordinary Members.—Every candidate for admission into the class of Ordinary Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-eight years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other recognised branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least five years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have practised on his own account in the profession of an Engineer for at least five years, and have acquired a considerable degree of eminence in the same.

4.—Associate Members shall be persons practising as Mining or Mechanical Engineers, or in some other recognised branch of Engineering, and other persons connected with or interested in Mining or Engineering.

5.—Honorary Members shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or some other of the recognised branches of Engineering, and such persons may continue Students until they attain the age of twenty-three years.

[l]

7.-The annual subscription of each Original Member, and of each Ordinary Member who was a Student on the 1st of August, 1877, shall be £2 2s., of each Ordinary Member (except as last mentioned) £3 3s., of each Associate Member £2 2s., and of each Student £1 1s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

8.—Any Member may, at any time, compound for all future subscriptions by a payment of £25, where the annual subscription is £3 3s., and by a payment of £20, where the annual subscription is £2 2s. All persons so compounding shall be Original, Ordinary, or Associate Members for life, as the case may be; but any Associate Member for life who may afterwards desire to become an Ordinary Member for life, may do so, after being elected in the manner described in Bye-law 13, and on payment of the further sum of £5.

9.—Owners of Collieries, Engineers, Manufacturers, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to a ticket to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible up to the number of ten 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.—In case any Member, who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-committee appointed for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the composition mentioned in Bye-law 8, and may thereupon constitute him a Life Member, or permit him to resume his former rank in the Institute.

11.—Persons desirous of becoming Ordinary Members shall be proposed and recommended, according to the Form A in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must be signed by the proposer, and at least five other Members, certifying a personal knowledge of the candidate. The proposal so made being delivered to the Secretary, shall be submitted to the Council, who, on approving the qualifications shall determine if the candidate is to be presented for ballot, and if it is so

determined, the Chairman of the Council shall sign such approbation. The same shall be read at the next Ordinary General Meeting, and afterwards be placed in some conspicuous situation until the following Ordinary General Meeting, when the candidate shall be balloted for.

12.—Persons desirous of being admitted into the Institute as Associate Members, or Students, shall be proposed by three Members; Honorary Members shall be proposed by at least five Members, and shall in addition be recommended by the Council, who shall also have the power of defining the time during which, and the circumstances under which, they shall be Honorary Members. The nomination shall be in writing, and signed by the proposers (according to the Form B in the Appendix), and shall be submitted to the first Ordinary General Meeting after the date thereof. The name of the person proposed shall be exhibited in the Society's room until the next Ordinary General Meeting, when the candidate shall be balloted for.

13.—Associate Members or Students, desirous of becoming Ordinary Members, shall be proposed and recommended according to the Form C in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must certify a personal knowledge of the candidate, and be signed by the proposer and at least two other Members, and the proposal shall then be treated in the manner described in Bye-law 11. Students may become Associate Members at any time after attaining the age of twenty-three on payment of an Associate Member's subscription.

14.—The balloting shall be conducted in the following manner:— Each Member attending the meeting at which a ballot is to take place shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the Form D in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members voting.

15.—Notice of election shall be sent to every person within one week after his election, according to the Form E in the Appendix, enclosing at the same time a copy of Form F, which shall be returned by the person elected, signed, and accompanied with the amount of his annual subscription, or life composition, within two months from the date of such election, which otherwise shall become void.

16.—Every Ordinary Member elected having signed a declaration in the Form F, and having likewise made the proper payment, shall receive a certificate of his election.

17.—Any person whose subscription is two years in arrear shall be reported to the Council, who shall direct application to be made for it, according to the Form G in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter, according to the Form H in the Appendix, of declaring that the defaulter has ceased to be a member.

18.—In case the expulsion of any person shall be judged expedient by ten or more Members, and they think fit to draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half the Members of the Institute; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the Form I in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion; and if a majority of the persons present at such Meeting (provided the number so present be not less than forty) vote that such person be expelled, the Chairman of that Meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the Form J in the Appendix.

19.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Original, Ordinary and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council. The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies), and shall be eligible for re-election, with the exception of any President or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest Council Meetings during the

past year; but such Members shall be eligible for re-election after being one year out of office.

20.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

21.—Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Original, Ordinary, and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the Scrutineers. The votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four Scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the Scrutineers for the election of Officers.

22.—In case of the decease or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a list of persons whom they nominate as suitable for the vacant offices, and a new Officer or Officers shall be elected at the succeeding Ordinary General Meeting.

23.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being ex-officio a member of all), and shall regulate and keep order in the proceedings.

24.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member present, to take the chair at the meeting.

25.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating specific subjects connected with the objects of the Institute. Such Committees shall report to the Council, who shall act thereon as they see occasion.

26.—The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

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

28.—The Copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise without the written permission of the Council.

29.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council. A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

30.—At meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members.

31.—All Past-Presidents shall be ex-officio Members of the Council so long as they continue Members of the Institute, and Vice-Presidents who have not been re-elected, or have become ineligible from having held office for three consecutive years, shall be ex-officio Members of the Council for the following year.

32.—Every question, not otherwise provided for, which shall come before any Meeting, shall be decided by the votes of the majority of the Original, Ordinary, and Associate Members then present.

33.—All papers shall be sent for the approval of the Council at least twelve days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and notice shall be given to the writer within one month after it has been read, whether it is to be printed or not.

34.—All proofs of reports of discussions, forwarded to Members for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

35.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

36.—Twelve copies of each paper printed by the Institute shall be presented to the author for private use.

37.—Members elected at any meeting between the Annual Meetings shall be entitled to all papers issued in that year, so soon as they have signed and returned Form F, and paid their subscriptions.

38.—The Transactions of the Institute shall not be forwarded to Members whose subscriptions are more than one year in arrear.

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

40.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote. Any Member of the Institute shall also have power to introduce two strangers (see Form L) to any General Meeting, but they shall not take part in the proceedings except by permission of the Meeting.

41.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

Approved,

R. ASSHETON CROSS.

Whitehall,

2nd July. 1877.

APPENDIX TO THE BYE-LAWS.

[FORM. A.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being upwards of twenty-eight years of age, and desirous of being elected an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him from personal knowledge as a person in every respect worthy of that distinction, because—

[Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed Member

Dated this day of 18

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an Ordinary Member.

From personal knowledge.

-------------------- 5 Members.

[To be filled up by the Council.]

The Council, having considered the above recommendation, present A. B. to be balloted for as a of the North of England Institute of Mining and Mechanical Engineers.

Signed Chairman.

Dated this day of 18

[FORM B.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being desirous of admission into the North of England Institute of Mining and Mechanical Engineers, we, the undersigned, propose and recommend that he shall become [an Honorary Member, or an Associate Member, or a Student] thereof.

----------------- Three* Members.

* If an Honorary Member, five signatures are necessary, and the following Form must be filled in by the Council.

Dated this day of 18

[To be filled up by the Council.] The Council, having considered the above recommendation, present A. B. to be balloted for as an Honorary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed ---------------------------------Chairman.

Dated this day of 18

[FORM C]

A. B. [Christian Name, Surname, Occupation, and Address in full], being at present a of the North of England Institute of Mining and Mechanical Engineers, and upwards of twenty-eight years of age, and being desirous of becoming an Ordinary Member of the said Institute, I recommend him, from personal knowledge, as a person in every respect worthy of that distinction, because—

[Here specify distinctly the Qualifications of the Candidate according to the spirit of Bye-law 3.]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being

[lviii]

convinced that A. B. is in every respect a proper person to be admitted an Ordinary Member.

From personal knowledge.

Two Members.

[To be filled up by the Council].

The Council, having considered the above recommendation, present A. B. to be balloted for as an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed Chairman.

Dated day of 18

[FORM D.]

List of the names of persons to be balloted for at the Meeting on , the day of 187

Ordinary Members:—

Associate Members:—

Honorary Members:—

Students:—

Strike out the names of such persons as you desire should not be elected, and hand the list to the Chairman.

[FORM E.]

Sir,—I beg leave to inform you that on the day of you were elected a of the North of England Institute of Mining and Mechanical Engineers, but in conformity with its Rules your election cannot be confirmed until the enclosed form be returned to me

with your signature, and until your first annual subscription be paid, the amount of which is £ , or, at your option, the life-composition of £

If the subscription is not received within two months from the present date, the election will become void under Bye-law 15.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM F.]

I, the undersigned, being elected a of the North of England Institute of Mining and Mechanical Engineers, do hereby agree that I will be governed by the Charter and Bye-laws of the said Institute for the time being; and that I will advance the objects of the Institute as far as shall be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to be a Member.

Witness my hand this day of 18

[FORM G.]

Sir,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 17, and to remind you that the sum of £ of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, Sir,

Yours faithfully,

Secretary. Dated 18

[lx]

[FORM H.]

Sir,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you, that in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 17, the Council have determined that unless payment of the amount £ is made previous to the day of next, they will proceed to declare that you have ceased to be a Member of the Institute.

But notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM I.]

Sir,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 18.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM J.]

Sir,—It is my duty to inform you that, under a resolution passed at a Special General Meeting of the North of England Institute of Mining and Mechanical Engineers, held on the day of 18 , according to the provisions of Bye-law 18, you have ceased to be a Member of the Institute.

I am, Sir,

Yours faithfully,

Secretary. Dated 18

[lxi]

[FORM K]

BALLOTING LIST.

Ballot to take place at the Meeting of 18 at Two o'clock.

President—One name only to be returned, or the vote will be lost.

----------- President for the current year eligible for re-election.

----------- New Nominations.

Vice-Presidents—Six Names only to be returned, or the vote will be lost.

The Votes for any Members who may not be elected as President or Vice-Presidents will count for them as other Members of the Council.

----------- Vice-Presidents for the current year eligible for re-election.

----------- New Nominations.

Council- Eighteen Names only to be returned, or the vote will be lost.

----------- Members of the Council for the current year eligible for re-election.

----------- New Nominations.

Any list returned with a greater number of Names than One President, Six Vice-Presidents, Eighteen Councillors, Will be rejected by the Scrutineers as informal, and the Votes will consequently be lost.

Extract from Bye-law 21.

Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the Offices of President, Vice-Presidents, and Members of

Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days

previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office ; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the Scrutineers. The votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four Scrutineers, who shall receive the balloting papers, and after making the necessary scrutiny destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the Scrutineers for the election of Officers.

Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede. The following Members are ineligible from causes specified in

Bye-law 19:—

As President____

As Vice-President______________________________________

As Councillors____

[FORM L.]

Admit of to the Meeting on Saturday, the

(Signature of Member or Student)

The Chair to be taken at Two o'clock. I undertake to abide by the Regulations of the North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor) Not transferable.

[1]

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING, SATURDAY, SEPTEMBER 1st, 1877, IN THE WOOD MEMORIAL HALL,

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

The Assistant Secretary read the minutes of the last General Meeting, which were confirmed and signed, and the proceedings of the Council meetings were also read.

The following gentlemen were elected:—

Members—

Mons. de Cizancourt, President of the Société de l'lndustrie Minérale, St. Etienne.

Mons. Devillaine, Vice-President of the same Society.

Mr. Robert Urwin, North-Eastern Railway, Neville Hall, Newcastle-on-Tyne.

Mr. J. W. Sandeman. C.E., 1, St. Nicholas' Buildings, Newcastle.

Mr. Nicholas Dixon, Dudley Colliery, Dudley, Northumberland.

Mr. Francis France, St. Helens Colliery Co., St. Helens, Lancashire.

Students—

Mr. Robert Morrison, Lofthouse Mines, Saltburn-by-the-Sea.

Mr. Charles Fry, Lofthouse Mines, Saltburn-by-the-Sea.

Mr. E. H. Liveing, Browney Colliery, Durham.

The following were nominated for election at the next meeting, under the new bye-laws:—

Associate Members—

Mr. Fidel Cabrera, Mining Engineer, Lota, Chili.

Mr. Stephen Humble, Derby.

[2]

Students—

Mr. Matthew Armitage, Mining Student, Birtley, near Chester-le-Street.

Mr. Arthur Pierce Stoker, Mining Student, Birtley, near Chester-le-Street.

Mr. John P. Hunter, Mining Surveyor, Backworth Colliery, near Newcastle.

Mr. Leonard Hill, Articled Pupil, No. 4, Brancepeth, Durham.

Mr. C. Z. Bunning read the following paper by Mr. T. L. Galloway and himself:—

DESCRIPTION OF AN INSTRUMENT FOR LEVELLING UNDERGROUND.

By T. LINDSAY GALLOWAY, M.A., and C. Z. BUNNING.

The levelling apparatus about to be described is a modification of an instrument which, in various forms, is already known to the engineering profession. Its general principle was brought under the notice of the writers by a short account which appeared in a recent number of the "Engineer," of the system which had been adopted by Dr. Luigi Aita in taking the levels for certain important sanitary works at Padua, under peculiar difficulties. It occurred to the writers that the principle of Dr. Aita's instrument was particularly adapted to the circumstances of underground levelling; but they have found reason, in the course of their experiments, while retaining the general principle of that apparatus, to make several improvements in its construction, and an important change in the mode of applying it.

The apparatus consists essentially of two glass tubes, connected together by an India-rubber pipe, which may be of any convenient length, say from ten yards upwards. Each glass tube is attached to a suitable scale, upon which are marked subdivisions into feet, tenths, and hundredths, in the same manner as upon the ordinary levelling staff. The tubes are filled up to about the centre of each scale with water, coloured so as to render it more distinctly visible. If now the scales be held vertically upon any sloping or uneven surface, and at any distance apart that the length of the India-rubber pipe will admit of, the difference of the reading denoting the position of the coloured liquid in each tube will represent the difference of height between the stations at which the scales are held. In the instrument now submitted for inspection the length of the glass tubes is three feet, and of the India-rubber connection twelve yards. This instrument has been specially constructed to meet the requirements of low workings in mines, but longer scales and tubes might be employed with advantage, either in surface levelling or in mines where the workings

are high. In thus adopting long glass tubes and attaching them permanently to the scales, the writers have found it advisable to depart considerably from the form of apparatus which is used by Dr. Aita. The glass tubes in the Aita level are only a few inches in length, and are moveable upon the scales, being attached by means of a sliding frame, which can be raised or lowered at pleasure. Instead, therefore, of the liquid, as in the present apparatus, simply finding its own level in the tubes, the tubes themselves are shifted in the Aita instrument so as to suit the level of the liquid. It will be therefore seen that the apparatus in its present form, besides being more simple, is necessarily quicker in its action, no adjustment of any sort being required before reading. In order to expedite its use still further, a short piece of tube of small diameter has been placed near one end of the India-rubber hose, which resists the oscillations of the liquid, and at each observation brings it rapidly to rest. By this means a levelling can be made almost as quickly as the apparatus can be moved from station to station, and many sights may be readily taken during the time which would be spent in simply setting up the telescopic level and adjusting the plate screws and focus.

The writers have, however, no desire to under-estimate the qualities of the telescopic level. No one will deny the high degree of accuracy which is attainable with it; nor can they fail to admire the marvellous proofs of its capabilities which have been given on many occasions. An undoubted advantage which this instrument possesses is in the great extent of its range; for it is clear that the likelihood of error increases, cœteris paribus, in proportion to the number of distinct sights required within a given distance. But in many circumstances, and especially in mines, where the seams are so often thin and more or less inclined, the use of the telescopic instrument is attended with great inconvenience, and the operation of levelling becomes tedious in the extreme. It is for such work that the present apparatus is best adapted, particularly in those cases where the line of section happens to be tortuous and irregular, or where various obstructions interrupt its course. The falls of stone, timbering, or sudden bends of the road, which, in everyday levelling in mines, so frequently intercept the line of vision and render short sights necessary even in flat measures, present no difficulty under this system, as it is plainly as easy to proceed around or over any obstacle as it is to advance in a straight line.

In the first trials, however, of the present apparatus, a difficulty occurred which threatened seriously to detract from its trustworthiness, arising from the presence of air-bubbles among the liquid. When, in

[5]

carrying the apparatus along, the liquid happened to oscillate beyond the bend of either of the glass tubes, a quantity of air almost invariably lodged there and was liable to remain undetected during the succeeding observations. Its presence in the vertical portion of the tube would, as will readily be understood, give rise to an error in the readings, by rendering the length of the liquid column apparently greater.

This source of error has, however, been completely removed by fitting a stop-cock at each end of the India-rubber pipe. These stop-cocks, when in use, being closed under water, prevent all oscillation whatever, the liquid in the tubes remaining absolutely stationary while the apparatus is being carried forward, so that there can be no possibility of the intrusion of air-bubbles. The writers have found this to be a very considerable improvement, which has rendered instruments of the class for the first time perfectly reliable.

A sufficient number of practical trials of the apparatus have already been made to convince the writers of its general fitness for work both underground and upon the surface. They have successfully levelled an engine-plane of 1,500 yards length in nearly half the time which would have been necessary in using the ordinary levelling instrument. They have used the apparatus in all situations, and tested it in every way, and have obtained results which were completely satisfactory. As there is no possibility of an error in the apparatus itself, its precision is limited only by the care of the person who uses it. The writers hope, however, presently to give a practical illustration which will be found to confirm their statement.

In conclusion, it is necessary to add that it has transpired since the substance of this paper was written, and after the apparatus had been exhibited to a number of gentlemen at the last meeting, that a member of this Institute had some time ago patented the use of a flexible pipe for the purpose of levelling. The writers understand that this general principle of levelling has long been known, but they have no desire to enter into the merits of such a patent, and had they been soon enough aware of its existence, would not, probably, have brought forward the present instrument. Having, however, experimented in perfect independence, and arrived at what they believe to be one or two considerable improvements, they trust that no further apology is needed for bringing under the notice of the Institute an instrument which promises to be of such considerable service to mining engineers.

A levelling was then made, starting from the left hand side of the table, passing round the seats, and returning to the starting point; the sights tied in to the .005 of a foot.

Mr. Bewick begged to move a vote of thanks to Messrs. Galloway and Bunning for their contribution to the Institute. In many cases such an instrument would be found very useful, especially in slightly inclined sumps and rises where it was almost impossible to get an ordinary levelling instrument placed. It was of course limited in its scope, inasmuch as more could not be taken than the height of the instrument at any one reading; but by having it made longer, greater heights might be measured at each reading.

Mr. Greenwell asked if the instrument could be used on the surface, and whether it could be used to level over falls, and what were the limits of height of such fall?

Mr. C. Z. Bunning said, they had used it successfully to level on the surface. It would also level over falls, in fact that was one of the chief advantages claimed for the instrument, but the height of the fall should not exceed thirty feet.

Mr. Greenwell wished to know the effect of raising the India-rubber tube.

Dr. Saise said, that if the sum of the readings, when the India-rubber tube is not strained, be compared with the sum of readings when the connecting tube is strained, either by raising it or in any other way, there would be found a difference of about six inches. This was due to the elasticity of the India-rubber tube and its consequent varying capacity.

Mr. Greenwell said, he thought that would be the result. He compared the levelling just made to levelling round a pillar, and remarked that the six readings were taken in the time necessary to set an ordinary level. They were all glad to have instruments brought before them which were designed to lessen the difficulties of underground levelling.

Mr. Ground said, that he had taken out a patent for this invention last October. Of course, the present instrument was entirely the work of Messrs. Galloway and C. Z. Bunning, and they knew nothing about his patent. He himself had used the instrument some considerable time, and had found it invariably correct; and he found he could do levelling in about half the time it took with an ordinary instrument in the pit. There was also a very great advantage aboveground in levelling with a standard six feet long, which was the longest that could be used, as the

[Plates I and II. Sketch view to show method of levelling round a pillar] to II, showing levelling instrument]

scale could not well be read higher than that. Nearly half the time was saved by using it at bank as well.

The Chairman—And with equal accuracy?

Mr. Ground—Yes. The first levelling he did was about a mile, and it tied in to a very minute fraction.

The Chairman said, he thought it was not necessary to say how pleased they were to find anything which would facilitate any operations which involved any difficulty or delay. The instrument shown by Messrs. Galloway and Bunning seemed to make levellings in certain conditions very much easier than the ordinary way of setting a level. Of course, they were to assume that in the levelling which they had seen there, there must have been a holing round, round which it has been necessary to make a levelling. Considering the length of time it took to set a level accurately, he thought they might say with tolerable safety that this had been done nearly in the time it would have occupied to have taken one set with the ordinary level. He did not, however, exactly understand one remark which had been made in the paper with respect to falls. He was afraid that circumstances might arise under which it would not be possible to level over falls.

Mr. C. Z. Bunning said, under any circumstances, falls could be levelled over where their height did not exceed thirty feet.

Mr. Galloway said, the tube in that case would be like a syphon with both legs in water standing at the same level.

The Chairman—Yes, but if the fall was great, the liquid would run into the tube.

Mr. Bunning held the tube up, and it was found not to go into the tube.

The Chairman—No; but in levelling over a certain height it would be found that all the liquid there was would get into the tube itself.

Mr. Ground said, of course it could not be expected that if one standard were set on the top of a high fall the fluid would be seen in both standards; it would all come into the bottom one. But although part of the tube might be higher than the standards, the fluid came to its own level in each standard.

A Student—Will the stretching of the tube make no difference?

Mr. Ground—Not the slightest.

Mr. Galloway said, it made about half a foot difference in the height of the water in the level when there was a strain, owing to the stretching of the tube.

A Student—Nevertheless, both standards would be quite level?

Mr. Ground—Yes; the level would be quite the same; but there would be less fluid shown in the two tubes.

[8]

Dr. Saise said, that as he had assisted the writers in making several levellings, he should like to make a few remarks as to the efficiency of the instrument. From what he had seen, it acted very well both underground and above. It acted well where the strata were comparatively flat, but in the district to which he had been accustomed—the Bristol coal-field—where the seams dipped at 25 or 80 degrees, he was afraid it would not be so useful, as the standards would have to be so close together, and they would have to fall back on the Hedley dial or the theodolite. While admitting its great usefulness, he thought it right to call attention to the limits of its use.

A Member thought the same remarks would apply to an ordinary level. In each case the height of staff limits the reading. Of course, levelling with a theodolite, was a different thing, and not to be compared with ordinary levelling. Aboveground he preferred the ordinary level, as it could be read up to any height to which a staff could be held, but for underground work he thought this a great improvement.

Dr. Saise said, he made no comparison with the ordinary level. He wished merely to point out the limits within which the instrument now submitted could be used. He believed in its great practical utility.

The resolution of a vote of thanks was then put and carried by acclamation.

Mr. Emerson Bainbridge's paper "On Different Methods of Lubricating Coal Tubs or Corves" was then announced to be open for discussion, and the following additional notes by Mr. Bainbridge were read by the Assistant Secretary:—

Since the paper describing the number of different modes of lubricating coal-tubs or corves was read the author has not been able to obtain much more data as to the relative economy of the various systems described; but, from what he has been able to learn, there is no system under the second series of apparatus—viz., those which supply the oil by the chamber attached to the tub—which has stood a practical test for a sufficiently long time to prove it thoroughly reliable. Three new systems under this head have been brought to his notice recently. The first two, Figs, a a a and b b, Plate III., are adaptations of Mr. Lupton's mode of making the tub-wheel contain the lubricant.

In the case of a wheel designed by Mr. W. Thomas, of Neath, Figs, a a, lubrication is performed, as shown by the sketch, by the application of the oil contained in the hollow bush of the wheel, which oil is applied to a

[Plate III. Various lubricating apparatus]

large area of the axle. One application is stated to last for three days, which can scarcely be expected to represent economical working.

The other lubricator of this class has been invented by Mr. Hadfield, of Sheffield, and in this case the oil is passed on to the axle by two small holes, as shown by Fig. c c, Plate III.

The other mode of lubricating referred to has been patented by Messrs. Johnson, of Dudley, and appears to be similar in idea to the mode shown on Plate LXIV., Vol. XXV. In place, however, of the oil being applied by means of a lubricating needle, there appears to be no arrangement for checking its flow upon the axle.

It will be seen that if this plan were applied to wooden tubs it would cause the top of the wheel to be an inconvenient distance from the bottom of the tub.

A similar mode of greasing tubs to Anker's method is in operation in the Glasgow district. In this case star-wheels are placed as shown by the sketch, Fig. d d d, Plate III., and the strap which passes below the axle is made very narrow (see elevation); so that as the tub passes over the four wheels, two of the wheels strike the axle on the inside of the strap and two on the outside.

A discussion then took place on Mr. Shaw's paper "On a New Form of Marine Boiler":—

Mr. Richardson said, as Mr. Shaw had been prevented from coming, if the Chairman would allow him, he would like to make a few remarks in respect of the subject of the paper, he himself being a partner in Mr, Shaw's firm. At the last meeting some questions were asked as to the working of the boiler, and since that time—about a month ago—he had taken a trip across to the continent, in the steamer the "Royal Dane," a drawing of whose boilers was shown in Plates XI and XII., Vol. XXVI. Naturally one had a great deal of time at sea, and he was a good deal in the engine-room, and he might say that he was perfectly satisfied with the working of the boilers. Now, after about two years' trial, they all knew that engineers on board ship, who had nothing to do but to watch their engines and find out every fault, generally had several complaints to make; but really there was no complaint that the engineer on board the "Royal Dane" had to make, except that on one occasion there was something to be done at the top of the boiler, and the engineer complained that a great heat came up between the two boilers. These difficulties had been foreseen, and he was convinced that they could be entirely got over. His own firm of shipbuilders were so satisfied about it that they were now entering into a contract to build three steamers somewhat similar to the "Royal Dane," and they had decided to adopt that form of boiler in all three. He did not think that, in his experience of nearly twenty years, he had known any vessel designed to go at a high speed, concerning which, after two years' working, the engineer should make no complaint about the capacity for raising steam. The engineer of the "Royal Dane" went so far as to say that he could run his boat with one of the boilers laid off altogether. The matter had further come under their notice as a shipbuilding firm, by their having been asked recently to design and tender for a vessel in which extreme lightness was requisite. As the vessel was intended for a very high rate of speed—a speed of over twenty statute miles an hour; there was a difficulty in getting a sufficient horse-power into the vessel with such a small draft of water, which he thought could be overcome by using the form of boiler which was under discussion. He thought that in any of the criticisms which had been made as to details of construction or consumption of fuel, it must always be born in mind that the machine must be looked upon as a whole; and the main condition of the boiler was, that it should raise steam with an economical consumption of fuel and as little weight as possible, both of iron and of water, always combined with the conditions which every boiler must observe of durability and accessibility for repairs. He had thought it would interest the members of the Institution to know what further experience there had been of these boilers.

The Chairman asked what was the consumption of coal per indicated horse-power?

Mr. Richardson said, that if he recollected rightly, at the time the trials were made, the "Royal Dane" consumed something like 1⅞ lbs. of coal per hour for each indicated horse-power; that was when burning the Ravensworth Allerdean coal, which, he thought, could hardly be considered the best. The impression which his firm had, was that the best Welsh steam coals or some of the West Hartley coals would give a higher economic result than the Ravensworth Allerdean coal, although from what he heard it was a coal which was liked well by stokers.

Mr. Ramsay asked whether they used large or small coal for the boilers of the "Royal Dane?"

Mr. Richardson said, in this case it was unscreened coal.

Mr. Lawrence said, he would like to ask Mr. Richardson whether he could inform them at what temperature the gases were escaping up the funnel in this boiler? His first impressions when he saw the Transactions were that there would be less economy than in other boilers where the

flues did not come together at the middle or back of the boiler, and in which there was a water space between the two boilers, so that each fire would come into its own separate combustion chamber, and the gases from each fire would pass through a separate set of tubes to the uptake; a very large amount of heating surface would be obtained by this water space between the two fires, the insertion of which he had been informed by marine engineers was a very great improvement where two boilers were put back to back. He was not quite aware of the object sought to be attained in the design of that boiler, but Mr. Richardson could tell him if he was wrong in supposing the object was to join the two boilers by the diaphragm only, and have no water space between. As Mr. Richardson had been on board the ship where they were in use, perhaps he got the information from the stokers as to the draught; but he (Mr. L.) should imagine that when the stoker was firing one side, the door being open, and there being a connection between the fires, the rush of cold air into one furnace would be detrimental to the draft of the opposite furnace, seeing that the gases met together. This objection would not arise if there were a combustion chamber to each boiler flue in the way he had described.

Mr. Richardson in reply said, with reference to the question as to the temperature of the gases at the foot of the chimney, no experiments were made, and therefore he could not tell what it might be. There was, however, a very striking absence of smoke, and perhaps that absence of smoke might partly hang upon the other observation which was made about the draft through, viz:—that when the door was opened at one end, it would let in the cold air and would interfere with the draft at the other end. He was only speculating, and could not say positively, but he rather imagined that that admission of air was beneficial. In practical working there had been no complaint on either of these heads, nor had there been any difficulty about the admission of air which would in any way affect the durability of the interior portion of the boiler. As regarded having an ordinary double-ended boiler with a mid-division containing water with the idea of getting a large amount of heating surface, that very question was discussed in the paper which Mr. Shaw wrote, and the very element of the design was to do away with that. It was evident that as diaphragms and water spaces were introduced, the heating surface of a boiler increased. In this boiler, for instance, if Galloway tubes were inserted, in some way or other, the heating surface would thereby be increased, but the question would still remain open how to get the best, most efficient, and largest amount of heating surface with the greatest simplicity in a given weight of boiler, and the contention was

[12]

that this boiler had a very marked advantage over any other form of boiler which had hitherto been used on board steamships.

Mr. Lawrence said, he could quite understand that what Mr. Richardson said as to the smoke would be correct, because when a man put coal on one furnace the chances were that the flame from the other furnaces would be very intense, and would consume the smoke by its coming into contact with the whole of the flame from the other fires in the combustion chamber. Of course, as Mr. Richardson stated, experience was everything, but he (Mr. L.) knew of very large steamers which were being fitted at the present time with this same class of boiler, except that they had a very large water space behind—a space large enough for a man to go into and move about for examination and repairs. There was also another thing about which he would remark, that was as to high-pressure boilers. This boiler seemed to have a very large number of stays, seeing that the sides were flat. He would not say whether they were right or wrong, but, as the members knew, the marine engineers of the present day made the boilers entirely round, and scarcely one of them needed stays.

Mr. Richardson said, that on this part of the subject he would just like to observe that it was no part of the design to have the boilers flat-sided or oval, the flatness was required by the exigencies of the vessel. As he had stated, his firm were intending to fit out three steamers with this kind of boiler, and they would be circular. They would never think of making the boilers flat unless it was absolutely necessary to do so.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, OCTOBER 6th, 1877, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

Mr. WILLIAM COCHRANE, in the Chair.

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

The following gentlemen were then elected:—

Associate Members—

Mr. Fidel Cabrera, Mining Engineer, Lota, Chile.

Mr. Stephen Humble, Engineer, Uttoxeter Road, Derby.

Students—

Mr. Arthur Pierce Stoker, Mining Student, Birtley, near Chester-le-Street.

Mr. Matthew Armitage, Do. Do.

Mr. John P. Hunter, Mining Surveyor, Backworth Colliery, near Newcastle-upon-Tyne.

Mr. Leonard Hill, Mining Student, No. 4, Brancepeth, Durham.

The following were nominated for election at the next meeting:—

Honorary Member-

The Right Honourable Lord Eslington.

Associate Members—

Mr. Arthur Henry Bacon, Mining Engineer, Murton Colliery, Sunderland.

Mr. Walter Saise (Doctor of Science, London), Mining Engineer, Barmoor, Ryton-on-Tyne.

Students—

Mr. Stephen Price, Mining Engineer, Mining Offices, Tynemouth.

Mr. Edward Clough Topham,	Do.	Do.
Mr. Charles Edward Peake,	Do.	Do.
Mr. Ernest Craig,	Do.	Do.

No papers were read.

[14]

[blank page]

[15]

VISIT TO THE STONECROFT AND GREYSIDE LEAD MINES, THE PRUDHAM QUARRIES, AND THE SETTLINGSTONES LEAD MINES.

OCTOBER 19th, 1877.

At the time of starting from Newcastle it was found that upwards of a hundred members had availed themselves of the kind permission of the Stonecroft and Greyside Mining Company, Mr. W. Benson, and Mr. F. W. Hall, to view the quarries and lead mines near Newbrough; and at 10.15 the special train, kindly placed at the disposal of the Institute, took the party to its destination.

At Fourstones the party was received by Mr. Benson and his son, Mr. T. W. Benson, and conducted over the colliery, limeworks, and quarries belonging to the former gentleman. The first thing to attract the attention of the visitors was Hunter's patent stone-dressing machine, employed in dressing the stones obtained from the quarry. It was put in operation on the arrival of the visitors, and a stone about five feet nine inches in length and eighteen inches broad was dressed in about four and a half minutes. This, however, was no test of the quantity of work the machine is capable of doing in the time, for it will dress a stone twice the breadth in the same time, and in practice it does the work of from fifteen to thirty men according to the breadth of stone. The machine is a great improvement upon those of the same kind formerly used. In the older machines the cut was straight upon the face of the stone, and consequently the wear and tear of the knives was very great. In the new arrangement, the cutters revolve upon an axle, so that the cut is given in the shape of a curve or scoop, and consequently the edge of the cutter is much less damaged than in the former case. The machine is capable of dressing 300 superficial feet per day. In the same works are machines for similarly saving manual labour in the case of timber sawing and planing. The instruments are both manufactured by Messrs. Ransome and Co., of Chelsea, London. One is a band saw which cuts out curves, cart-wheel felloes, brake wheels, and similar articles, and does the work of seven or eight men; the other is a boring, sawing, and planing machine. It is used for morticing door frames as well as cutting, and does an immense quantity of work. An instrument, by the same makers, also in this workshop, is used for sharpening saws. It consists of a circular disc of emery stone, about ten and a half inches in diameter, attached to a swing frame, revolving at a very high speed. This frame can, by means of a handle, be raised or lowered at the will of the operator; the saw is fixed below, and the disc is brought down on the teeth. The emery stone cuts the steel with the greatest rapidity, and the saw is speedily sharpened.

The party next visited the selenitic works at the same place. They comprise a pair of edge stones and four feet six inches mill stones, elevators, etc. The material produced is largely used for plastering in place of mortar.

Here also are nine lime-kilns capable of turning out 150 tons of lime per day, and adjoining is a colliery employing between fifty and sixty men and boys. The coal is found in the limestone measures, and from the circumstance of its lying immediately underneath them is not unfrequently called the Little Limestone coal. The quarries of limestone and freestone are situated about half a mile to the north of the railway station. The freestone is the well-known Prudham stone, so largely used for building purposes, and the only stone of the kind to be found in the district. At this place and in the immediate neighbourhood alone, is found the stratum of this quality. Large quantities are sent into Lancashire, Westmorland, and Scotland for the construction of buildings of the better class. Some of the principal buildings in Newcastle, the new Post Office, the Mining Institute, the new Club House, and the Central Station, are built of it. The limestone which Mr. Benson is working is lying immediately over this, and is the well-known Great Limestone prevailing over the whole of the mining district of the North of England, and which in the Alston Moor and adjacent lead mining territories has been and is still so productive of lead ore. In the district of Newbrough, Fourstones, and Prudham it is denuded; and the lead ore is raised from beds immediately underneath, down to the whin sill, and also upon the whin sill.

To enable the members more particularly to observe the leading features of the Stonecroft and Settlingstones lead-mines, the following description of the geological features of the neighbourhood to be visited was kindly supplied by G. A. Lebour, Esq., F.G.S:—

The group of lead-mines between Haydon Bridge and the line of the Roman Wall is situated (geologically speaking) in the upper portion of the Bernician or Carboniferous Limestone Series of Northumberland, the beds exposed lying between the "Little Limestone" above and the strata associated with the Great Whin Sill below.

A walk from Fourstones Station, northwards, to the Roman Wall, on Limestone Edge, exhibits the successive outcrops of the rocks in question admirably.

The Little Limestone coal (the same as that worked at Acomb) crops out at the railway station; the dip of the beds being S. to S.E., and at a considerably greater angle than the slope of the country, every step towards Teppermoor takes one from higher to lower beds. In this way is passed over the "Great Limestone" in which are opened the large quarries at Fourstones; the Prudham Sandstone, also largely quarried; the "Four-fathom Limestone," which is well seen in a small quarry in a corner of the Newbrough grounds, just below the great quarries, and which here abounds in the curious fossil, *Saccammina Carteri*, Brady; then come other conspicuous sandstones and grits with limestones, until one of the latter is found lying immediately upon the great sheet of basalt, which is so well known as the Great Whin Sill. The horizon occupied by the Whin here is about 400 feet higher than that at which it stands at its next prominent outburst (well seen in the distance to the N.E. from Limestone Edge) at Gunnerton Heugh. In places, the Limestone capping the Whin is seen to be separated from it by a thin bed of shale; and when this is the case, the shale is seen very clearly to be burnt and baked by its proximity to the igneous rock. This, together with its change of horizons, even if unsupported by other facts, would be amply sufficient proof of the intrusive character of the Great Whin Sill. In the mines themselves, where the sheet of trap is faulted by the veins in the same manner as the sedimentary sandstones and limestones, the deceptive interbedded appearance of the Whin is that which is best shown.

Roughly speaking, the veins of the district as a whole may be said to run in a broad band, having a N.E. and S.W. direction, and lying between the Prudham and Carr Edge Hills on the East, and the Grindon Hills on the West. The individual directions and throws of the veins are of course various, and it is only of their complicated network collectively that the above general statement is true. Of the veins little need here be said, but attention may perhaps be called to the following points,

[18]

wherein they differ from those of the Alston and Derwent districts, viz., their throws as faults are frequently great, although taken together they in the end compensate one another; their hades are sometimes to the upthrow (or, in other words, they are sometimes reversed faults), and they frequently are very rich in Carbonate and (less markedly) in Sulphate of Barytes. The spar filling up vein-cavities is generally Carbonate of Lime, and very rarely Fluor-spar.

The Great Fallowfield Vein, which may be regarded as the advanced guard of the whole group, although it lies outside the limits mentioned, crosses the South Tyne in a line nearly, but not quite, parallel to that of the St. Oswald's Basaltic Dyke, a little below the Fourstones Station.

A great portion of the lead-mining area, as above circumscribed, lies in a comparative hollow, which is more or less filled up with Boulder Clay. The re-assortment of this clay has given rise to detached patches of finer clay suitable for tile-making, etc., and which have been utilized in this manner at Fourstones, etc.

A still newer deposit is that of ancient river gravels, which are beautifully seen on both sides of the South Tyne valley, rising in well-shaped terraces to a height of 300 feet and more.

To the fossil hunter, the thick shale above the Great Limestone in the Fourstones quarries, and the Four-fathoms Limestone in the small but rich Newbrough quarry, are the chief attractions, whilst the mineralogist will find much to interest him in the beautiful specimens of Witherite to be seen in the neighbourhood of the mines.

The Stonecroft Mines, the property of the Stonecroft and Greyside Mining Company, are about two miles and a quarter from the Fourstones Station. The members who went underground were conducted through the workings by the chief agent, Mr. Thomas Ware, and the surface operations were shown by Mr. Benson, one of the managing partners.

The mines have been worked on three distinct veins, the first Main Vein, runs nearly due E. and W., and has an upthrow to the north of 14 fathoms. It has been worked extensively, and proved more or less productive the whole length, varying very much at times from very rich to poor.

The second, known as the South X Vein, has been extensively worked, but not so productive. Its throw is comparatively small.

The third, the South Vein, has also been worked to a considerable extent, and has been very productive. This vein has an upthrow to the north of 14 fathoms.

[Diagram of the veins]

The matrix is composed of Carbonate of Iron, Sulphate and Carbonate of Barytes, and Iron Pyrites.

About 130 men are employed in the underground workings, and about 70 at the surface.

The great art of lead mining is in driving amongst and towards those portions of the veins which contain the most lead. In some cases the choice of direction, to some extent, is allowed the men, who are paid on the lead actually procured at stated settling times, drawing money from time to time in the interim for their daily wants. This, of course, causes them to make as little dead work as possible. In other cases the men are paid by the square fathom, i.e., 6 feet high and 6 feet forward, and such width as may be indicated to them by the superintendent.

In these mines the latter system prevails. All that portion of the matrix that can at sight be seen to contain no lead is left below, and that sent to bank contains on an average 12 to 15 per cent. of lead; and it is to separate this from the matrix, by means of crushing, washing, and the action of gravity, that the surface works are constructed.

The first process consists of screening the material close to the opening from the mine. Here the stones are wailed, the pure lead ore selected and

set apart, and that portion of the matrix containing lead allowed to descend into a crushing machine, where it is reduced to pieces from the size of nuts to that of the finest sand.

It has been found that in washing, the lead can be very much more easily separated from the matrix if the particles of a similar size are treated together and not mixed with each other. The first thing, therefore, is to size the particles coming from the crushing machine. They are accordingly lifted by a series of buckets from the well where they are deposited by the machine and conducted, mixed with a stream of water, to the top of a series of circular rotating sieves, placed at an angle; the largest meshes of this sieve are at the top, and the largest particles fall through it first, leaving the smallest, which are carried by the rush of water, to escape at the bottom. At different intervals down the screens there are conduits which lead the particles now properly sized into a series of boxes full of water, in which are trays working rapidly up and down. In these the lead separates itself from the matrix by its superior weight and falls to the bottom. There are seven of these jiggers to one rotating sieve, and consequently there are seven different sizes of crushed matrix, and seven different sizes of lead ore deposited. Each of the seven jiggers has three compartments. The material which passes from the first into a box below is clean ore; and this also is the case to some extent in the second compartment; the third compartment, which contains but little lead ore with other mineral, is re-crushed with a pair of fine rollers, and again goes through a similar process to that above described.

The water passing from the crushers, &c, and containing sludge and slime, is conducted to classifiers by means of launders, as shown in Plate IV. There is a grating or sieve in the launder over the classifier, through which the greatest proportion of the slime water falls, leaving on the grating any substance which may have been carried with it. There is a plug a at the bottom of the classifier, by which the slime is drawn off and allowed to pass to the circular buddles. The slime falls into a cup b and percolates through holes in the bottom into the basin c. Such water as does not fall into the classifier passes on and falls into catch-pits, where the residue of the slime is deposited, and from whence it is lifted and conveyed to other circular buddles.

A stream of clear water flows from a pipe into the receptacle d attached to the revolving shaft e, and, passing downwards, is distributed by means of a tube f projecting through the side of the cup b over the surface of the material deposited from the slime, the water flowing

[Plate IV. Sketch of washing apparatus]

[21]

out of the basin c through an aperture g, and being carried away by a launder to the catch-pits. A thin board h is attached to the exterior of the cup b on the side opposite to the projecting tube, and hanging lightly to this board is a piece of rough cloth i called a brush. This passes over the surface of the matter deposited and causes the small particles of ore to collect round the centre of the basin, from which it is afterwards collected. The ore is not yet, however, clean enough for market, and has yet to pass through the process of dollying.

[Diagram of dolley tub]

The dolley tub, a sketch of which is annexed, is filled slowly with the slime ore and water, which is kept in motion by means of the revolving wing A, to prevent the ore depositing until the tub is full, when the wing is quickly withdrawn, and two hammers actuated by the same machinery which causes the wing to revolve are set in motion, and, by striking rapid blows on the outside of the tub, assist in causing the ore to be precipitated to the bottom of the tub, leaving the waste, which is of a lighter nature, at the top.

From all these processes the production of marketable lead ore is about 250 tons per month. This, after being sampled, is sold to the refiners in the neighbourhood.

The mine is kept free from water by a Cornish pumping-engine, with a 70-inch cylinder and a stroke of 10 feet, beam 32 feet. The water is pumped by a plunger, 21 inches diameter, driven by the weight of the spears, which are lifted by the pressure of the steam. The surplus weight of these spears is taken off by a counterbalance weight, attached to an auxiliary lever or beam. About 558 gallons of water are lifted 58 fathoms per minute. This engine works up to 250 horse-power and consumes four pounds of coal per horse-power per hour. The valves for the plunger set are Husband's (quadruple) patent.

The depth of the winding shaft is 70 fathoms, and levels are driven off at 15, 30, 40, and 50 fathoms.

[22]

At Settlingstones the members were conducted over the mine by Mr. F. W. Hall and Mr. Watson.

Lead ore has been raised in this neighbourhood for many years. At Settlingstones the vein is visible in the works by the side of the Burn, and bears evident traces of having been worked by the Romans. John Hall, M.D., commenced working it in 1770, and continued to do so for some years, after which the mine was abandoned, but was re-opened in 1833, by the present proprietors, and it has been worked continually since that time.

The surface works for crushing, separating, and preparing the ores for market, are on the same principle as at Stonecroft, and do not require special description. The water is extracted at Settlingstones by a 60-inch cylinder Cornish engine, a description of which was given by Mr. F. W. Hall, in Vol. XXI. of the Transactions of the Institute, page 59.

For winding there is a condensing engine of 16 horse-power and two of 25 horse-power. One of the shafts is 100, another 75, and another 60 fathoms deep. The barytes is drawn from the workings at from 60, 70, and 80 fathoms lift. Between 2,000 and 3,000 tons of barytes, chiefly in the form of carbonate, are annually produced, and are shipped principally to France and Germany. A little goes to America, and some is used in England for glassmaking and other industrial arts. The chief production of barytes is found in two or three mines in the North of England, and here is one of the principal sources of supply. Almost the entire product of the British Islands is, in fact, within a few miles of this place. The mine is also worked for lead ore. The run of the known veins through the royalty is about a mile and a quarter, and includes all works in the district. The mines are situated in a very picturesque neighbourhood, close to the Roman Wall, and in the neighbourhood of that portion of the wall where the great discovery was made of Roman coins in the well consecrated to the goddess Coventina, at the Roman camp at Procolitia, on the estate of Mr. John Clayton. A large party of the members visited the shrine, and the whole company afterwards assembled in the village of Newbrough, where they had luncheon provided by Mr. Surtees, innkeeper. Mr. Benson occupied the chair, and various toasts having been proposed, the party proceeded to Fourstones Station, from which place a special train brought them back to Newcastle. The weather throughout the day was exceedingly fine, and the excursion was greatly enjoyed.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, NOVEMBER 3, 1877, IN THE WOOD MEMORIAL HALL.

LINDSAY WOOD, Esq., President, in the Chair.

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

The following gentlemen were elected:—

Honorary Member-

The Right Honourable Lord Eslington.

Associate Members—

Mr. Arthur Henry Bacon, Mining Engineer, Murton Colliery, Sunderland.

Mr. Walter Saise (Doctor of Science, London), Mining Engineer, Barmoor, Ryton-on-Tyne.

Students—

Mr. Stephen Price, Mining Engineer, Mining Offices, Tynemouth.

Mr. Edward Clough Topham, Mining Engineer, Mining Offices, Tynemouth.

Mr. Charles Edward Peake, Mining Engineer, Mining Offices, Tynemouth.

Mr. Ernest Craig, Mining Engineer, Mining Offices, Tynemouth.

The following were nominated for election at the next meeting:—

Associate— Mr. John Sutherst, Ironfounder, Cleveland Foundry, Guisborough.

Students—

Mr. John C. Fletcher, Peases' West Collieries, Crook, Darlington.

Mr. Alexander Gould, The Vicarage, Earsdon, Newcastle.

Mr. J. B. Simpson then read the following paper:—

[24]

[blank page]

[25]

AN ACCOUNT OF THE CONDITION OF THE MINING INDUSTRIES OF PRUSSIA IN THE YEAR 1875

By J. B. SIMPSON.

At the present time, when the depressed condition of the coal trade is so great in this country, it cannot but be interesting to compare what is being done in other countries, especially in those with which we have to compete, and it is proposed to carry out the comparison by a review of the condition of coal-mining in Germany, the next largest coal-producing country to our own.

The paper on this subject is chiefly a translation from the official journals of the Prussian Government in their annual reports, and the author has to acknowledge the great assistance he has received from Mr. C. Z. Bunning and Dr. Saise.

The most important coal-fields of Germany are the basins of the Saar, Aix-la-Chapelle, Ruhr, Zwickau, and Upper and Lower Silesia; the oldest coal-workings are probably those of Aix-la-Chapelle, which were commenced as far back as the eleventh or twelfth century; of not much later date are those of some parts of Westphalia and Saxony; whilst those of the Saar date from about 1529. There are no accurate data as to the earliest workings in Lower and Upper Silesia, but they probably began before the thirty years' war [1618 - 1648].

Coal-mining has no doubt been much retarded in Germany, indeed was almost impossible until the Napoleonic wars were ended, and the subsequent restoration of the peace of Europe. Since then coal and lignite have gradually usurped the place of wood as fuel not only for workshops but also for dwelling-houses.

One of the German authors says:—"It was reserved for this age, one directed chiefly to the pursuits of peace, to bring again to light in Germany the petrified remains of the vegetation of an older world, and to win and work coal for the purpose of again converting it into light and heat and power."

The progress of coal-mining has been extremely rapid in Germany during the present century, and, going no further back than 1853, has increased from about eight and a half millions to forty-three and a half millions in 1876, or upwards of five times. The following Tables, which have been taken chiefly from "Mineralische Kohle," by Messrs. Pechar and Peez, supply interesting statistics:—

TABLE No. 1.—TOTAL GERMAN PRODUCTION.

Year.	True Coal.	Brown Coal.	Total.
1853	6,331,417	1,986,715	8,318,132
1860	12,347,828	4,382,664	16,730,492
1861	14,133,048	4,622,312	18,755,360
1862	15,576,278	5,084,399	20,660,677
1863	16,906,708	5,459,495	22,366,203
1864	19,408,982	6,203,918	25,612,900
1865	21,794,705	6,758,052	28,552,757
1866	21,629,746	6,533,059	28,162,805
1867	23,738,327	6,994,818	30,733,145
1868	25,704,758	7,174,365	32,879,123
1869	26,774,368	7,569,545	34,343,913
1870	26,397,769	7,605,234	34,303,003
1871	29,373,272	8,483,249	37,856,521
1872	33,306,418	9,018,053	42,324,471
1873	32,347,909	7,987,832	40,335,741
1874	31,491,542	8,594,616	40,086,158
1875	32,951,429	8,223,495	41,174,924
1876	34,466,250	8,985,122	43,451,372

TABLE No. 2.—IMPORTS AND EXPORTS.

Year.	IMPORTS.		EXPORTS.	
	True Coal.	Brown Coal.	True Coal.	Brown Coal.

1860	755,086		1,810,472	
1861	871,298		2,074,906	
1862	894,893		2,107,384	
1863	925,899		2,078,889	
1864	733,592		2,438,777	
1865	1,089,535		2,962,300	
1866	1,152,758		3,309,273	
1867	1,303,662		3,805,510	
1868	1,643,360	608,627	3,770,601	7,872
1869	1,856.149	611,734	3,984,828	15,116
1870	1,681,573	760,711	4,007,401	1,797
1871	2,395,072	874,673	3,699,691	3,856
1872	2,533,884	1,016,734	3,743,752	19,729

[27]

TABLE No. 3.—OUTPUT OF WESTPHALIAN COAL.

Year.	Tons.	
1737	20,724	
1759	43,109	Mark
1769	73,329	
1779	95,020	
1790	137,617	
1800	177 082	Mark and Ibbenküren.
1810	360,000	
1817	410,359	

1820	528,448	Mark, Essen, and Ibbenküren.
1830	564,862	
1840	993,108	Mark, Essen, Ruhr,Ibbenküren, and Minden
1850	1,694,208	
1860	4,366,000	
1870	12,219,432	Ruhr, Ibbenküren, Minden, and Osnabruck
1871	12,715,248	
1872	14,430,965	
1873	16,219,914	
1874	15,539,567	
1875	16,983,139	

TABLE No. 4.—OUTPUT OF THE SAARBRÜCKEN COAL-FIELD.

Year.	Tons.	Year.	Tons.
1817	186,500	1862	2,137,741
1847	608,000	1863	2,252,557
1852	757,335	1864	2,660,748
1853	981,194	1865	2,946,652
1854	1,209,057	1866	3,065,450
1855	1,529,917	1867	3,238,800
1856	1.567,247	1868	3,338,400
1857	1,773,941	1869	3,444,895
1858	1,923,408	1870	2,734,319
1859	1,735.255	1871	3,263,058

1860	2,019,500	1872	4,222,234
1861	2,154,082		

TABLE No. 5.—LOWER SILESIAN COAL-FIELD.

Year.	Tons.	Year.	Tons.
1740	1,900	1861	777,463
1790	62,190	1862	898,281
1805	166,250	1863	969,132
1817	175,000	1864	1,070,746
1847	353,400	1865	1,208,090
1854	472,119	1866	1,125,246
1855	563,727	1867	1,254,574
1856	629,914	1868	1,445,135
1857	705,963	1869	1,411,140
1858	790,562	1870	1,570,227
1859	731,918	1871	1,970,037
1860	758,515	1872	2,119,590

TABLE No. 6.—UPPER SILESIAN COAL-FIELD.

Year.	True Coal.	Brown Coal.
1790	7,850	
1805	84,500	
1817	146,850	
1842	546.808	
1847	931,000	
1854	1,513,800	

1855	1,747,450	
1856	2,032,650	
1857	2,119,156	
1858	2,463,700	
1859	2,227,553	
1860	2,478,276	2,668
1861	2,537,938	1,268
1862	3,072,748	2,562
1863	3,458,920	2,465
1864	3,859,485	1,306
1865	4,304,669	1,875
1866	4,241,376	2,676
1867	4,631,938	2,498
1868	5,307,140	4,015
1869	5,555,333	2,769
1870	5,854,403	2,763
1871	6,552,202	3,084
1872	7,251,838	3,026
1873	7,839,315	

[29]

TABLE No. 7.—PLAUEN AND ZUICKAU (Saxony)

Year.	Tons.	Year.	Tons.
1850	652,374	1868	3,105,701
1860	1.784,031	1869	3,096,330
1865	2,923,059	1870	3,116,084
1866	2,659,294	1871	3,460,735

1867	2,871,551	1872	3,547,709

I.—THE GENERAL POSITION OF THE MINING INDUSTRY IN 1875.

The mining industry of Prussia during the year 1875, taking the production only into account, is not such a failure as was expected in the beginning of the year; and, when looked at from a commercial point of view, the result may be considered almost favourable. The ironworks, the foundries working for home consumption, and the puddling and rolling mills, with the exception of those making bars, which were almost completely stopped, were, throughout the whole year, sufficiently occupied; but the home trade was reduced to a minimum; and the exports, especially to North America and Austria, completely lost. Through this, many ironworks were obliged to reduce their prices, not wishing to lose orders and lie completely idle; and the prices, notwithstanding the reduction in the two previous years, fell still further, viz., pig iron 27 per cent., wrought iron 21.3 per cent., and rails 20 per cent., thus coming closely down to, and in some cases even receding below cost price. Towards the end of the year, as trade did not improve, some of the larger works were closed, others reduced their output, and others again, during the following year, followed their example.

The bad condition of the ironworks had a great influence on the price of fuel, because they could afford to work only on the condition that they could get fuel cheaper. Accordingly, the price for both iron and coal went down considerably. Coals fell, on the average, from 12 to 15 per cent. This reduction of price extended over nearly all the mining products, with the sole exception of zinc and lead ores, which even advanced a little. In consequence of this, notwithstanding the overproduction, the joint value of the mine and salt products was 18.56 per cent. less in the year 1875 than in the preceding year. This great production on the one side, and the extremely low prices on the other, give the results of the year 1875 a peculiar and characteristic stamp.

[30]

In order to get some chance of profit, there was a universal endeavour on the part of the coal-owners to increase quantities as much as possible, with a view to decreasing the cost of production, and to reduce the number of men employed in mining; and the produce rose 2.786 per cent, above the year 1874, and even surpassed the year 1873 by 505,811 tons. By far the largest portion of this increase was in the coal mines. The other important branches of the mining industries, however, all more or less shared in the advance, with the exception of the lignite or brown coal mines, which hitherto had not been disturbed by trade fluctuations.

It may be observed that a feeling of greater security has sprung up, and there is a firm conviction in the minds of all that the return of better conditions can only be brought about by increased activity, strict management, and saving administration; and in these directions much has been done already.

Endeavours have been successfully made nearly everywhere, to obtain a large reduction in wages, which amounted in the aggregate to 15 per cent. on the wages paid in the beginning of the year. This was effected little by little; and the pitmen were also persuaded to do more for a day's work. It fortunately happened that food became a little cheaper, and this compensated the men, in a great measure, for the lessened wages, and their comfort was but little interfered with. Coal-owners also made earnest endeavours to remove many of the difficulties that interfered with the transport of their produce. They succeeded, especially, in reducing the railway tariffs, so as to be able to compete with other countries. By these means the Westphalian coal has succeeded in enlarging its market in France and Belgium; and, after the encouraging results of their former attempts, there is a possible chance that it will be able partially to replace the English coal in the ports of the North Sea and elsewhere; but this result can only be reached by still further reducing the price at the pit's mouth.

That the financial income of 1875 is far behind that of 1872-1873 is not to be disputed; but those periods of unwholesome speculation can give no proper datum for deciding as to the fair success of the trade as regards profit. To get at this, one would have to look back to the year 1869, which, upon industrial grounds, showed a normal and satisfactory development. A comparison with this year is not so unsatisfactory as one would think, especially in those works conducted by the Government.

[31]

II.—THE COLLIERIES.

The increase in the production has been mostly in coal, for while the total increase of all minerals was 1,223,142 tons above the foregoing year, the coal mines alone produced a surplus of 1,459,887 tons, or 4.63 per cent. upon the foregoing year. At the same time, the coals on hand have not increased, but even coals which have been stored from previous years, have been partially got rid of; as for example, in the Silesian District, where the production amounted to 10,298,143 tons, and the sales effected were 10,456,208 tons.

Many circumstances would have to unite to produce, in such a crisis, such an unexpectedly successful result as regards the coal mines.

The long and severe winter had considerable influence upon the consumption of coal, in raising the house-coal consumption; and in compelling many factories to resort to steam power, which, in milder weather, were usually driven by water, so that the efforts made by the coal-owners to extend their sale and raise their exports were successful. Again, the water being exceptionally high in the rivers, especially in the Saar, Ruhr, and the Rhein, the freight of ships to Holland, France, and Belgium, became considerably reduced. Added to this, the railway companies took off the advance of 20 per cent. on their rates put on in 1874, so that the inland coal-owners found it possible, even in such distant places as the shores of the North Sea, to compete with the English coal.

The west coal-fields, especially those of the Ruhr and Saarbrück districts, had a greater export than usual, owing to large cessations of work in the Belgian collieries, which prevented them from being able to satisfy the demands of their own country, especially for gas-coal and coke, and it was found necessary to import German coal In the same way, the exports to France, from the Government mines in Saarbrück, rose considerably, so that the total quantity of sales from these Government collieries, were, with the exception of the coal used in coke manufacture, as follows:—

[32]

	1875.	1874.	1873.	1872.	1869.

	per cent.	per cent.	per cent.	per cent.	per cent.
Home Consumption	30.3	29.3	30.3	30.6	28.3
To South Germany	25.6	27.8	24.8	25.4)	21.7
„ Luxemburg	0.8	0.8	0.7	0.5)	
„ Elsass and Lorraine	23.8	24.3	27.6	28.7)	45.8
„ France	14.1	12.0	11.6	9.9)	
„ Switzerland	5.3	5.7	4.7	4.4)	4.2
„ Austria and Italy	0.1	0.1	0.2	0.5)	
	100.0	100.0	100.0	100.0	100.0

At the same time, the production of coals in the Dortmund district rose 1,423,367 tons, or 9.2 per cent., and in the Bonn district 221,005 tons, or 4.2 per cent.; on the other hand, in the remaining districts where the conditions for export were not so favourable, the production fell off considerably. In the Breslau district, where, in the year 1874, there was an advance of 5.5 per cent., the production went back 1.6 per cent, in 1875; also, in Upper Silesia, there was a decrease in the production of 0.15; and in Lower Silesia, 6.8 per cent. The cause of this was principally in the prostration of the industry of Austria, and the effort made by that country to increase the output of its own collieries, by still keeping in force the import duty on coals in Poland, by which the exports from Germany to these countries were completely stopped. All efforts, also, to get a more extended market for the Silesian coal in the East Sea Provinces were rendered unavailable by the high transport dues, and, in Stettin alone, was there any trace of former activity.

The coal produce of the Breslau coal-field was distributed as follows, in 1875:—

8,183,568 tons were used in home consumption.

1,121,651 tons went to Austria.

172,049 tons went to Russia.

The sale of such a large increased production of coal was only possible by a reduction of price to the extent of 10 to 12 per cent., so that the

prices, after going down in 1874, were still further reduced at the end of 1875, and, at last, reached the standard of 1871. The average selling price per ton was as follows in 1875:-

s.	d.	s.	d.

Breslau District		6	7	against	8	1¾	in 1874.
Bonn „	1	0	8¾	„	14	4½	
Dortmund „		7	4½	„	11	2	„
Halle „		11	10¾	„	12	4½	
Clausthal „		11	1¾	„	12	11¾	
Saarbruck Gov. Collieries		11	3¾	„	13	5½	„

Much more attention has been paid to the careful working and separation of the coals to enable them to travel greater distances and secure a wider area of sale. This has, however, had the evil effect of heaping the collieries up with small coals, which are difficult to dispose of, especially as the tile and fire-brick works, which consumed a large amount, were standing idle by the stoppage of building operations. In order to get rid of the small at some price, however low, a briquette manufactory (on a French principle) was started at a colliery in the district of Aix-la-Chapelle, whilst in Westphalia an effort was made to consume the small by making more coke. With 1,971 ovens in 1875, 577,264 tons of coke were made from 874,580 tons of coal in Westphalia, giving 66 per cent. of coke made from the coal. In the year 1874, 327,401 tons of coke were made, so that in 1875, 249,863 tons, or 76.4 per cent. more was produced.

Considering this large production, it is not to be wondered at that the price of coke receded more than that of coal; indeed the price of coke fell in Westphalia to 10s. 2d. and 12s. 2d. a ton, and in the Saarbrück District to 15s. 0½ d. per ton. In the Government Mines the manufacture of coke was much restricted. The remaining districts, owing to the small consumption of coke in the iron trade, were not quite able to keep up to their former output.

The number of working coal collieries has been reduced by twenty-seven during the year, through the laying in of several small collieries, but many new shafts which were being sunk in former years have commenced work. In the Dortmund District alone, eighteen large collieries are nearly finished, so that in future a still higher production may be looked forward to; but unfortunately this does not necessarily imply that a rise in price may be expected.

It is worthy of notice that the increase in production of coal during the year 1875 has been attained by the employment of 1,800 fewer men.

[34]

This arises partly from more careful management, on the increase of large pits in Westphalia (raising more than 50,000 tons per annum), and by the increased performance of the men.

The reason there has been such a marked decrease in the lignite and brown coal trades is that the cheapness of coal proper has more or less driven them out of the market. The high prices in 1874 increased the production of lignite and brown coal 9.12 per cent.; the production in 1875 fell

371,121 tons, representing a value of £95,121 5s., and amounting to 4.3 per cent. in quantity and 6.4 per cent. in value. The quantity of lignite produced during the year 1875 was 8,223,495 tons, with a value of £1,478,271 1s., against 8,594,616 tons, and a value of £1,573,392 6s., in 1874. The number of men working in the lignite mines in 1875, was less by 107 than in 1874. Of the total quantity produced, the district of Halle alone produced 90.2 per cent., and 88.6 per cent. of the value. By far the largest falling off in the production was in the Province of Saxony, where alone it reached 361,961 tons, or 5.7 per cent. less than 1874. This great falling off was not entirely due to competition, but to the fact that large quantities of superior Bohemian lignite were imported owing to the state of the Elbe affording during the year increased facilities for transit, and owing to the quantities of this superior fuel being disposable for export on account of the home consumption falling off through the failure of the beet-root harvest, the falling off in the brick, woollen cloth, and chemical trades, and the introduction of American oil on a large scale, which has almost completely destroyed the manufacture of shale oils which at one time was so flourishing.

In the other districts the fall in the production is less observed. In the Province of Brandenburg the production rose from 1,468,586 tons in 1874 to 1,489,054 tons in 1875, or an increase of 1.39 per cent. In the Provinces of Breslau, Posen, and Bromberg, the production of lignite even increased.

In the district of Bonn there was a fall of 10,582 tons in the production, but the Westerwald colliery was enabled to increase its quantities without lowering its prices. Altogether, the falling in value of lignite was not so great proportionally as the fall in other descriptions of coal, the price per ton being upon the average 3s. 7¼ d. in 1875 against 3s. 8d. in 1874, and 3s. 6½ d. in 1873. In the district of Halle it fell from 3s. 7½ d. in 1874 to 3s. 6½ d. Against that, however, it rose in the Breslau district from 3s. 8d. to 3s. 10d.

This satisfactory result has been principally obtained by the manufacture

of lignite into coal bricks, and the extent of this trade is rapidly increasing. These bricks are principally used in the Halle District; also in some of the collieries on the Rhein, and in Silesia. In the Halle District, twelve wet-coal presses and two dried-coal presses were being erected during 1875. Altogether, there are sixty-two wet-coal presses and twenty-two dried-coal presses at work, which have already manufactured 486,815 tons of bricks.

The demand for dry-coal bricks was so great that it could not be satisfied, although the production had risen so enormously, which proves that the public are gradually taking to this fuel. There is, therefore, no doubt that this branch of industry can look forward to still greater success, and will soon be able to check the great consumption of Bohemian lignite in Saxony.

The total output of mineral fuel in Prussia, during the year 1875, was, on the whole, equal to 41,174,924 tons. The production was 1,088,766 tons in excess of the preceding year, being 91.99 per cent. of the quantity, and 81.33 per cent. of the total mining produce. The proportion between coals and lignite respectively, being in 1875, 80.03 per cent., and 19.97 per cent. against 78.56 per cent., and 21.44 per cent. in 1874.

The iron-ore production has risen this year 52,787 tons, being an increase of 2.1 per cent, upon 1874. This is explained by the small stock in hand at the commencement of the year, which compelled many ironworks to purchase, also because some of the larger iron mines were compelled to keep working, in order to secure the safety of the mines, and keep their men together. The sale was far from satisfactory, the prices were still further reduced from 5 to 6 per cent., and the value of the production fell, by £31,207 2s. lower than in 1874. Even at these low prices, it was often very difficult to get rid of the ore, so that large masses remained on stock at the end of the year.

Under such circumstances a great many of the smaller mines found it impossible to work any longer, and, in consequence, the number of the working iron-mines was reduced by 193, and the number of men reduced by 1,628. In the district of Bonn alone, there were 151 mines less at work than in 1874.

The iron-mines in the left Rhein provinces suffered the most, because of their unfavourable position as to transport, and the competition of cheaper ores from Luxemburg and Lorraine. For these reasons, the new mines which had sprung up in the county of Stolberg were laid entirely idle. Only in such districts a better quality was produced, and where the cost of transport formed but a small item in the cost as in the mines and

[36]

on the rivers Lahn and Sieg, and in the neighbourhood of Kams Dorf in Thuringen was it possible to maintain a regular sale. These favourable circumstances applied also to the mines in Silesia, where 532,025 tons, with a value of £127,288 13s. were won; while, in 1874, the production was only 450,763 tons, with a value of £104,215 10s.

III.—A COMPLETE SUMMARY OF THE MINING PRODUCTIONS AND MONEY VALUE OF THE SAME, WITH THE NUMBER OF WORKS AND MEN:

The total production, including the coal and lignite in Prussia, was:— In 1875, 43,733,024 tons, with a value of £15,172,939 13s.; in 1874, 42,591,471 tons, with a value of £19,439,866 1s. This shows that the quantity has risen, and the value has fallen, the former by 1,141,553 tons, or 2.7 per cent., and the latter by £4,266,926 8s., or 18.8 per cent.

The production rose principally in the Bonn and Dortmund Mines; the value has fallen in all the districts, principally in Dortmund, Clausthal, and Halle. This was the inevitable result of the retrograde movement in prices, which in 1872 and 1873 rose to an unprecedented height; the prices, however, were much higher than in the year 1869. The average sale price was 1s. a cwt.

The total number of mines at work were as follows:—

	1875.	1874.
Coal	475	501
Lignite	537	549
Iron-mines	928	1,121

Metalliferous	312	326
Other mines and quarries	738	750
Total	2,990	3,247

According to this there were 257 mines less at work in 1875 than in 1874. The total number of men employed in the above mines in 1875 was 237,026 against 239,884 in 1874, or a decrease of 1.19 per cent.

IV.—THE GOVERNMENT COAL, LIGNITE, AND IRON-MINES.

The circumstances attending the working of the government mines were altogether analogous to those of private companies, the trade of which suffered in no way by any appreciable interruption. This, however, does not apply to the Government iron-works, which were brought to a standstill by the severe competition that they had to sustain.

The total production of the iron-works was, however, more than was ever reached in any preceding year, and the economic results of the trade

[37]

were thoroughly satisfactory. Every effort was made to reduce the cost so as to face the steady reduction in prices, and, by this means, the whole of the large and extensive new works were enabled to work with much more favourable results than could have been expected.

The number of Government collieries, iron-mines, and iron-works are as follows:—

	1875.	1874.		1875.	1874.
A.—Mines,					
	55	56	Coal-mines	17	17
			Lignite „	10	10
			Iron „	18	19
			Lead, silver and copper mines	5	6
			Other metalliferous mines	5	4
B.—Ironworks	7	7.			

The number of men employed upon the Government works rose, in 1875, from 42,020 to 44,409. The following results will show the increase upon the different works:—

	1875.	1874.
Upon coal and metalliferous mines	39,764 or 89.53%	37,602 or 89.49%
iron and metalliferous mines	3,048 or 6.86%	2,821 or 6.71%
„ other works	1,597 or 3.61%	1,597 or 3.80%
Total	44,409 or 100%	42,020 or 100%

V.—RESEARCHES.

1.—The Geological Survey.

The geological researches carried on by the State have been very actively pursued, especially in the Harz and Thüringen, the Province Hessen-Nassau, the Rhein Provinces, in Schleswig-Holstein, and the environs of Berlin and Stendal. Several valuable works have been published.

2.—Government Boreholes.

It will, perhaps, not be uninteresting to state the position and nature of these boreholes.

a.—The boring by Bischofswerder, in West Prussia, was sunk during the year to a depth of 109⅓ fathoms. Having reached the upper measures of the chalk series, the boring was stopped because it was not thought probable that any minerals could be found below this, but the experiment was so far successful, inasmuch as it fixed the age of the older mountain ranges.

b.—The borehole put down by Sudenburg, near Magdeburg, together with the one commenced in 1874, and which seemed to have reached the

Kulm shale measures, were discontinued in the beginning of 1875, after having attained a depth of 811 fathoms.

c.—After the borehole, which had been put down for finding the coal measures in Niederlausitz, near Dobrilugk, had been given up in 1874, a second one was started eighteen miles north, near Dahme, in April, 1875. The borehole, which was driven by means of water rushing, was carried to a depth of 79 fathoms, through diluvial and tertiary measures. At the depth of 76 fathoms, it reached a lignite seam of 16½ feet in thickness. During the year 1876, the borehole passed through the tertiary and entered the new red sandstone formation.

d.—In September, 1875, the old borehole, No. 1, in Durrenberg, which was bored during the years 1839 to 1849, and which had been stopped in the coal formation at a depth of 288 fathoms, was opened out again, to prove if any workable coal measures existed. The results are not yet known.

e.—The borehole which had been put down to examine the Jurassic formation at Cammin, in Pomerania, was continued in 1875, from a depth of 7 fathoms to 139 fathoms. The strata, through which it passed, consisted of loose sand and clay and some small seams of Jurassic coal (oolitic.) After that, the strata consisted of dark clayey slates, which, according to the fossils found therein, were looked upon as belonging to the lias formation.

f.—The borehole which had been put down to explore the mountain system on the lower Elbe, near Lieth, was bored 161 fathoms deeper during 1875, and reached a total depth of 557 fathoms at the end of the year, without getting any further than the previous mountain formation, which consisted of red slatey clay and rock salt.

3.—Other winnings or sinkings and borings.

Owing to the depressed trade of the mining industry in 1875, few private Companies were willing to bear the expenses of sinking or boring, but rather limited themselves to finishing those operations already commenced. In Dortmund, however, many important coal districts were examined. A borehole of 262 fathoms was put down to the coal-measures near Dinslaken, but the boreholes in Gelsenkirchen were stopped without having obtained any satisfactory results; the coal formation in their neighbourhood was, however, opened out by means of seven shafts. Near Buer and Gladbeck the same seams have been found in some new winnings (which had been hitherto totally unknown) which exist in the collieries "Nordstern," "Wilhelmine," "Victoria," and "Consolidation,"

[39]

and it is hoped that in this northern part of the coal-field the same valuable seams will also be found which have been so successfully worked by the above-mentioned collieries.

The largest number of new winnings were made in the Recklinghausen district. In the west part of this district, near Haltern, many seams were found at a depth of 317½ and 341½ fathoms; also, a mile west of Marl, seams were found at a depth of 293 fathoms, and, near Bockholt, at a depth of 271 and 273 fathoms. Near the village of Polsum the first seam was reached at a depth of 302 fathoms, and near the village of Hochlar (by means of two boreholes) two seams were found at a depth of 228 and 231¼ fathoms, of which one is workable. Further searches were made north of Buer, at a depth of 237¼ fathoms, and in the neighbourhood of the town of Recklinghausen, at a depth of 293 fathoms.

In the easterly portion of this district, two boreholes, near the "Prince Friedrich Carl" colliery, reached the first coal seam at a depth respectively of 212½ and 291 fathoms; another borehole, near the Löhringhof farm, reached coal at a depth of 329 fathoms. The "Moltke" Company proved, by means of two boreholes near the village Levringhausen, the position of seams at a depth of 205 and 241½ fathoms; while the "Vereinigung" Company, north of the village Oer, found coal at a depth of

317½ fathoms. Still further to the east, at Lüdinghausen, near Alstäde, a search has been made by the "Kobold" Boring Company to the depth of 319 fathoms.

It has been found, through a number of boreholes, stretching from Werl in a northerly direction, that the chalk marl gets thicker towards the east than towards the north, and that, while at the "Carl I." colliery, near Hilbeck, the coal is found at a depth of only 60 fathoms; near Aahlen and Ostönnen, the coal lies at a depth of 191 to 246 fathoms. Near Hamm a borehole has been put down more than 327½ fathoms, and still has not got through the marl. The boreholes in the neighbourhood of Rheda have been stopped without any results at a less depth. Whilst boring in the neighbourhood of Höxter, iron pyrites has been found, and it seems to lie in still larger quantities and under a greater surface, between Maria Munster and Bergheim, below the black coloured strata of the Keuper formation of the triassic system.

No new brine or rock salt researches of any interest have been made during the year 1875. Two borings, which were begun near Tröchtelborn in Halle, in 1874, reach a depth of 106 and 96 fathoms, but there was no trace of brine. A third newly-commenced borehole stood at the end of the year at a depth of 46 fathoms.

[40]

The Government has searched for brine with success near Oeynhausen, the boring got down to a depth of 322 fathoms, where the brine spring flowed at 9 cubic feet a minute, and the temperature of the brine reached 89°, with strong evolutions of carbonic acid. At the latter end of 1876 this spring had reached a depth of 335 fathoms, yielding 28 cubic feet a minute of brine, at a temperature of 93° F.

VI— GOVERNMENT GRANTS.

The demand for colliery property, which, in the years 1872 and 1873, was very great, diminished in 1874, as the prospects of the industry became unfavourable, and decreased to a greater extent in 1875.

Including the demands for surface land, there were only 1,923 requisitions sent in, which were 1,411 less than in the year 1874. In the years 1873 and 1872 the number of requisitions was 7,555 and 7,111 respectively.

The number of leases for the working and carrying on of mining came to 1,144 against 2,025 in the year 1874, and were thus divided:—

	1875.	1874.
New leases	1,007	1,844
Surface requirements, leases and declarations	81	129
Consolidations	54	48
Separation of surface ground	2	4

Total	1,144	2,025

Also, thirteen new coal mines were entered at the chief mining office in Halle, and two at the chief mining office in Breslau.

In 1874, there were four mining properties relinquished, while in 1875 only one was given up. The number of mines at the end of 1875 was as follows:—

	1875.	1874.
Leased mines, including government and reserved mines	26,270	25,739
Not leased mines	1,989	1,948

Of the leased mines, the number working in 1875 was 1,824 or 6.94 per cent.; in 1874, 2,323, or 9.02 per cent. Of those not leased the number of working mines was in 1875, 853, or 42.88 per cent., and in 1874, 862, or 44.25 per cent.

The total of all existing mines was:—

	Working.	Idle.
At the end of 1875	9.46 per cent.	90.54 per cent.
1874	9.63 „	90.37
1873	11.68 „	88.32
1872	11.84 „	88.16

[41]

VII.—MINE TAXES.

As a natural consequence, the reduction in value of nearly all mining products, and the especial diminution in the value of coal, caused a corresponding reduction in the revenue. The number of taxed mines was 1,132, or 24 less than in 1874, and the total tax from these collieries reached a sum of £205,732 13s., which was £67,283 15s., or 24.64 per cent. less than the amount levied in 1874. In 1874, the amount was £273,015 18s.

These taxes are levied as follows:—

£163,565 14s.	Upon the coal mines	=	79.51 per cent.
13,940 11s	„ lignite „	=	6.78 „

27,561 14s	„ iron „	=	13.39
664 14s	„ other „	=	0.32
£205,732 13s.			100.00

VIII.—MINING COLLEGES AND MINING SCHOOLS IN PRUSSIA.

Of the two Government Mining Colleges, the one in Berlin during the Summer Session of 1875 had eighty-two students, and during the Winter Session of 1875-1876 ninety-three students. During the same Sessions, in 1874, the number of students was respectively sixty and ninety-three, showing a marked increase during the summer of 1875.

The other mining college, which is situated at Clausthal, had, during the Winter Session of 1875-1876, sixty-three students, or twenty-one more during the same Session of 1874. Under this number there were thirty-five foreigners.

The mining school attached to the College was attended by a greater number of students in 1875 than in the preceding year, while the two preparatory schools to this establishment were discontinued.

The number of schools and elementary schools with the number of students is as follows:—

Government Colleges.

	1875.	1874
1st. Berlin	87	76
2nd. Clausthal	63	42

Mining Schools.

1st. Clausthal Government School	25	—
Elementary School at Clausthal	—	16
Do. at Oberkirchen	—	10
Government School at Saarbrücken	11	—

Elementary Schools in the Bonn District.

1. Neunkirchen 2. Dudweiler	74	—

3. Altenkessel

Mining School at Siegener	43	—
Do. at Dillenburg	22	—
Do. at Bardenberg	24	—
The four Elementary Schools belonging to the latter three Mining Schools	43	—

Elementary and other Mining Schools.

Elementary and Mining School at Wetzler	16	—

These Schools have had Doctors instructing the Pupils as to what they have to do to save life and restore animation after serious accidents.

The two Westphalian Mining Schools	116	—
The Surveyors' School was closed.		
The ten Elementary Schools belonging to the above Mining Schools had	273	—
Mining School at Essen had	31	40
Do. at Halle	31	—
At the three Elementary Schools for Do.—		
At Eisleben	11	—
At Wettin	12	—
At Frankfurt	5	—
Lower Silesia Mining School at Waldenburg had	19	—
The four Elementary Schools	56	—
Upper Silesia Mining School at Tarnowitz	45	—

Giving a total number of 150 students for the year 1875, at the Government Colleges, while the total number of the students attending the Principal and Elementary Mining Schools, which educate the students for positions as colliery officials of minor rank, is 857 for the year 1875.

IX.—MINING LAWS AND MINING POLICE.

There have been no new laws in 1875, modifying existing arrangements with reference to the working of former changes relating to mining matters. The alteration of paragraph 235 of the General Mining Law determined by the law of the 9th April, 1873, has been attended with such very satisfactory results that, during the last year, a number of old mining societies have decided to accept the new law relative to their constitution.

This was particularly the case in several instances in the inspectorships of Dortmund and Halle, in which latter place the Mansfield Mine has adopted the improvement.

[43]

The number of processes begun against the masters, under the law of 1871, determining the liability of masters for accidents, were very few, the masters being always willing, in doubtful cases, to settle amicably with the men.

To ensure their workmen against the consequences of any accident, such as their law would recognise as involving the masters in responsibility, two insurance societies have been formed in the chief districts by the masters:—1. The Heller Society for general liability in case of accidents; 2. The Rechts-rheinische Colliery and Ironworks Society for the same purpose. Both societies do not alone compensate the men for accidents which come under the law, but also for other accidents for which they could not by law obtain compensation, so that they help the men's societies as well as those of the masters.

The order for the dissolution of the Mining Mortgages Committee has been definitely carried out during this year, and the mortgage books have been given up to the land registration offices.

The desire manifested in mining circles for an official Mining Companies' Register, has apparently received a satisfactory solution, through the execution of a ministerial decree, so that those interested can now ascertain the legal position of the representatives, directors, and partners of mining societies at the offices of the several mining districts.

The mining inspectors have had occasion to seek for the enactment of new laws for the protection of the workmen, in consequence of the number of accidents which have happened from the use of new preparations of Nitro-glycerine.

X.—TRANSPORT.

Very few new railways have been opened in mining districts, but the old railways have continued to extend their lines, and, by branch railways, to connect new collieries with the main lines.

In the mining district of Bonn, a new railway was opened on the 1st February, 1875, from Limburg, on the Lahn, to Niderselters, but it has not yet been of much use. Another was opened in October, 1875, called the Kalscheuren-Euskirchen Railway, which runs through the lignite district of Brühl-unkel.

The so-called Aix-la-Chapelle Industrial Railway has been pushed forward to such an extent, that it was already opened in the autumn of 1875. The aim of this railway is to connect the coal mines "Maria," near Höngen, "Gemeinshaft," "Gouley," "Teut," and "Königsgrube," near Morsbach, and "Grevenberg," in the district of Aix-la-Chapelle, with

the town of Aix-la-Chapelle and the "Rotherde" iron works. Unfortunately, this useful railway, owing to the depressed state of trade, has not been able to perform the work for which it was intended. The Rheme-Diemelthal Colliery line, which was opened in 1874, was extended in 1875 to the Martenberg iron-mine, in the Principality of Waldeck, and finished.

The building of the railways in the Dortmund district did not make so much progress as in the previous years; nevertheless, the work done on the part of the Cologne Mindener Railway Company was considerable. The Emscherthal Railway was finished, except the sidings to one mine. The Bergish-Märkischen Railway Company opened the branch from Bochum to Herne, which will be continued to Recklinghausen. The Rheinish Railway Company finished the railway from Wattenscheid Dortmund to Hörde, and the whole railway was opened to the trade by way of the Kray-Wanne line, and the connection of that line with the Wanne-Homburger line of the Cologne Mindener Railway was completed. The Dortmund Enscheder Railway started in August, 1875, in full operation along the whole line. The Westphalian Railway Company finished their line from Welver to Dortmund, which will be formally opened in 1876. The work of laying out the continuation of this branch line from Dortmund to Oberhausen has just been finished.

In the District of Clausthal, the railways Vinenburg-Hameln and Grauhof-Lautenthal were opened for traffic, but they will be of no great use to the collieries and iron-works until the branch of the Upper Harz Lautenthal-Clausthal has been finished.

In the mining district of Halle, the railways which have been lately opened out in 1875, and which are of importance to the lignite trade in the province of Saxony and Brandenburg, are the following:—Berlin-Dresden and Elsterwerda—Riesa, the lines Falkenberg-Wittenberg, Ruhland, Lauchhammer, and Wolfsgefärth-Plauen.

The number of colliery branch lines has been increased by two in these districts during the year 1875, and eight more are in progress. The lignite transport per railway, has therefore increased in 1875, and reached 2,001,580 tons.

In the mining district of Breslau, the railways from Oels to Guesen and Creutzburg to Posen, have been opened, without having shown any influence upon the sale of the mine production. The lines which are being laid out from Freiburg, over Sorge to Friedland, to connect the Braunauer and the Upper Silesian Railways, with the railway from Neisse over Ziegenhals, and the Mährisch-Silesian Central Railway, will greatly facilitate the sale of the Upper Silesian coal in Böhmen and Mähren.

The railway companies in Westphalia have helped the coal-owners in sending large quantities of the Ruhr coal to France, Belgium, and to oversea countries, by reducing the tariffs, and otherwise easing the transport. The railway freight in coals in the Dortmund district was very heavy in the greater part of 1875. The number of wagons which the three principal railway companies daily had on hand for the collieries during the last month was over 10,000.

The total quantity of railway freighted coal in Westphalia came to 13,108,438 tons from the private mining companies, against 12,018,737 tons in 1874, making an advance of over nine per cent.

The total sale of these mines was divided over the different modes of transport as follows:—

	1875. per cent.	1874. per cent.	1873. per cent.
By railway	85.0	86.3	83.6
Shipping on the Ruhr	0.5	0.7	1.7
Landsale	8.45	9.1	9.4
Sent to their coke-ovens	6.05	3.9	5.3

The transport of coals upon the Rhein has risen greatly in consequence of the river freights in 1875 being favourable. The total quantity of coal shipped in the Rhein from the Ruhr basin reached the height of 1,991,955 tons, which is not alone higher than the quantity shipped in 1874, which was about 1½ million tons, but has exceeded the quantity in 1872, until then the highest known, which came to 1,785,313. Thereby, the transit of coal by water to Coblenz and higher up the Rhein was doubled towards the close of 1875. The sale to Holland rose from 803,590 tons to 1,064,880 tons, and to Belgium from 19,720 tons to 73,950 tons.

The canal, which is to be made from the Saar to Louisenthal to Saarlouis, for the sale of the Saarbrück coal, has already been begun, the permission of an Act of Parliament having been obtained in February, 1874.

XI.—THE CONDITION OF THE MEN EMPLOYED.

1.—The general condition of the men employed was such that no complaints were made on their behalf. The average number of men coming under the Mining Inspectors' control has been diminished by 2,715, owing partly to want of trade, and partly to the large number of men which the iron-mines have thrown out of work. The men discharged were mostly men of other trades who had joined the mining trade during the good times, and who have now returned to their former occupations. This is of some importance to the collieries, as the work done by these men was altogether unsatisfactory. Real and able miners easily found work, owing to the increased production. In places such as Westerwald, at Habichtswalde, in Oberharze, and in the districts Hamm, Müsen, and Commern, the demand for men in general was greater than the supply. Large masses of men have therefore not been laid idle, neither has there been any distress amongst the men.

2.—The number of men employed about the mines and rock salt works, including the number under the inspectors, amounted during the year to 239,026, of which 75.0 per cent. were employed underground and 25 per cent. above-ground. The number of persons (including children) dependent upon the workmen for their livelihood amounted to 485,355, which, upon an average, amounts to 1.82 persons per man.

Young persons under 16 years (male and female) are included in the above: their number amounted to 7,204, or 3.01 per cent. of the total against 8,636 and 3.60 per cent. in 1874. The number of females employed amongst the above-ground working men was 4,832, or 2.02 per cent. upon the total number of men both above and below ground.

In 1875, 44,409 persons were employed on the Government mines, among which were 1,170 youths and 237 females, which gives 2.63 per cent. and 0.53 per cent. respectively of the total number of persons employed. In 1874 the youths employed on these mines amounted to 1,267 and the females to 276; this shows a decrease of 79 youths and 39 females, while the total number of persons employed increased by 2,389, or 5.92 per cent.

In the face of the large reduction in price, which rendered it necessary to reduce the cost of working, the workmen's wages could not be kept at the same height which they had reached in previous years. Already, in 1875, they had been reduced (excepting in the lead and zinc mines in some of the Rhein provinces), but as this was brought about slowly, it did not disturb the position of the men in the least. On the whole, the wages fell 10 to 20 per cent. principally upon piece-work, which the men recovered by working more quantity, while day-work wages were little disturbed.

The men employed in the iron-mines suffered the most, for in these works the reduction in prices was chiefly felt. The hewers in the principal iron-mines in the district of Bonn got on an average from 2s. 6d. to 3s. 1d. a day.

In the coal-mines at Saarbrücken the wage per shift of bargain men was, on an average, 3s. 5d., or 7.86 per cent. lower than in 1874; for shaft and other work, the wage was 2s. 10½ d., 3.35 per cent. lower. The

real yearly income of a workman of both the named classes was £44 4s., or £8 19s. 0d. (8.20 per cent.) lower than in the year 1874. In the district of Aix-la-Chapelle, where the wages of the coal-miners went up in 1874 by 7 per cent., they went down during the year 1875 from 10 to 13 per cent.

In the Dortmund district the average wage of the coal-miners, in the northern part, was 3s. to 4s.; in the southern part, 2s. to 3s.

In the iron-mines in Oberharz the miners had the same wages as before. In the lignite mines the reduction in wages was not great. In many of the districts, as Magdeburg, East Halle, Zeitz, and Fürstenwalde, the wages have never risen since 1874, and in the Guben district the wages have not been reduced, but are constantly rising a little.

In the mining district of Breslau, especially in Upper Silesia, the wages of the coal-miners have been reduced. The hewing prices per shift, on an average, in Upper Silesia, were 2s. 4½ d., compared with 2s. 7½ d. in 1874. The Government miners enjoyed the highest average, 2s. 9¾ d., and the lowest, 1s. 5½ d., was in the Ratibor district. In Lower Silesia the total average was 2s. 6¾ d., against 2s. 11¾ d. in 1874.

In the iron-mines in Silesia the hewers received, on an average, 1s. 10d. per shift; and in the lignite mines 1s. 10¾ d., against 1s. 11¼ d. and 2s. 0½ d. respectively in 1874.

If, as has been stated, the wages in 1875 have been practically but little reduced, in spite of the lessened wage, it must be because each man produced more, and there seems to be no doubt, from the Government reports, that this is the case, and that the men strive under the depressed state of trade to keep themselves in the same position as before by working harder.

It is very difficult, however, to show in figures the increased work done. It is impossible to give a correct statement by giving the number of tons worked per man per year. To get the work done by the men by the output, one would have to take into account the number of men directly connected in the output at each colliery, and also, at the same time, the changes and different circumstances attending the different methods of working; the mineralogy and geology of the different seams; the alterations in the working places; the putting; the ventilation; the delays through water and gas; and the age and condition of the men themselves. Many more circumstances would have to be taken into account, the influences of which would be small in single mines, but which should not be overlooked in the average. However, those who know something of practical mining will appreciate these remarks, and

will take the figures below, stating the quantity per man worked per year, at their true value.

The quantity worked per man, including all the men working, per year for the last four years, in coal, lignite, and iron mining, in tons per man per annum:—

	Altogether.				Government mines.			
	1875.	1874	1873.	1872.	1875.	1874.	1873.	1872.
Coalmines	206	194	204	207	209	205	215	217
Lignite mines	443	461	436	421	427	428	404	394

Iron mines	118	105	112	112		115	111	137	134

The reason why, in the lignite mines, the quantity per man has fallen off, is that there was no sale for their production, and that the men were employed in alterations and repairs.

In the coal-mines of Dortmund the average work done per man employed at the end of the year 1875 was 199¾ tons, against 184¼ tons in the year 1874, or an increase of 9.2 per cent.

In the district of Breslau the following table will show the work per man employed in the coal collieries in tons per man per annum:—

	Upper Silesia.	Lower Silesia.	In the whole District.
1875.	252.761	191.037	236.689
1874.	244.514	183.889	228.554
More in 1875 by	8.247	7.148	8.185

If only the men working underground be taken into account, then, in 1875, the tons worked per man per year would be:—In Upper Silesia, 314.8 tons; in Lower Silesia, 233.2 tons; and in the two districts together, 293.3 tons. In the Government coal-mines, "Königsgrube" and "Königin Louisengrube," the numbers are 329.9 tons and 368.7 tons respectively.

The quantity per man employed in the three largest Government mines is as follows:—

	1875.	1874.	1873.	1872.	1869.
A Saarbrück mine	200	194	205	209	188
Königs Colliery, in Upper Silesia	282	292	310	317	268
Königin Louisen Colliery do.	301	271	265	261	268

[49]

The reason that the work of the men has not been so great in the Königs Colliery as in the foregoing years was that the seam which they work became very bad through meeting with some strong faults or dykes.

Altogether, it will be seen from these figures that the work of the men in 1875 has been greater than in the preceding years.

XII.—THE ECONOMICAL AND MORAL SITUATION OF THE MEN; REGULATIONS AS TO THEIR WELFARE.

In consequence of the favourable harvest, the prices of provisions receded, and the welfare of the men connected with the mines in Prussia was, notwithstanding the reduction of wages, very satisfactory during 1875, and the men have nowhere shown signs of discontent or any inclination to strike. The moral conduct of the men has taken a decided turn for the better, for, as work became scarce, the men became more diligent, orderly, and saving, and very few complaints have been heard of extravagance and violence. There also seemed to be a better desire among the men to educate and better themselves than in the previous years.

It is not alone the financial position of the men that has produced this satisfactory result, but the coal-owners, during the last year, have striven to improve the position of their men not alone materially but morally. Also, the pamphlet which was issued by the home department of the Government, explaining the contrivances and arrangements by which the welfare of the men might be improved (of which a second edition has appeared), has done a great deal in that direction.

At the Government mines in Saarbrücken, sums of £75 for building purposes were advanced to 266 miners, amounting to £19,950; added to this, premiums amounting to £12,971, in sums of from £37 to £45, were given to 292 men.

The miners of the colliery "New Essen," in Westphalia, have formed amongst themselves small clubs of six to twelve persons each, consisting, principally, of masons and joiners, for building their own houses, helping each other after work hours. The materials for the same are sold to the men by the colliery at cost price, and are paid for in monthly instalments.

The cost of these houses, for one family, came to from £270 to £300 each. At the end of autumn, in 1875, twenty such houses were built and ready for the men.

Co-operative Societies and other arrangements for the welfare of the men, have done much good, by enabling them to get provisions at cheap rates.

The schools and classes which had been formed especially for young

men (the benefit of which the men had gradually come to appreciate), were attended by larger numbers than in any of the previous years. In the district of Saarbrücken, there were twelve workmen's schools, with 853 scholars. Also a workmen's club which possessed several industrial schools, for teaching the miner's daughters to sew, etc.; two of these the Government undertook to keep, and nine remain in the hands of the club.

Working men's clubs and institutions have done much good to the men employed in the mining and iron industries, but although some of the larger and more influential of them have survived the depression of trade, some of the smaller ones have failed.

The reason of this seems to be the number of members who left, the increased number of sick on account of the reduced wages, and the increased demand on the funds for pensions, the income being insufficient to meet the expenditure.

In the Dortmund district the Märkische society, with its connected clubs, is the only one left; its total income fell off £8,467 18s. in 1875, namely from £174,456 5s. in 1874, to £165,988 7s. in 1875. In the districts Breslau, Halle, and Clausthal, the income of these unions have increased during 1875:—

In Breslau from £191,866 12s. in 1874 to £202,631 13s. in 1875.

In Halle „ £93,423 4s. „ „ £99,419 11s. „

In Clausthal „ £141,922 10s. „ „ £144,007 4s. „

XIII.—ACCIDENTS.

The number of accidents in mining in Prussia, in 1875, amounted to 587 deaths, or of 2.449 for 1,000 working miners; while in 1873, it stood at 2.504; in 1874, at 2.431; and the average for ten years, from 1866 to 1875, was 2.471 per thousand.

The number of accidents per thousand is as follows:—

	1874.	1875.
1. Coal mines	2.988	2.829
2. Lignite mines	2.043	2.331
3. Iron mines	1.082	1.499
4. Other mines	1.268	1.368

In the various Government Inspectors' districts, the number of deaths per 1,000 men is as follows. In the coal, lignite, and iron mines:—

	1874.	1875.
1. Breslau	2.564	2.569
2. Halle	1.591	1.607
3. Dortmund	3.222	3.319
4. Bonn	1.698	1.614
5. Clausthal	1.933	1.939

[51]

In the principal coal basins, the following are the number of deaths per thousand:—

	1874.	1875.

1. Upper Silesia	3.404	3.450
2. Lower Silesia	1.745	1.020
3. Ruhr	3.318	3.417
4. Saar	2.255.	2.154
5. Worm and Inder	2.384	1.882

If the total number of accidents be divided by the tons produced, and the money value of the product, it gives one fatal accident in coal mines to the following:—

		1874.	1875.		
For every 65,290 tons, worth		£350,131	72,799 tons, worth		£28,171 in coal mines.
226,169	„	£41,405	191,244	„	£34,378 in lignite mines.
57,901	„	£49,173	38,623	„	£38,367 in iron mines.

The average of coal, lignite, and iron mines gives one death for every 75,073 tons, 1875, worth £36,923; 76,954 tons, 1874, worth £30,033.

In the Government mines, there were 89 fatal accidents in 1875, or 2.178 per 1,000 men, against 2.473 in 1874, and 2.536 per 1,000 men in 1873, which is considered a very satisfactory result.

By the total Government coal mines, the figures are:—For 1875, 2.223 per 1,000, against 2.610 in 1874, and 2.693 in 1873; and in the other mines, in 1875, it came to 2.192 per 1,000, against 1.552 in 1874, and 1.784 in 1873. Upon the Government mines, in Saarbrücken, there were fifty fatal accidents, which makes 2.154 per 1,000 in 1875, against 2.255 in 1874, and 2.292 in 1873.

In the Government coal-mines, altogether, there was one fatal accident in 1875.

For 94,096 tons, worth	£47,357 4s.	in	1875.
For 78,873 „	£52,425 3s.	„	1874.
For 80,114 „	£58,990 13s.	„	1873.

Comparison or quantities raised, persons employed, and persons killed in the British and Prussian Mines in 1875.

	British.	Prussian.
Number of mines	4,501	2,990

Tons of coal wrought	133,306,485	32,951,429
Do. ironstone	12,018,594	2,558,100
Do. Fire clay	1,932,294	—
Do. shale, &c.	442,940	—
Do. lignite	—	8,223,495

[52]

	British.	Prussian.
Persons employed	535,845	199,856
Do. do. underground	427,017	149,892
Do. do. aboveground	108,828	49,964
Females employed aboveground	6,504	4,832
Deaths by accident	1,244	587
Deaths per persons employed	430	340
Tons wrought per life lost	118,730	74,502
Tons wrought per person per annum	276	218

XIV.-EXPERIENCES IN MECHANICAL AND OTHER CONTRIVANCES GAINED IN 1875.

Mechanical Boring Machines.

Many trials have been made in the various coal-fields with boring or drilling machines, but they have not met with great success. The only machines that have worked satisfactorily are those by Dubois and Francois. They require few repairs in comparison with other machines, and all the parts are made so strong, and are so simply constructed, that if any part of the machine breaks down it can be replaced easily and quickly. The cost of sinking with this machine, when constantly at work, was per cubic yard:

	£5	8	7½	for wages.
	2	7	0¾	for blast materials.
Total	£7	15	8¼	

By hand boring, the price would have amounted to £12 10s.

Coal-Cutting Machines.

In Upper Silesia a few trials have been made with Wistanley's Coal-cutting machine. The trials were not satisfactory, owing to the teeth of the cutter not being made of good enough steel. The trials are going to be continued after a harder quality of steel has been substituted. Trials have also been made with the machines of Hoppe, in Berlin, without success.

Blasting Materials.

A patent blasting powder has been brought into use in some collieries which only explodes when compressed; otherwise it burns quietly. Not much saving, however, is made, and it is therefore falling into disuse. A new sort of dynamite has been introduced called Pantopollit. Trials of this explosive were made in one colliery, but the gases which were emitted after firing gave the men pains in the head and chest; but more work was done than with ordinary powder.

[53]

Dynamite.—This explosive is coming greatly into use in Clausthal; 152 cwts were used in 1875, against 48 cwts. in 1874. The price was reduced from £7 10s. a cwt. to £6 a cwt.

A new explosive called Lignose was tried, but given up, on account of the gases given off, and some unaccountable explosions which happened. Powder is, therefore, still the favourite explosive.

Electric Firing.

Unsuccessful trials have been made with electric firing in Upper Silesia. The men show a decided unwillingness to work with it, on account of the time wasted in coupling and uncoupling the wires; besides, it often happens that only a few of the shots are fired out of the many to which it is applied, which is dangerous and unsatisfactory.

The Preserving of Timber.

At the "Brandenburg" colliery, in Upper Silesia, the timbering in the shaft has been painted over with a mixture of sulphate of iron and powdered slag to keep it from decay. Within a short period the timber was stained a deep brown to the core.

Iron Props.

Upon the "Königin Luise" colliery, in Upper Silesia, iron props have been used with great success. The props are cast-iron pipes; and in the place of top planks or head pieces in the principal rolleyways old iron rails are used.

Pump Rods or Spears.

At the "Heinrich Gustav" colliery, near Bochum, Bessemer steel spears have been supplied; they are 25¼ feet long. The same rods have been supplied to the "Monopol" colliery, near Camen, for a pump with 18 inches forcing sets, pumping from a depth of 270½ yards, with spears 62 feet long.

Rails.

The Cologne Mining Company, in Westphalia, have laid all their principal rolleyways with Bessemer rails, 2.6 inches high, with fish joints. A larger quantity of coals is conveyed with nearly the same first cost of way, and with less cost for repairs. This improvement has also been introduced in the brown coal district, in the province of Hessen.

Tubs.

The tub-wheels of tempered cast steel, made by Poulet and Dejain, in Lüttich, and introduced into the Government Mines at Saarbrück,

[54]

have stood very well. In Saxony the Government have adopted for the mines light tempered cast steel wheels with spokes. They are from a Belgian firm, and have given great satisfaction.

Upon the principal collieries in Gelsen Kirchen, Westphalia, tempered steel wheels are used, manufactured by Mundsheid and Co., in Gelsen Kirchen. These wheels, 1 foot diameter, weigh only 17.6 lbs.; a 10-inch wheel, 15.9 lbs., against 28.8 lbs. when cast iron; a 13-inch wheel, 26.6 lbs., against 37.9 lbs. when cast iron. The cost is 3½ d. a pound.

Molecular Change in Iron Chains by Winding.

The known appearance that iron assumes when fractured, after being subjected to shocks for some time, namely, that of showing a coarse grained structure, has been prominently noticed at the "Friedenshoffnung" colliery, near Waldenburg, where experiments have been made with a chain, which has been in use two years. A ring of this chain sprung in four pieces by the first blow of a twelve-pound hammer, the fractures showing a crystalline structure; whereas, another ring of the same chain, which had been heated to a red heat and then cooled, broke on one side only after twenty-three blows with the same hammer; the other side was half broken. This shows that in winding the greatest care should be exercised in examining the chains. The shock might be alleviated to a great extent by using springs between the rope and the chain, or by heating the chain to a red heat from time to time.

System of Tickets.

At the mine "Wiesche," in Westphalia, a ticket system has been introduced, with very great success, which may be thus described:— Every man, in descending, gets a ticket which he gives up at the bottom. Here they are hung up in a line as they are given up, and later, when riding, those men whose tickets were hung up first ride first. Hereby, the men not only come to their work earlier, but do not leave their work before proper time, for if they did they would have to wait till their turn. "At the Mansfield colliery," this ticket control has been introduced. They expect, that through this system the real working time in the face in an eight-hours' shift from bank to bank will be seven hours, and the work of the men correspondingly increased.

Pumps.

At the Government Salt Mines in Saxony, near Stassfurt, they are using, in the sinking of one of their shafts, wrought-iron pumps, 9¾ feet long.

[55]

The pipes are welded in longitudinal seams, and are recommended on account of their lightness. As they require careful workmanship on account of the flanges, they are made in England, and are expensive.

Ropes.

It may be, perhaps, interesting to know that a rope which has been used two-and-a-half years upon an underground horizontal plane at the "Gerhard" colliery, at Saarbrücken, has shown a loss of 32 per cent. in weight. It hauled on an average about 370 tons a day. It has been noticed that ropes not only wear at the circumference, but also wear in the interior, through the friction of the strands and wires, and that this wearing in the interior is greater and more dangerous than that of the circumference. At "Altenwald" colliery, near Saarbrücken, an iron wire rope was replaced, after being in use for one year and having drawn its given quantity of coals, which showed scarcely any wear on the circumference; but, on unwinding the rope, it was found that the wear of wires had been considerable, owing to the friction of the strands against each other. By experiment, it was found that the breaking strain of the single wires was 755 lbs., while, when new, it was at least 860 lbs.

Cast steel wire ropes are gradually replacing iron wire ropes with considerable success at the collieries near Aix-la-Chapelle. They have, however, experienced that steel, after having reached the limit of its elasticity, breaks like rod iron; and, although there is a saving in weight, a larger drum diameter is required than for iron wire ropes.

Cast steel flat ropes have been used upon the "Rheinpreussen" and "Gouley" collieries for a short time. At the "Kraempchen" and "New Voccart" collieries flat aloe ropes have been used since 1874 with great success. These ropes, which weigh 9¾ lbs. a yard, and cost 5d. per lb., or 4s. 0d. per yard, have been in use upon Dutch Government mines for six years without having been repaired, drawing on an average 3,000 scheffels of coals daily. They are greased with hot oil and ox fat every three months.

Phosphor bronze ropes are in use upon the " Rheinpreussen" colliery.

Detaching Hooks.

These hooks, which are similar to those of King's and Ormerod's, are in use upon several of the mines near Gelsenkirchen, and have given universal satisfaction.

Safety Cages.

At the "Friedrich Joachim" colliery, near Altenessen, safety cages have been fitted up on the Fritz system. These cages act by means of

eccentric claws, which are operated on by springs. The claws dig into the guides when the rope breaks, and thus hold the cage. The springs, however, in time, lose their strength, and, in order to do away with this objection, the springs, with the claws, are made to slide upwards in a groove, so that in the case of a rope breaking, the spring acts upon the axle and claws only, and these fasten themselves in the guides and remain stationary; the cage still falling, drives the claws further into the guides and ensures absolute safety. Thus it will be understood that the work of the spring is reduced to a minimum by having only to be of sufficient strength to fix the claws and their axle, and the cage by its weight acts as a hammer in driving the claws further into the wood.

Cage Keps.

Mr. Büsher, in Schalke, has patented a machine for breaking the fall of cages on the bottom keps in shafts. The cages, when coming near the bottom of the shaft, press against a guide, which is connected to one of the guides of the other cage, by a horizontal bar which is in connection with a cataract. When the cage comes near the bottom the guide is pressed outwards and acts as a brake; the cataract, regulating the descent, brings the cage gently to the bottom.

[see in original text Diagram of braking device]

Heapstead.

At the "Hugo" colliery, near Buer, which is being sunk, a wrought iron heapstead is being constructed. It has been made as light as possible, consistent with strength, and has been manufactured by the Essen Union Factory. The total cost is £2,325, and weighs 29¾ tons.

Sinking Ventilators.

In sinking the "Bismarck" Pits, at the "König" colliery, in Upper Silesia, a Roots blower has been at work since August, 1875, without ceasing, requiring no repairs. The air-pipes are 5¼ inches in diameter. It cost £11 15s.

The Roots hand-blowers have been used with great success upon several collieries in Westphalia.

Life-saving Apparatus.

The firm, L. von Bremen and Co., Kiel, have constructed, after the system of Denayrouze, a

portable high-pressure breathing apparatus. The apparatus is carried on the back in the form of a knapsack, and has no pipe or air-pump attached to it. A man can work in any atmosphere from thirty to forty minutes with a lamp, which is fed from the same apparatus. The apparatus weighs 27½ lbs. and is charged with air to a pressure of from 25 to 30 atmospheres, and the air is supplied by a breathing regulator to the operator and his lamp at the proper pressure required.

At the "Gottes Hülfe" colliery, near Guben, in the seams in which many fires have happened lately, Tyndall's respirator has acted very well. It consists, simply, of cotton wool soaked in glycerine, and a layer of charcoal. A man could work at this colliery during a fire twenty minutes unceasingly, without the slightest inconvenience, who, without it, could with difficulty work five minutes.

In conclusion, the author would remark that:—

First.—It is quite evident from the statistics quoted that great efforts are being made in the various districts of Germany to develop the coal and other mining industries, and taking the last fifteen years there was no less than 134 per cent. increase of output in coal, whereas in Great Britain there was only 58 per cent., as will be apparent from the following figures—

Great Britain, in 1861	96,419,941 tons	
And in 1876	133,344,766 „	
Showing an increase of	36,924,825 „	or 38 per cent.

Whilst in Germany the production was—

In 1861	18,755,360 Tons.	
And in 1876	43,451,372 „	
Showing an increase of	24,696,012 „	or 131 per cent.

However, it may be observed that the quantity produced is far short of the ultimate requirements of the country, giving, in fact, only one ton per annum per head, whereas in Great Britain four tons are required. Of course there is no doubt that wood is still used extensively in Germany, yet to fully develop the manufactures of the country the consumption of coal must approximate more nearly to that of our own country.

Second.—The establishment of mining colleges and schools for all classes of the community engaged in mining is very praiseworthy, and shows that technical education is very much appreciated.

Third.—It will be seen that the Germans are alive to all new inventions and improvements for the safe and economical working of their mines.

XV.—OUTPUT PER MAN PER ANNUM.

The following table shows the output of the coal, fire-clay, ironstone, and shale:—

IN GREAT BRITAIN.

Year.	Persons employed.	Tons.	Tons per Annum.
1873	514,149	128,680,131	240
1874	538,829	140,718,382	260
1875	535,845	147,700,133	275

IN PRUSSIA.

Year.	Persons employed.	Tons.	Tons per Annum.
1869	111,325	29,428,438	232
1871	133,023	32,843,288	221
1872	157,991	36,973,412	234
1873	205,806	43,894,159	213
1874	203,915	42,591,471	208
1875	199,856	43,733,024	219

XVI.-ACCIDENTS.

The total number of deaths from accidents in Prussia in 1875, in the production of 43,733,024 tons of coal, fire clay, and ironstone was 587, with the employment of 199,856 persons, or one person killed for every 74,508 tons, or 348 persons employed.

In Great Britain in 1875, with a total production of 147,700,313 of minerals, by the employment of 542,349 persons, 1,244 were killed; or one person killed for 118,730 tons produced, or for each 436 employed.

In other words, there are 28 per cent. more persons killed per annum per person employed in Germany than in England, and for each death there is a production of 59 per cent. more mineral in England than in Germany; and when it is considered that the mines in Germany are shallow, many of the lignite ones often worked at the surface, with little or no inflammable gas, there is reason, sad enough as the losses are here, for congratulation on the comparison. Whilst speaking on this subject it may be stated that although there are too frequently most disastrous

fatal accidents occurring, yet there are other branches of industry which apparently are not so hazardous as mines, yet annually have a more fearful calendar. In proof of this the author quotes from the report of Mr. Willis:— "Notwithstanding the large number of lives lost annually in mining operations, it is a fact, which I believe is not generally recognised, that in proportion to the number of persons employed there is really a much greater exemption from loss of life than in some other employments—railways for example. I gather from a speech made by Sir R. W. Carden as chairman of a meeting on behalf of the Railway Servants Orphanage, held in the Mansion House in October of last year (1875), that on the authority of Board of Trade Returns, in a total of 270,000 persons employed on the railways of the kingdom in 1874, 1,000 lost their lives. If these figures are correct they would show that the number of persons employed per life lost is equal to 270. In the same year (1874), in mines under the Coal Mines Regulation Act, the number employed per life lost was 510, and under the Metalliferous Mines Act, 609; or in the entire mining industry of the kingdom, 519."

There is no reason, however, that efforts should be relaxed to lessen these most grievous calamities which still continue to occur; and it seems highly desirable that this Institute, which has for its principal object the safety of life, should at the present time especially endeavour to use the means that it is possessed of in endeavouring if possible to find some method by which the mines not only of this country but of others should be worked without so great an annual loss of life, not only as regards the explosions of gas, which represent about 23 per cent., of the accidents, but of the remaining 77 per cent.

[see in original text Table showing the number and causes of colliery accidents in coal, fireclay, and shale mines in Great Britain in 1875. Compiled from the Government inspectors' reports.

The total number of persons employed amounted to 535,845, and in Coal, Ironstone, Fireclay, and Shale Mines the number of deaths resulting from Accidents was 1,244, giving a life lost for every 4307 persons engaged, and 118,730 tons wrought.

[61]

[see in original text Table showing the number of colliery accident in coal mines in Prussia, in the principal coal basins, in 1875]

The total number of persons engaged number 159,702, and the number of deaths by accident was 454, giving a life lost for every 351.7 persons engaged: 1 life lost for 90,693 tons of mineral wrought.

[62]

[see in original text Table of comparison of the output of coal, its value, price per ton, the number of men employed, and quantity worked per man. Between the year 1869 and 1875, in several parts of Germany]

[63]

[see in original text Table of the production of coal, lignite and iron ore in Prussia, 1874 and 1875]

[64]

The President said, the members must feel very much obliged to Mr. Simpson for his very valuable paper, and especially for the statistics which he had given them. He would be glad to hear any remarks or questions which any gentleman had to ask Mr. Simpson.

Mr. Greenwell said, there seemed to be so much brought before them in the paper that probably it would be more convenient to wait till it was printed before they had the discussion upon it, as very much depended upon the figures, and there was no doubt some of the figures would be discussed.

Mr. Bewick said, he thought the course suggested by Mr. Greenwell was desirable on account of the number of figures given in the paper. Every one acquainted with the mining industry of this country and of Germany would acknowledge the great importance of the paper submitted to them by Mr. Simpson. He was to a less or greater extent personally acquainted with several of the fields mentioned by Mr. Simpson; and when the paper came up for discussion he would be glad to go into some of the details respecting them gathered from his enquiries on the spot. Some of the figures given by Mr. Simpson were rather striking, especially (as it occurred to him at the moment) those with reference to the number of deaths resulting from accidents, inasmuch as most of the German coal-fields are free from inflammable gases. The only way in which he (Mr. Bewick) could account for such a circumstance off-hand was the fact that the seams in Germany were generally much thicker than those in England, and hence the greater difficulty in working the coal. In Germany thick seams of coal are of frequent occurrence, some of them being 40 feet. There was a point on which he thought they would need some explanation—he would not say correction—that was as to the depths of the pits. Some very deep pits existed in Germany, especially in the Saxon field, where shafts from 1,800 to 2,000 feet in depth were of common occurrence. It is true that the pits in the brown coal, which forms no little portion of the total quantity worked in Germany, were naturally, from the geological position of the deposits, mostly shallow; and whether or not many accidents occurred in them, he did not know. Perhaps it would be worth while to enquire into these points; and he would, as he had already said, be glad if he could add anything of value to Mr. Simpson's excellent paper.

The President asked, if it was not also true that in addition to the great thickness of the seams of coal, some of the seams of lignite lay at a great angle?

Mr. Bewick—Yes, some of them are at a great angle as well.

[65]

Mr. Simpson said, with regard to Mr. Bewick's remarks as to the accidents in Prussian mines, he had a number of tables which he had not read, showing the proportions of accidents from every cause; and he found that the accidents from explosion were only 6 per cent. as compared with 24 in England; so that there the accidents were chiefly, he believed, from falls of stone and blasting, and falls in the shaft were more frequent than in this country.

Mr. Bewick said, he believed he had some geological maps of Germany—of, at any rate, parts of the coal-fields—which had been published by the Government of that country, and if the Institute would permit him, he would gladly submit them when the paper was discussed. As to these maps he would not say that the Germans excelled, but they certainly equalled the English in the geological information published, and went into much more detail as to the division of the several formations. Whether there was any great advantage in that was a matter of opinion. Then again, they had some very excellent, what he might call diagram, maps, showing the production, consumption, and circulation of the coal in Prussia. These maps were extremely interesting, and showed not only what was raised in the country itself, but also what was imported, and where it went to. The information was in a good form, and laid down to scale.

The President said, the members would be glad to accept Mr. Bewick's offer.

The meeting then proceeded to discuss Mr. Steavenson's paper "On an Improved Method of Detecting Small Quantities of Inflammable Gas."

Professor Herschel said, that it having been pointed out by Professor Marreco, as was mentioned in the paper which was now under discussion, that the blue colour of the flame-cap, which is most readily visible in some motionless and stagnant places in pits where fire-damp seems to have accumulated slowly, may very probably be owing to the presence of carbonic oxide among the gases burning in the safety-lamp flame; he had attempted, a few weeks ago, to obtain if possible a well-marked spectrum in blue flames of this gas produced experimentally, which might enable its light, when it is plentifully present in the flame-cap, to be singled out, and to be observed most readily with a properly selected kind of glass. The experiments were made in the College of Science by the Assistant

[66]

Demonstrator of Chemistry and Physics, Mr. J. T. Dunn, and by Mr. G. Austen, upon a considerable quantity of the pure gas stored in a gas-holder, and burned, sometimes mixed with hydrogen (but not with coal gas) in air and in oxygen, as well as mixed with oxygen, through a Hemming's oxy-hydrogen wire-stuffed blow-pipe jet. While burning in oxygen gas, the gas jet was also sometimes made to issue from a tube of tobacco pipe heated white hot. It was only in this last condition, when a flame of mixed hydrogen and carbonic oxide was so hot as to melt platinum instantly, that he had, he thought, observed symptoms of the proper bright line spectrum of the gas, but they might be owing to an impurity, as similar lines were sometimes glimpsed when the point of a very small Bunsen gas flame was brought near enough to the gas jets to kindle them, when from the speed of the gas it was found difficult otherwise to keep them burning. With this rather doubtful exception the light of the pale bluish flame always consisted of a band of pretty even strength extending from the yellowish green over the whole green, blue, and indigo part of the spectrum; and although the highest heat of the electric spark passed through the flame was not tried, be believed that in no flame of carbonic oxide burning by itself would any other combination of coloured rays than this uniform succession of all the rays between the green and the violet, or on the blue side of the yellow part of the spectrum, ever be found to present itself. The blue cobalt glass, which was recommended by the author of the paper, was therefore, Professor Herschel thought, the best that could be used to assist the eye in insulating and identifying the presence of the blue flame-cap, by its property of transmitting quite freely the blue part and stopping the orange, yellow, and green rays which make up the body of the light of the oil lamp flame, and preventing these rays from entering the eye. Another point in the paper, regarding which he wished to ask a question—although it was a matter of very trivial detail —was, if the name of "pot-opal," by which the glass is described in the paper, was correct? White opal glass is used in plates by photographers for printing transparent or glass-positives upon; and like all plate glass which is coloured artificially it is known as "flashed" or "pot-opal" glass, according as the pigment is only applied on one of its surfaces, or pervades the whole substance of the glass. The glass coloured blue with oxide of cobalt may in this way be either "flashed" or "pot-cobalt" glass, according as it is coloured only on its surface or quite through; and he thought that from the similarity of the sounds the name of "blue pot-opal," instead of "blue pot-cobalt" glass had perhaps been inadvertently understood as given to the glass by the makers or glass-merchants from whom

[67]

the glass was obtained. He thought that it would be interesting to the members present to know if Mr. Steavenson had received any reports from viewers or overmen in pits of the results of their experience in using the blue glass; or if he had found in the collieries under his charge that the use of this glass in the safety-lamps had been attended with very marked advantages; because it was this practical use of the glass in the mines to which we must look as the best test of the utility of the invention.

Mr. Steavenson said, if no other gentleman had any remarks to make, he thought the words he had to say need be very few. The proper name of the glass was undoubtedly "pot-cobalt;" but the similarity of name when the glass was given to him by the manufacturer had probably— as he did not hear very well—been mistaken by him, and therefore he was glad to have the correction. The utility of the method had, he thought, been pretty well proved by those to whom he had spoken. The operation was at all times a very delicate one, and those who used the glass must not suppose they would at once see the gases with any very great degree of brightness; of course to distinguish the cap on the top of the flame required a considerable amount of experience, and it was a matter which any man might easily be mistaken in. Therefore he would not have any one to suppose that the use of the glass would at once do away with any necessity for experience in detecting the gases, but from his own experience and the experience of those who had spoken to him, there could be no doubt it was a very great assistance in debarring the bright yellow colour of the flame and allowing the blue colour to appear more distinctly. The question of the gas burning on the top of the flame was one on which Mr. Pattinson (an esteemed member, he believed, of that Institute) had spoken to him, and he seemed to think it was probably carburetted hydrogen in such a diluted state that it would not explode, but merely in a condition in which heated flame was sufficient to burn it. Whether that was so or not was more for a gentleman of Professor Herschel or Professor Marreco's experience than his own to decide. What they had got to know was that there was such a cap, and that they could distinguish it in small quantities by the use of this glass better than they could without it. He was very glad that he had been able to call the attention of the members of the Institute to the subject. They showed that they appreciated the very great importance of all these questions. Although he saw that Lord Kinnear was recommending the Government to introduce by Act of Parliament the detector of Ansel in every mine, he (Mr. Steavenson) still remained of the opinion which he had previously

expressed, that the use of these detectors would be impossible. If it was known where an explosion of gas was going to occur, of course detectors would not be required at all; and if it was not known where an explosion of gas was going to occur, there might be a detector in every place in the mine, and the mine might be of two thousand acres in area. It therefore seemed to him to be a machine which was almost beyond a question of utility at all. He would not like to deter any one from using any instrument which was intended to be of any benefit whatever; but he was very strongly of opinion, after having tried it for several months, that this detector was not a machine upon which they could place very much reliance. One or two gentlemen seemed to think that blue glass was not beneficial—they had spoken to him to that effect; but he thought that after all they must see for themselves that, according to the natural laws under which light acts, it must be beneficial. The principle of absorption was the law upon which this method was founded, and there could be no doubt whatever that with care and experience the use of blue glass would be beneficial.

The President asked, if Mr. Steavenson was using this method practically in his mines?

Mr. Steavenson said, the deputies had it where they fired shots.

The President—And the master-wastemen?

Mr. Steavenson—Yes, whenever they have to examine for gas.

The President—And you find it of great utility?

Mr. Steavenson said, he thought the reports were generally satisfactory; but that people were led away by expecting too much.

The President said, he was quite sure there was no instrument more required than a detector which would show in a much plainer manner than anything they had now in use the presence of small quantities of gas. Nearly all the best regulated mines are almost entirely worked by lamps, and therefore the mine was comparatively safe; but as many seams could not be worked without blasting powder, they had to fire shots, and therefore, in examining the mine previous to the shot being fired, it was most essential that they should have a detector instrument, an instrument of some sort which would detect any appearance of gas previous to the shot being fired. He was sure the members must be much obliged to Mr. Steavenson for the trouble he had taken in bringing before them his application of coloured glass, and for the experiments which they had seen. He thought there was no doubt that the use of cobalt glass was a much more easy manner of detecting gas than by the ordinary blue flame of the Davy lamp. He could quite endorse what Mr. Steavenson had said about

the detectors: in some cases they did not act at all; in other cases their action was so slow in detecting the gases that the place was full of gas some distance beyond the detector before it gave the signal.

Mr. Steavenson said, he would like to speak further with regard to the detectors. If in the mine a slow accumulation of gas took place, bringing, into action both the principles of effusion and diffusion, the necessary pressure to make the detector act, or, as was often the case during thunder storms with the telegraphic bell in his own house, earth-currents might act on the detectors when there really was no gas accumulation at all.

Mr. Freire-Marreco said, he would like to ask Mr. Steavenson whether he had arrived at any definite idea as to the minimum quantity of gas which could be detected with the blue glass? Mr. Galloway was of opinion that by careful manipulation of the lamp (pulling the wick down till it just showed the smallest yellow point on the top), about one and a half per cent. of damp could be detected with tolerable certainty. He did not know that there was any statement elsewhere in print as to the exact quantity which could be detected, and he thought that one of the first things to determine was the smallest percentage of gas which could be detected by any means at present in use, if a comparison was to be instituted.

Mr. Steavenson said, he was afraid he could not answer that question, because to do that the gas which was present would have to be analysed. If Professor Marreco would undertake that analysis, he would obtain some useful information. He (Mr. S.) knew some natural blowers in the district where they could get any quantity of gas they liked. He would undertake to supply Professor Marreco with the gas if he would undertake the experiment.

Mr. Freire-Marreco said, he would much rather begin at the other end, namely, prepare mixtures of known composition, and examine their behaviour with the lamp.

Mr. Steavenson said, Professor Marreco could mix the gases himself, and he could get him any quantity. They had at collieries immediately adjoining him large blowers of gas brought out and burnt at the surface, and if Professor Marreco could bring his apparatus there he could try as much as he liked.

The President said, he was sure that if Mr. Steavenson would furnish Professor Marreco with some of the gas, the result of the experiments would be very useful information for the Institute to have, so that it could be decided what was the minimum quantity of gas which they

could detect, and also what would be the condition of the minimum quantity as compared with the larger quantity. If there were any means of ascertaining the proportions of the gases it would be very desirable, but he did not know whether that could be done.

Mr. Freire-Marreco said, Mr. Galloway had a fixed apparatus at bank at a Welsh colliery, with which he made some experiments, and the results were published, with illustrative drawings, in considerable detail in the Transactions of the Royal Society about eighteen months ago. He only mentioned it because he happened to have seen Mr. Galloway within the last week, and he expressed himself as satisfied that his method would detect down to about one and a half per cent.

The President said, that was a very small proportion.

Professor Herschel observed that he did not wish it to be understood from the description which he had given of some experiments on the spectrum of the blue flame of burning carbonic oxide, that he had contemplated pitmen and overmen being provided with spectroscopes, with which to examine the cap of flame in their safety-lamps in order to recognise this gas, if it was burning there; but only that an attempt had been made to determine the real character of its spectrum, so as, if possible, to obtain a guide in choosing the kind of coloured glass, which would act as a substitute for the spectroscope, and which would allow the flame-cap to be observed through it with the best advantage. The cobalt glass was found, both in the opinion of its discoverer, Mr. Steavenson, and as the result of these experiments (as far as they can be supposed to deal with a flame resembling the real one), to be the best description of glass that could be selected for the purpose, and he need not remind the members that the assistance which it offers to the eye is of that simple and easily procurable kind which will certainly make it a very valuable introduction, whatever merits, great or small, experience may prove it really to possess of that particular kind which is so very urgently required.

The meeting then terminated.

[71]

PROCEEDINGS.

GENERAL MEETING, SATURDAY, DECEMBER 1st, 1877, IN THE WOOD MEMORIAL HALL.

LINDSAY WOOD, Esq., President, in the Chair.

The President said, as their first duty would be to appoint a scrutineer to examine the balloting papers for the election of members, the Secretary had better read the names of those gentlemen who stood for election, and he moved that he (the Secretary) be appointed to make the necessary scrutiny.

Mr. Greenwell seconded the motion, and it was carried unanimously.

The following gentlemen were afterwards declared to have been duly elected:—

Associate Member—

Mr. John Sutherst, Iron Founder, Cleveland Foundry, Guisbro'.

Students—

Mr. John C. Fletcher, Peases' West Collieries, Crook.

Mr. Alexander Gould, Mining Student, The Vicarage, Earsdon, Newcastle.

The Secretary having read the minutes of the last general meeting, and the minutes of the Council;

Mr. Burns read the following paper "On the Intrusion of the Whin Sill:"—

[72]

[blank page]

[73]

ON THE INTRUSION OF THE WHIN SILL.

By DAVID BURNS.

In the highly suggestive paper read before this Institute on the Harkess Rocks, by Messrs. Lebour and Fryar,* attention is drawn to the frequency of the occurrence of whin under limestone and over shale. This arrangement, or an approximation to it in the form of a thin stratum of shale between the whin and the limestone, the writer frequently observed. In several of the Alston Moor sections, the "Tyne Bottom Limestone" holds this position with a thin stratum of altered shale or whetstone occasionally between; and it is very probably the frequency of the occurrence of some limestone in this position, that has given rise to the confirmed impression among miners, that the whin holds an invariable position under the Tyne Bottom Limestone.

The authors of the paper already alluded to suggest, in explanation of this phenomenon, that it is due to the greater softness of shale over other rocks. This, no doubt, is a factor in the explanation, but it is not in itself quite satisfactory, as they confess†. Examining the section given in Fig. 5 of that paper, and repeated here in Fig. 1, Plate V.; and supposing the basalt to be spreading in a direction from left to right along the section, the whin by this theory will pass from shale 6 to shale 4 in quite a satisfactory way; but when it begins to rise again and reaches shale 6, that stratum might be expected to yield and the whin to spread below it. Indeed, it is perfectly clear that if the yielding of the shale were the predominating cause, the whin would be over the shale when it approached it from above, and under the shale when it approached from a lower horizon, inasmuch as the shale would yield on the first contact of the whin, and not, as occurs in half the cases, after the intruded mass had passed through it.

In view of the comprehensive treatment of the stratigraphical distribution of the whin by Messrs. Topley and Lebour and others, as well as the forward state of the geological survey of the country where it extends, it is time that attention was directed to the physical aspects of its

* On the Harkess Rocks, near Bamburgh. Transactions, Vol. XXVI., page 121.

† On the Harkess Rocks, page 126.

intrusion; and the writer thinks that the suggestions that occurred to him on reading the paper on the Harkess Rocks, may throw some light on the subject.

Limestone exposed to heat gives off carbonic acid gas, and any limestone stratum exposed to the action of molten whin, must have given off gas proportionate to the heat of the whin, and in some inverse proportion to the pressure it was subjected to.

This characteristic of limestone, which distinguishes it from most other rocks, contains, the writer believes, the secret of the frequent occurrence of whin under it.

The reasons for thinking so will be most easily seen by reference to Fig. 2, Plate V. The molten whin is supposed to be spreading from left to right, and in a more or less obliquely upward direction. On approaching the limestone, its heat, which is going before it, acts upon the limestone and generates a quantity of gas. Should the limestone and higher beds prove open enough for the exit of the gas, it would rush upwards, and in all probability the whin would follow it for a greater or lesser distance; should, however, the carbonic acid gas find no escape, the limestone would become the roof of a gas chamber, and the shale would be pressed downwards as represented. Under such circumstances the whin could scarcely do otherwise than follow the bottom layer of the limestone as represented in Fig. 3.

If the whin should approach the limestone in a direction nearly normal to its bedding, the gas chamber might extend on both sides of the point of contact, and the whin, on moving forward, would be at liberty to spread both to the right and to the left. This is represented in Figs. 4 and 5, and explains the frequent phenomenon of shale caught in the whin.

On reaching the top of the limestone it might at first be supposed that the disengagement of gas would favour the spread of the whin on the top of the limestone, as much as it did under it. But when it is considered that the limestone is a crystalline and unyielding body, it will be seen that, on the entrance of the whin on the limestone, its disturbing influence would be felt all through the latter, and the top stratum of limestone would be pushed against and into the more accommodating shale. The conditions would be much the same as those of the "cupped leather collar" used in the hydraulic press. The greater the force of the gas the more it would press the limestone against the shale, and the less opportunity it would have of entering between them. Accordingly the gas, disengaged by the passage of the whin up through the limestone, would rush up through and prolong the rift already formed in the shale. This passage the whin would follow, and so be led away from the top of the limestone.

[75]

When this theory is applied to the progress of the whin from a higher to a lower horizon, it makes out that on all such occasions the whin would spread upon and not below the limestone. As this is a rare position for the whin to occupy, it may be inferred that it was correspondingly seldom that the whin moved from a higher to a lower stratum, except when it crossed a previously existing fault, or was led to degrade itself by some other untoward circumstance. Most of those sections which seem to show the whin bursting down through beds as well as up through them, can be explained without such a supposition. Fig. 1 represents a case in point. Whether the whin be regarded as flowing from left to right, or from right to left along the section, it passes up through and down through strata 5 and 6. On getting down through shale 6, it does not spread along the top of limestone 5, but bursts through, and spreads below that bed and over the next shale, as is its wont. Should the whin, however, be regarded as flowing in a direction normal to the plane of the section, it will not be necessary to suppose it to burst down through limestone 5 at all. At first it flows in a narrow channel about the middle of the figure under limestone 5 ; but, as it goes on, this channel widens, and on either hand the whin, as it spreads laterally, bursts up to the top of shale 6. Thus viewed, most sections could be explained in perfect consonance with the writer's hypothesis. It has been usual to regard the whin as coming vertically up through a central vent, and then spreading horizontally at a uniform rate all round, sometimes getting a little higher among the beds, sometimes a little lower. But may it not rather be supposed that it starts from some deep-seated lava-filled cavern, and spreads obliquely upward in a fan shape? As it gets higher, it probably becomes on the whole more horizontal. It is not, however, regular in the horizon which it occupies, nor is it regular in its onward progress. Its outline shows great protuberances, which widen and coalesce, and thus cover the ground. They shoot forth at one horizon, and, as they spread laterally, rise to higher horizons from the reasons above detailed. Breaks in the whin have been frequently observed by those who have traced its present outcrop, and no doubt each of these marks the limits of two tongues of lava which have failed, it may be, to reach exactly the same position among the beds, and whose power of further extension has failed them as they have approached each other. Again, the phenomenon of a double sheet of basalt may be due to one of these tongues extending at a different level into the area occupied by another.

Messrs. Topley and Lebour, in an elaborate paper on the Whin Sill, read before the Geological Society,* have given a series of sections across

* Quarterly Journal of the Geological Society, for May, 1877, Vol. XXXIII.

Northumberland, in which the position of the whin is shown. It would be interesting to follow the "stratigraphical relations" of the whin recorded in that paper, and interpret them in the light of this theory of its flow. But, for the present, it may be sufficient to illustrate the writer's meaning by referring to a few of the sections which they give—

1. At Crag Lough—Whin under third limestone, from Great Limestone.
2. Gunnerton—Whin under seventh limestone, from Great Limestone.
3. Great Bavington—Whin some distance below the seventh limestone, from Great Limestone.
4. Green Leighton—Whin under third limestone, from Great Limestone.
5. Rugley—Whin under eighth limestone, from Great Limestone.
6. Dunstanburgh—Whin under Great Limestone.

Now, following out the principle that the whin first arrived at those places where it is now lowest in the strata, the writer has prepared an ideal sketch, showing what may have been the limit of the whin at some point of time during its flow.

[Sketch map showing extent of Whin relative to above locations]

It does not take cognizance of any evidence but that of the above enumerated sections, and, therefore, the curve given for the outline of the whin has no pretensions to accuracy of detail. Were, however, a sufficiently minute survey of the whin to be made in the stratigraphical relations, without doubt a very accurate chart could be formed of its flow.

North of Haltwhistle, a bed of limestone extends over the whin. In a quarry in that limestone, the writer has noticed that there are cavities in the lowest post of the limestone directly over the whin. In these cavities is a black carbonaceous looking substance, and it would be an interesting matter to suggest as a question for discussion, whether this may not be the carbon of the carbonic acid gas disengaged by the whin, the oxygen having left the carbon and united with some other substance.

In Weardale, what has been called the Little Whin Sill, crops out from Rookhope to Stanhope, and it may extend much further eastward, between two posts of the Three Yard Limestone. This limestone is pretty uniformly of the thickness which its name implies, but where it includes the whin, there is at some points only two feet of limestone on the top, and one foot below. This shows that the limestone is either abnormally thin, or that the whin in some way has destroyed a fathom of it; the latter interpretation is certainly much more probable than the other. It is further observed, that in the limestone near the whin, there are crystals of iron pyrites, showing that in the solid limestone left, little cavities have been formed by the action of heat, and the place filled up again by extraneous matter, which accompanied the whin. These facts seem to afford conclusive proofs that the molten whin decomposed a portion of those limestones with which it came in contact. The fact that the whin keeps for a distance of over three miles in the centre of a not very thick limestone, is in itself very remarkable; nor is this an isolated instance of whin contained between posts of limestone, as the sections of Topley and Lebour show. Some distinctive characteristic of limestone has, therefore, in many cases determined the positions in which the whin is now found, as has been pointed out by Lebour and Fryar. The writer hopes, therefore, that the above speculations, however erroneous they may prove in themselves, will direct further attention to this most interesting subject.

In their paper before the Geological Society, Messrs. Topley and Lebour give a section, repeated in Fig. 6, Plate V., to show that the whin is intrusive. To the writer's mind it conclusively proves that the direction of flow at the point in question, was from east to west. It is impossible to conceive how a flow from the west could force up the limestone in the way shown, but it might very readily occur if the flow was in the opposite direction. The lava first burst up through the limestone, and its further flow dragged the edge of the limestone up. Here, it will be observed, the whin on getting over the limestone quickly leaves it, even when the next stratum is a sandstone.

The writer has frequently been struck by the resemblance which limestone, altered by whin, sometimes has to mortar from an old wall. If the above speculations be at all correct, the processes which they have each

undergone are nearly identical. Limestone, which is a carbonate of lime with more or less impurities mixed with it, is represented by the chemical formula $Ca\ CO_3$. When this is heated in a lime kiln, CO_2 is given off, and $Ca\ O$, or quick lime, remains. The next process in the making of mortar, is to mix the quick lime with water and sand. The hardening of the mortar in the building arises from the re-absorption of CO2, and by the union of the lime with the silica of the sand. These processes the limestone, affected by the whin, partially underwent. It was in part burned by the contact of the molten whin, and a proportion of the carbonic acid gas was given off. In like proportion after a time, from circulating water, and, possibly, from the whin, it absorbed carbonic acid gas and silica, and hence became the hard flinty limestone which is so frequently met with near the whin.

Mr. Greenwell said, he would take it that the condition of the limestone, after being affected by an igneous rock, would depend very much upon the means there were of passing off any gases which might be driven off by the heat. He had frequently seen cases in which the limestone had been said to be unfit for burning into lime, because it had been affected by being next to whin or to the Whin Sill. But he would like to ask a question: was there any known instance where, by contact with the Whin Sill, there had been quick or caustic lime produced?

Mr. Burns said, he was not aware of any instance in which it was in the state of quick lime. He did not think it would remain in that state for any length of time. It was very frequently found that the limestones near the whin had very little lime in them, but a great deal of silica, as though a great proportion of the lime had been removed by some cause, and siliceous matter had taken its place.

Mr. Greenwell said, he thought he had seen very recently a specimen in which crystallized carbonate of lime was in immediate contact with the Whin Sill; how was that to be accounted for?

Mr. Burns—There was such a specimen of carbonate of lime in contact with the whin on the table, and this might be the result of the lime water percolating through a cavity in the whin after its formation. It had not necessarily any connection with the whin in its molten state, and he did not believe it could have been formed at that time.

Dr. Saise said, the case of the crystals carbonate of lime was quite paralleled by the existence of zeolites, under somewhat similar circumstances, in the basalts of the North of Ireland. It would be formed a long time after the whin by filtration; but he agreed with Mr. Greenwell

in thinking that carbonic acid was hardly likely to be given off by heating limestone under great pressure. Bischoff, in his "Chemical Geology," said, that heat under great pressure converted carbonate of lime into crystalline, carbonic acid not being given off. With reference to the presence of iron pyrites in the limestone, iron pyrites was found in the chalk along the South of England. He had found it in the Lias limestone, also where there had been no whin at all. Iron pyrites resulted from the deoxidation of sulphate of iron, as it percolated through the rocks. He thought that when this whin-flow occurred, there was a large accumulation of measures over the carboniferous limestone, and that, therefore, there was great pressure. He thought that could be explained simply on mechanical grounds—the whin took the line of least resistance— without calling in the aid of chemical forces to explain the supposed production of carbonic acid.

Mr. Lebour said, he did not know whether he might tax the recollection of the members of the Institute so far as to ask them to remember a paper which appeared in the Transactions in relation to the Whin Sill and the Great Limestone. In it there was a section (Vol. XXIV., Plate XXXIII.), showing that the whin ran into a number of narrow veins or strings along the joints and planes of the bedding of the limestone. These shoots gradually got thinner and thinner till they died out altogether. Now, at the very extremity of these strings, in every case, there was found a certain amount of black matter which strikingly recalled to his mind what Mr. Burns had mentioned in his paper to-day, as to the black matter which occurred where there was contact between the limestone and the whin. As to the chemical part of Mr. Burns' paper, he did not at all feel competent to discuss it, but he might say that all the data Mr. Burns had adduced, tallied to a great extent with the facts of the Whin Sill, as they were exhibited in Northumberland, West Durham, and parts of Westmoreland. The gaseous bag which Mr. Burns had figured was, of course, purely hypothetical, and in order to make it intelligible it was largely exaggerated in the drawings; but that such a thing could be, he thought was imaginable, although it was quite beyond the possibility of proof. The occurrence of iron pyrites in the limestone near the whin was interesting.

Mr. Lebour then described some specimens on the table illustrative of the alteration of the rocks in contact with the Whin Sill, and especially above it. One instance was part of a burnt shale lying upon the Whin Sill, which was well known in the mining districts as the whetstone bed. There were also specimens representing the Whin Sill itself in various

conditions, and on one tray were fragments of altered rocks (chiefly limestone) from the Harkess Rocks and the Farne Islands, where they were enclosed in the whin; and these masses of enclosed rock were not only a few feet in area, but occasionally half or three-quarters of an acre, and even more, so that there were, along the north-east coast of the county, some very marked illustrations of the intrusive character of the Whin Sill. But what pleased him most in Mr. Burns' paper was, that it assumed the fact of that intrusion as a proved matter. He (the speaker) had been so used to unbelief as to this intrusion of the Whin Sill, that to find it assumed as a fact, as a sort of premise on which to base theories, was quite a treat. He was afraid, however, that Mr. Bewick, standing at his left, was going to dash his hopes in the continuance of this state of things; but he might say, that although in England it was found so difficult to prove the intrusion of the Whin Sill to the satisfaction of those who really know the facts of the case, it was amusing to hear that in Scotland they had so many Whin Sills; that they laughed at persons who, like himself, tried to prove a fact, to them so self-evident, as the intrusion of these shoots. He was sorry that Mr. Fryar was not present. He had hoped that he would have been there, but he was glad to see that in the report of the Council some notice was taken of his having taken part, as a student of the Institute, in the preparation of this paper. He might say that the whole of the drawings which illustrated the paper, and which were very carefully drawn to scale, had been made either by Mr. Fryar or from his drawings; and the whole of this survey, which was, he believed, extremely accurate, was done by him and did him great credit. He (the speaker) had had the greatest pleasure in joining with him in bringing the paper before the Institute.

Mr. John Daglish said, referring for a moment to the question of free carbonic acid, presuming that the whin had been intruded, it must have been with very great violence, and under very great pressure. Now, as carbonic acid is liquefied at very moderate pressures, he ventured to think it could not have existed in the form of a gas under the circumstances.

Mr. Bewick said, he was sorry to interfere with the feelings of delight expressed by Mr. Lebour, but he felt compelled to remark (and that without at all detracting from the merit of Mr. Burns' ingenious paper) that what had been said did not convert him to the belief that the Whin Sill was an intrusive rock. As was known to the members of the Institute he had taken considerable interest in the subject, and had read all or most of the papers which had been written upon it; amongst others he had read the

elaborate paper written by Mr. Lebour and Mr. Topley, recently published in the Transactions of the Geological Society, and even with that, he was far from being satisfied there was sufficient evidence that the whin was an intruded rock. Mr. Daglish had just alluded to the chemical aspect of the question. He did not profess to be a chemist, and, therefore, would leave it to those who were acquainted with that branch of the subject, but looking at it mechanically he could not conceive it possible for the Whin Sill to have intruded itself in the way described. The writers of papers on the Whin Sill had, for the most part, confined their observations to its outburst at the northern, and perhaps the middle part of this county, and again at the other end in the county of Durham, and on the borders of Yorkshire, without taking into account that part of the whin which had been laid open by mining operations, where no circumstances, which he had ever seen, occurred to show that it was an intruded rock. Now, he could not but think that at a great depth from the surface was a better position to base an argument upon, than from a mere outcrop of the basalt; and, as he had already stated on former occasions, there were places at depths varying from fifty to one hundred fathoms, or more, under the surface where it could be examined, and where no such indications existed as were described by the different writers on the subject. This he thought ought not to be ignored. The Whin Sill was found extending through a considerable area in Weardale, in Alston Moor, and in Northumberland, and veins of lead ore were being worked therein. He would like very much if Mr. Lebour, Mr. Burns, and other gentlemen who took so much interest in this matter, would examine and study the Whin Sill under these circumstances. If this was done he could not but think that many of the theories which had been propounded in connection with it, would be upset. His own impression was that several of the interesting sections which had been produced by Mr. Lebour and Mr. Burns were cases in which there were other whins, if he might so term them; that is, a second, or third, or even perhaps a further outburst or overflow of basalt. This was only what occurred in his own mind, because he freely admitted that he had not examined any of the places referred to by Mr. Lebour and Mr. Burns. His experience of the Whin Sill was confined almost entirely to the mining districts extending between the rivers North Tyne and Tees, and its long outburst in that district. Beyond that he had not investigated the matter, but he thought that the members of the Institute could not but be pleased that gentlemen of experience, who possessed the opportunities which Mr. Lebour had had, and which Mr. Burns has, of investigating this subject, should have given so much

attention to it. He felt obliged to them for bringing the matter forward; although, at the same time, they had not satisfied him that the whin was an intrusive rock.

Mr. W. H. Hedley said, that he also had noticed in Mr. Burns' paper the same peculiarity which Mr. Lebour had remarked upon, namely, that it took for granted the intrusive origin of the Whin Sill—that it, in fact, somewhat begged the question; and although the theories advanced in Mr. Burns' paper were very attractive, it hardly appeared to him that they contributed so much to strengthen the belief of those disposed to think that such had been its origin, as did certain stratigraphical characteristics described by Messrs. Lebour and Topley, in the paper referred to by Mr. Burns, read before the Geological Society, and which, to his mind, were very much more convincing. He scarcely thought that, as an Institute, they had before them information sufficiently detailed and clear to warrant them in taking for granted as a fact that the Whin Sill was intrusive in its origin, and he considered it highly desirable, if Mr. Lebour would do so, that he should contribute either a digest, or an amplification of the paper which Mr. Topley and he put before the Geological Society, and which particularly described the district between the South Tyne and the Tweed. There, he thought, instances were given, and sections shown which were very much more convincing than anything else. As to the origin of the Whin Sill having been intrusive in its character, he would mention, for instance, the section at Ward's Hill, where at one point the whin was seen to overlie the limestone; and at another point, at no great distance, it was seen to underlie the same bed—the gradual change of position of the whin in relation to the bed of limestone—the protrusion, in fact, of the whin through the limestone being very plainly apparent. He hoped, therefore, that they might have some such contribution from Mr. Lebour, as he thought it would very much help to satisfy those who had any doubts as to the intrusive origin of the Whin Sill.

Mr. Bewick said, the observations of Mr. Hedley had just called to his recollection a section at Ward's Hill, given in Messrs. Topley and Lebour's paper, in the Geological Society's Transactions, where he always understood the Whin Sill was proved beyond doubt to have changed its geological horizon. In that diagram, the coal on the under side of the whin was shown by a solid black line, whilst on the opposite side of the whin, that is, where it is assumed the whin had passed through the coal, it is shown in dots as if it was mere supposition.

Mr. Greenwell—Yes. He would like to understand how the whin

could be called otherwise than intrusive if it was to be found passing through a certain well known bed of limestone—passing through strata— which, but for that whin, would be continuous, and through three or four different beds of limestone which would otherwise have been in existence as continuous beds. He would like to have some idea propounded as to how the Whin Sill could be otherwise than intrusive.

Mr. Bewick said, in answer to Mr. Greenwell's enquiry, he would simply say: Was there any well proved case in which the Whin Sill had passed through a stratum of either limestone, shale, or sandstone? That was what he doubted.

Mr. Greenwell said, he should think from what had been said and from the papers which had been read to them, and which must either be founded on fact or idea, that, if they had been founded on fact, the answer had been given to Mr. Bewick's question.

Mr. Lebour said, he ought to say a word as to the section at Ward's Hill to which Mr. Bewick had referred. Mr. Bewick was perfectly right as to the coal on one side of the whin being represented by a dotted line, and on the other side by a whole line. The reason why that was done was simply to follow out the practice—which he believed was that of all those who wished to represent sections accurately—of only drawing with entire lines those portions which could be actually seen, and with dotted lines those portions which are inferred, however certain the inference may be. In this case of Ward's Hill, he had no doubt whatever from the experience which Mr. Bewick had had with whin sill, limestone, and coal, that he would not be at the spot five minutes with him (the speaker) before he would infer the coal exactly as had been done in the paper referred to; and he (the speaker) was equally convinced that if he went to the other places alluded to he would draw the sections as they appeared in the diagrams, only he would draw them better no doubt. At the same time he quite saw the force of Mr. Bewick's arguments as to the possibility of the whin, which Mr. Fryar and himself represented, being another whin than the Great Whin Sill. That he thought was Mr. Bewick's strong point; but he would be very happy some day to take Mr. Bewick along the outcrop of the Whin Sill from the Tyne to the sea coast; and, with the exception of a few breaks to which Mr. Burns had called attention, he would stick to the whin as far as this particular whin at the Harkess Rocks. He could not state in so many words when he read his paper that this was the Whin Sill, nor could he do so now, but the inference that it was so was irresistible, and he would have no hesitation in drawing a dotted line— one of those to which Mr. Bewick objected—in connecting that whin

with the crags at Spindlestone and with those rocks which lie between Belford and the Harkess Rocks, near Bamborough.

Mr. Bewick said, he did not object to dotted lines; it was the distinction between the two to which he took exception. There had been much pleasant and useful experience gained by the recent excursions of the members of the Institute, and he suggested that they might spend a day or two in the field, examining the outcrop of the Whin Sill from the Tyne, say a few miles northwards, and then see for themselves really what is the state of the case.

Mr. Burns said, he would like to reply briefly to a few of the speakers. Perhaps he ought to apologize for having taken for granted that the whin was intrusive. Certainly it was no part of the object of his paper to prove that point; it was taken for granted, and he did not for a moment put forward the paper as a defence of it. What he wanted to explain was, why it had burst through so frequently under the limestones and over the shales. That was the whole scope of his paper, and it did not undertake to do with the question of whether or not the whin was intrusive. If the whin was not intrusive his paper was simply idle talk; but for years past it had been, to his mind, so conclusively proved that it was intrusive, that he expected that view of the whin would have been allowed without difficulty. Now, as to limestone under heat and under pressure, he was not much of a chemist, and if it could be proved that limestone under moderate pressure and exposed to a great heat did not give off carbonic acid, either in the gaseous or the liquid state, then his theory was a failure. For his part he did not know whether it would do so or not. He simply put it forward as a speculation; but he thought there was a great danger of making too much of this pressure. If the area of the cavity was small it would be protected from pressure from above by continuous strata of great strength and thickness. There was no necessity to take into consideration the whole weight of the strata above, for that was carried by the stratum on either side of where the action took place, as the roof of a level in good stone is carried by the sides. Now, if a very small aperture was caused in the way he suggested, all the force which the gas would require to exert would be to push the shale possibly an inch or a couple of inches aside, sufficient to determine the direction which the whin was to take. It did not need to have a great cavity like that shown, nor one sufficient to hold the whole of the whin. With regard to the pyrites, the limestone in the district, where it was not in contact with the whin, showed no pyrites, so far as he had seen, and in immediate contact with the whin there was a very great deal, showing that the limestone had

got this iron pyrites from the whin in some way; and, moreover, the iron pyrites could not have been there or in the solid limestone unless part of the limestone had been volatilized and this pyrites had taken its place. There was no doubt whatever that the whin flowed along the line of least resistance; but that was nothing to the point. The question was: why was the line of least resistance always, or nearly always, under a limestone and over a shale? That was the question which he had set himself to answer. If the pressure was sufficient to make the carbonic acid gas liquid, he did not know that that would matter very much. He thought that the whin could obtrude itself through the liquid, and so pass along the chamber containing it, just about as readily as if it were filled with gas. As to Mr. Bewick's objection respecting the intrusion of the whin, though it was foreign to his (Mr. Burns') paper to discuss the intrusion of the whin, he might say that he knew of two very deep shafts with which Mr. Bewick had been long and honourably connected. These were two shafts in the W. B. Mines, in Weardale, in which the whin had been sunk through. One was called the Burtree Pasture Shaft, the other was called the Slitt Shaft. In both of these cases the whin, from twenty-five to forty fathoms in thickness, had been sunk through, and he did not think that Mr. Bewick or anybody else had the slightest doubt that they both represented the Great Whin Sill. Now, if the sections of these shafts were compared, it would be seen very conclusively—at least to his mind it was quite conclusive—that in the two shafts the whin was in quite a different horizon. At the Slitt Shaft it was under the Tyne Bottom Limestone (a limestone about thirty or thirty-four feet thick), and at the Burtree Pasture it was over that limestone, the next limestone above being a thin limestone, four feet thick, which the miners of Weardale call the Tyne Bottom Limestone; but, from tracing it on Alston Moor and in Weardale, he was as certain as he could be of anything that it was the limestone next above the Tyne Bottom, usually called the Single Post Limestone. Such was the evidence derived from deep shafts and explorations which bore on the subject.

Mr. Bewick said, he knew both the shafts to which Mr. Burns had alluded; and it was the first time he had ever heard it mooted that the Whin Sill at these places was in different geological horizons. He could not believe that such was the fact. There must be some mistake. The shafts had been in use many years, and there were exact sections of the strata sunk through. The Great Limestone, which was a good datum or starting point, happened to be in both cases near the top of the shaft, and all the different limestones and other beds of sandstone and shale occurred in regular order, the Tyne Bottom Limestone being above the whin in both cases.

The President said, as no other gentleman had any further remarks to make, he would be very glad to move a vote of thanks to Mr. Burns for his very interesting paper. He did not know a great deal respecting the geology of this particular district, but the discussion had been most interesting, and he was sorry that there had not been more of what he might call their geological members present, such as Mr. Boyd and others, who had taken great interest in the geology of this district, and who would, no doubt, have added greatly to the discussion. He begged to move a vote of thanks to Mr. Burns for his paper.

The motion was carried by acclamation.

Dr. Walter Saise then read the following paper:—"Notes on the Geology of the Bristol Coal-field, with Special Reference to the Gloucestershire Basin."

[Plate V. To illustrate Mr. David Burns' paper "on the intrusion of the Whin Sill"]

NOTES ON THE GEOLOGY OF THE BRISTOL COAL-FIELD, WITH SPECIAL REFERENCE TO THE GLOUCESTERSHIRE BASIN.

By WALTER SAISE, D.Sc., F.C.S.

The papers already communicated to the Institute on this subject date as far back as 1854 and 1861. In 1854, and again in 1861, Mr. Greenwell gave a short account of the Somersetshire portion of the coal-field, a map and section accompanying the earlier paper. At the latter date also Mr. Handel Cossham gave some account of the Northern or Gloucestershire portion of the field, a map and several sections being appended. On referring to those papers, the writer has noticed that there are some points on which later observations and extended mining venture have shed additional light; and what were surmises then have either been since verified or corrected. The writer, who had the good fortune to commence his mining and geological studies under Mr. Handel Cossham, thinks that a short summary of the knowledge with regard to this complicated little field and a few particulars relative to the mining industry will not be unwelcome to the members of this Institute; and so, without going over the ground already so well dealt with by the gentlemen mentioned, he wishes to offer the present paper as a supplement to what has already appeared in the pages of the Transactions.

The Bristol Coal-field, as a glance at the map, Plate VI., will show, is almost entirely concealed by newer measures, the exposed having an area of about fifty square miles; the concealed, of about two hundred and forty square miles. It is this fact which has made the field so difficult to understand, and which has retarded in such a great degree the development of mining industry. The coal contained in this field is about $\frac{1}{17}$th of the total wealth of England, and yet the output is only $\frac{1}{125}$th of the total production. It is divided into several basins, those of Gloucestershire and Somersetshire being the two most important. The small basins of Nailsea, Clapton-in-Gordano, and the recently discovered one of the

[88]

Severn are of minor importance. They have been less explored, and in each of the three the upper measures seem to be absent.

The three latter basins are separated by well-defined anticlinal axes, as shown in the map, the Carboniferous Limestone forming these axes. The Gloucestershire and Somersetshire basins are separated by the Kingswood anticlinal only to the extent of the Upper Measures and the Pennant, the Lower being continuous. This fact was not thoroughly understood at the time the papers above cited were written, and consequently in each the Millstone Grit is represented as separating the two basins. The fact of this supposed Millstone Grit being a sandstone of the Coal Measures has been thoroughly established, and coal is being won seven hundred yards beneath it of superior quality. A paper, illustrated by sections, fully explaining the reason of the mistake being made, with several other interesting points as to the history of the district was read by Mr. Cossham and the writer before the British Association in 1875, and published in the Colliery Guardian, and need not be repeated here. The continuity of the Lower Measures is, however, interrupted by a fault of considerable magnitude. This fault (called "Great Fault" in Plate VI.) is an upthrow on the south, but the amount of dislocation has not been accurately determined. Assuming the general section, which has been prepared with great care from the least faulted parts of the district, to be correct, the fault is an upthrow at its western extremity of nine hundred yards; at its eastern end the throw has diminished to five hundred and sixty yards. The influence of this fault on mining explorations has been very great.

The map has been prepared to show at a glance the boundaries of the field, and, without introducing the complication of colouring the overlying strata, to indicate their extent. This, as will be seen, is obtained by colouring the exposed and concealed portions with different tints.

The influence of geological structure on the scenery is perhaps nowhere better shown than in the Bristol Coal-field. Here are the grassy downs, the high hills and the gorges characteristic of the Mountain Limestone. The gorge of the Avon, the combes and gorges of the Mendips, the downs, as Broadfield and Clifton, are familiar examples. The escarpments of the lias and trias which fringe the exposed portion of the coal-field, overlook the picturesquely weathered crags of the hard Silicious Pennant Rock wherever a brook or river has forced its way through it. Passing upwards from the lias, on the west and south, the Mountain Limestone is reached. On the east, the pleasant dales and hills of the oolites form the boundary of the basin-like valley, which is the site of mining activity in the Bristol district.

[89]

The Secondary Strata has been described by Mr. Greenwell at some length in his paper, and so the writer will not mention it here except to note that in the railway cutting between Yate and Thornbury at Grovesend a good section of the Dolomitic conglomerate (the age of which seems as doubtful now as then) may be seen lying on the upturned edges of the Old Red Sandstone.

The Coal Measures, which lie within the space marked by the yellow band of Millstone Grit, are divisible into—

Upper Measures,

Middle or Pennant Series,

Lower Series.

The three large divisions here indicated can be traced in the exposed portions with considerable accuracy, as the Pennant forms a landmark which cannot be mistaken. In the concealed portions the position and lie of the measures have been determined by pits. Although these groups can be recognised, the individual seams composing them vary much in different parts of the field. No doubt as successive links in the chain are filled up it will be possible to compare the opposite ends, and to see more relation in the comparison than at present. In the meantime, the following method of correlating, or rather placing the seams in position for comparison, is offered. Instead of a general section of the district (the sections by Mr. Greenwell and Mr. Cossham sufficing for that), a diagrammatic section is given, Plate VII., and at certain proved positions, almost in each case this is on the outcrops, a vertical section is added. Wherever there is sufficient similarity the seams in different sections have the same names.

Taking them in descending order, the Upper Series comes first. A glance at the diagrammatic section will show that in the northern basin the development of this series is not so great as in the southern. This is probably due to denudation, as there are indications in the central and deeper part of the basin that a higher series, corresponding to the Radstock group of the Somersetshire basin, once existed here. The group left consists of the six seams, four of which are workable. They are called the Parkfield or Coalpit Heath Series, and correspond to the Farringdon Gurney Series of the southern basin. In attempting to correlate the seams in the two basins, there is, however, no datum. Except at Brislington, where the four seams given in section have been worked, and where they crop out near the church, a larger number of seams are found than in the northern basin. The four seams of Brislington, and those of Queen Charlton, probably represent the four workable ones at Parkfield.

[90]

Above the Farringdon Gurney Series, in Somersetshire, come the Radstock Group, of which a section is given. As Mr. Greenwell has already given some account of them, and promised another paper on the subject, the writer will pass to the Pennant Series.

The Pennant is an easily recognisable sandstone, of a red colour, and often of a micaceous appearance. It is largely in request for building and paving, being obtained at various places of its outcrop in Somersetshire, along the River Avon, and at Stapleton, Frenchay, and Winterbourne, in Gloucestershire.

The watery nature of this strata has prevented the opening out of the seams to some extent, but along the outcrops the coal on nearly every seam has been taken to a greater or less extent, adit levels having been used for the purpose of draining.

It will be noticed that in the diagram some of the seams usually classed with the Lower Series have been put with the Pennant, the names of Middle and Lower Pennant being given to them, the term Upper Pennant being reserved for the great mass of Pennant which contains but one or two seams. The reason for this is that these seams in their grouping, in their quality, and in the nature of the enclosing strata, form a natural division, separated by well marked characters from the Lower Series. More than half the enclosing strata in the Lower Pennant is that hard red sandstone usually called Pennant; the seams are friable and of smith's coal character, and there is much fireclay. In Gloucestershire most of the Pennant Sandstone used in building, for paving, &c, is got from the Middle Pennant. This natural division can be traced from Bristol to Golden Valley on the south of the anticlinal, and exists along Stapleton, Fishponds, and Mangotsfield on the north of the anticlinal. It is true that on reaching Volster the character of the coals has changed. No longer friable and of smith's coal nature, they are good house and gas coals, and contain, the writer believes, better coal than the Lower Measures, though this may be the result of being more explored.

At Cromhall, and where exposed on the north of Gloucester basin, there are no seams of importance in the Pennant. At Mangotsfield on the south there are two or three seams of sulphury character in the Upper Pennant, and on the south of the River Avon, and at other points, seams of a similar nature have been met with. The Middle Pennant on the north contains at Fishponds three seams of good smith's coal. These seem to be the equivalents of the seams worked along from Pylemarsh to Newton St. Loe, and may be the equivalents of the New Rock Series of Nettlebridge. The Lower Pennant Series are also smith's coals at Kingswood

[91]

and at Golden Valley, but become house coals on the south at Nettlebridge. The change in the character of the coal precludes the hope of correlating these seams by their physical appearance. It seems to be one of the characteristic features of this field that the seams vary very much in each of the three series mentioned. The writer, however, was led, during a series of analyses he made of the coals of the Gloucester basin, to believe that the ash might be some criterion. It was noticed that each seam examined had a particular colour, varying from deep brown, through red and mauve, to pure white; and the structure, from sandy appearance to the fluffy feathery character which characterises the Upper Toad seam of the Lower Series. The specimens examined showed very similar appearances when taken from the seam at distances of about a mile apart, but whether it could hold for greater distances cannot be said. It was once used to test a leader of coal found in driving through a fault which had been a source of trouble for three years, and the proving of which has still to be done. The decision was against its being the seam wanted, and the decision proved to be correct.

There is another point, too, that the writer wishes to mention. Is the absence of sulphur essential to a good smith's coal? The writer has, in company with another gentleman, analysed a smith's coal, which is unequalled in the Bristol district, no less than four times, and each time 3 per cent. of sulphur was obtained. The statement of the analysis has been mislaid, but the amount was too great to be forgotten. From this it would appear that the physical nature of the coal has something to do with it; a bright, clear fire, where the particles do not agglomerate, being the requirements.

Below the Pennant Series come the Lower Series. A glance at Plate VII. will show that this series is very unequally developed at the three points of outcrop. At Cromhall two seams represent the measures, which at Kingswood are the seat of extensive mining enterprise. At Kingswood, in the Lower Series, there are about twenty-six seams, and at Nettlebridge about seventeen, though probably at the latter some may not have been noticed.

The relation of the three principal divisions having been shown for the whole coal-field, the writer wishes now to direct special attention to the Gloucestershire portion of the field, or the part north of the River Avon.

Plate VIII. gives sections of pits on the different series, and also a general section of the measures as they are, in all probability, developed in the Gloucester basin.

[92]

In the sheet of sections shown, four pit sections are taken from Somersetshire, but merely to complete the general section of measures in Gloucestershire.

The Upper Series consist, as shown in the section, of four workable seams, called respectively the Hard Vein, Top Vein, Hollybush and Great Veins. The thickest is the Hollybush Vein, 8 feet in thickness; the thinnest, the Top Vein, varying from 14 inches to 22. They are all gas coals, and find a ready market at Bath, Bristol, and Exeter.

The quantity of ash left by these seams is rather greater than some of the better class Newcastle and Midland Counties gas coals, but in other respects they compare favourably. The following is the average of several analyses of the four seams:—

Specific gravity	1.26
Volatile matter	33.77
Fixed carbon	60.67
Ash	5.60
	100.04
Sulphur	1.36

The Long-wall method appears to be the best adapted for the successful working of these seams. Either the floor or the roof is ripped up, and this ripping supplies packing, but large quantities of rubbish have to be sent to the surface. The total thickness of workable coal is 10 feet, and, taking the specific gravity at 1.26, there are 1,526 tons per foot per acre. This gives, for the whole basin, 48,768,000 tons, of which 17,000,000 have been gotten. Allowing one-fifth for waste, there remains 25,000,000 tons still to be worked. On these seams there are two collieries—Coalpit Heath and Parkfield. At Parkfield, where the Long-wall is adopted, 1,400 tons per foot per acre are gotten. The output of the two collieries is about 200,000 tons annually.

The Pennant Series, in the sense already mentioned, are not the scene of extended mining operations. Water too often brings the attempts to a close, the free and open nature of the rock allowing all the surface drainage of the district to percolate, at least this is the case in shallow mines. Mr. Cossham announced last year that he had pierced the Pennant below the Upper Measures and had not suffered from water. Too much reliance, however, cannot be placed on an isolated instance, as against this many opposite cases can be cited.

In the Middle Pennant, north of the fault, three seams—the Cock,

[93]

Chick, and Hen—have been worked from Mangotsfield, in the direction of Bristol, to depths varying from fifty to one hundred and thirty fathoms. Now, however, these works are standing full of water, and the newer formations hide the outcrops on the east and west. The coal was of good smiths' coal quality, and the seams averaged 2 feet 6 inches in thickness. The range of the three seams is unknown, but taking it at five miles, there remains about 24,000,000 tons of coal yet to be worked. Along the north of the River Avon these seams, under the names of the Millgrit, Rag, Devil's, Buff, and Parrot, have been worked to a considerable extent, as the sections given will show. The seams have not varied much in different places in relative position; but the thickness is very variable, even in the same mine. The only seam at present worked is the Parrot, at Golden Valley, though efforts are being made to win these seams at a place called California Pit. The Parrot, at Golden Valley, is only 1 foot 6 inches thick, but on account of its good quality as a steam coal it commands a ready sale. The Lower Pennant, or the seams that are also called Stibb's Series, have been proved under the above in Gloucestershire, from Bristol to Golden Valley. At the latter place one of them, the New Smith's Coal, is still worked. All other pits are stopped, but lines of old pit heaps mark the position of former activity, on a small scale it is true, but sufficiently large to show that the coal can be worked. On the north of the anticlinal these seams have not been proved. The fault, which has been mentioned as having such a great upthrow to the south, has cut off the outcrops. If they exist on the north of the anticlinal, and there seems to be no valid reason why they should not, they must underlie the Cock, Hen, and Chick, as shown on the general section.

South of the anticlinal, and occupying the ground between it and the series just mentioned, are the outcrops, where exposed, of the Lower Series. Of the higher members of these there seems to be some doubt. At Kingswood (Rose Green, Plate VIII.), the Whitehall and Queenbower have been worked in former times, but these seams have not been recognized either to the east or west of this district. Below these come the Kingswood Seams, so called from the Kingswood Collieries which have proved them from the Doxall, down to a new seam, probably one of the Ashton Series—a thickness of strata amounting to five hundred yards. This five hundred yards of strata contains many seams. Those that have been worked are called in descending order, Doxall, Upper Five Coals, Rock, Primrose, Lyalong, Old Toad Vein, Hole Vein, Lower Five Coals, Thorofare, Great Vein, Giller's Inn, Little Toad Vein, Little Fiery, and Parker's seams. Below these are the Ashton Series,

[94]

proved at Soundwell (for the Hard Venture Series of this pit are probably their equivalents) and at Ashton and Bedminster. Evidence is not so clear as could be wished on this point, as when a pit has been depended on for definite information, or a drift or branch has been driven to prove succession of strata, the one has gone through a fault and the other has met with troubled ground.

On these seams and in this district, that is, south of the anticlinal, the most important collieries of Gloucestershire are situated. The coal is of fair quality, and in request both as a steam and house coal, the Midland Railway, and the Somerset and Dorset Railway, taking large quantities for the former purpose. The results of the analyses of six seams by the writer gave the following average:—

Specific gravity	1.312
Volatile matter	22.20
Fixed carbon	71.93
Ash	5.71
Sulphur	1.46

The ash in the Lower Series is thus in excess of the standard steam coals of Newcastle and South Wales. The quantity of fixed carbon, which determines the value of a coal for steam purposes, varies from 68 per cent. in some seams to 81 per cent. in others. Taking only the seams that have been worked to some extent and have been well proved, namely, the Doxall, Five Coals, Toad Vein, Lower Five Coals, Great Vein, Little Toad, Parker's Top, Ashton Top and Great Seam, and excluding the Queenbower and Whitehall as doubtful, there is a thickness of twenty-seven feet. The specific gravity being taken as above, we have in an area of 8,800 acres, after allowing for what is already worked, for future waste, &c, 300,000,000 tons still to be gotten. The collieries on these seams are at present, Easton, Whitehall, Pennywell Road, Kingswood, Cheltenham, Warmley, and Crown Collieries, getting in all about 250,000 tons per annum, of which Kingswood supplies about 150,000 tons. Where these known seams pass into Somersetshire, are the Ashton, Malago Vale, and Bedminster Pits on the west, and on the east Pennyquick, which has now been closed. At Pennyquick, which is the most easterly situated colliery in the Lower Series, the seams have been found very contorted, and, consequently, the correlation has been hard to make out. The Black Chalk Seam, by the possession of this black chalk or jingle boys, seems to be the Giller's Inn Seam, and the presence of the peculiar worm bed points to the same conclusion.

[95]

On the north of the fault this valuable series of measures has only been proved at Cromhall, Yate, and Wapley. At the first, as the general section will show, the measures have thinned out to two seams. At Yate some seams are present above these, and at Wapley the disturbed ground prevents any conclusions being drawn. It should be mentioned that a little further south, viz., at Siston Hill, south of the fault, the Lower Measures were very productive.

Now when it is seen that the Soundwell Collieries which worked up to the fault on a northern dip, the Kingswood Collieries which have worked up to the anticlinal and over it to a fault, and Easton Colliery which is working up to the anticlinal, and each in good coal in no way deteriorated in quality or diminished in thickness, though thrown into a steep position, it must be concluded that on the other side of the fault these measures must exist, and probably in as good quality. The measures north of this fault are nearly flat, the Pennant from Mangotsfield, past Winterbourne, dipping at about three degrees, and a sinking through 200 feet of lias along a line drawn from Bristol, west of Winterbourne, should prove good coal, or a pit through the Pennant would come to the same thing. It may be objected that the thinning out of the measures towards Cromhall is against this supposition, but the influence of the thinning out can hardly be felt so soon. The Middle Pennant is well developed, and this supports the idea that the underlying Lower Measures will be also. Assuming this, but allowing that they only extend half over the basin, and then thin out to the Cromhall seams, there are 923,288,040 tons above 4,000 feet in depth. Allowing one-third for waste, pillars, etc., there are 615,525,368 tons of coal to be worked on the Lower Series. On the Upper Series, which contain about 25,000,000 tons yet to work, there are two large collieries producing about 200,000 tons of coal per annum. On this Lower Series, with more than 600,000,000 tons, there are two small collieries, viz., Yate and Rangeworthy. It is a rather noticeable fact that such a store is left neglected, and pits sunk where the chances are very great that the coal has already been worked, or the danger of being drowned from old workings is very probable.

It will be noticed that much stress has not been laid on the Pennant Series. The reason is the uncertain thickness of the coal, so that what may be a good seam in one district may be rubbish in another. The Parrot Seam, of Golden Valley, is replaced by black shale at Kingswood.

The changeable nature of the coal is a marked character of all the seams of this area, as before noticed. Still the chief seams are fairly persistent, and these only have been taken into account in calculating the

probable quantity hidden under the Trias, Lias, and Pennant Sandstone of the Gloucestershire basin. In connection with the geology of this district, it may be mentioned that faults parallel with, and near to, the anticlinal generally seem to be overlaps. The writer refers of course to the ordinary small faults met in underground working. The tendency too, in the coal, is to be very irregular in the dip, sometimes standing on end for a hundred yards or so, and then going off at the proper angle again. The anticlinal would appear to be the point of a great crushing strain, the natural result of which would be overlap faults and irregular strata. This irregularity has prevented in some measure the proving of the lowest members of the Lower Series in its neighbourhood.

It may not be uninteresting to notice the system of working in the Lower Series, where steep seams and bad roofs have combined to make the working difficult and expensive. Plate IX. shows the system on the Great Vein. From the main level hatchens, as they are called, are turned to the rise, a pack or clock being set on each side of the hatchen, four feet square. At these points a filling place is made, and a plate laid so that the tubs can be pushed in off the rails. These hatchens are not ripped, the coal being brought down in one of the following ways, the method being determined by several conditions, as inclination of place, scarcity of boys, &c.:— (1) Where lads are not employed the coal is let down in shoots, a hopper being used to let the coal into the tubs as required. (2) Sometimes self-acting inclines are made, the chain running over a small sheave, which is shifted up as the faces advance. (8) When lads go up and down with the sleds, as they are called, a chain has to be laid down the centre of the road to assist them in letting down the full sled, and to be used as a hand-rail when they are pulling the empties up. These hatchens only go up forty yards; one is driven forty-four yards, and is then ripped and rails laid; a reel or drum is set at the top, and the hatchen then becomes a "running gug," or self-acting incline. A level road is turned from this incline to the right and left, and this cuts all the hatchens of the lower level off as they come up the forty yards.

The level roads are ripped right into the face, one shift of rippers following two shifts of coalmen. The level heads are carried nine yards wide, five being to the rise and four to the deep side of the road. The rise side pack is four yards wide, the deep side pack is less. The packs on each side of the hatchens vary from three to four yards. From the lower side of the level a deep side cross-cut is turned off and continued parallel with the level as soon as there is sufficient room to give five yards of coal on the rise side. This cross-cut is ripped and packed in the same manner as the levels. Two hewers or coalmen work in each place.

The ventilation travels as shown in Plate IX. The chief use of the cross-cut is to carry the air in bye. After passing round the face the air escapes into a higher district or passes by a short stone drift or branch into the overlying seam, the Thorofare, on which, as the roof is a splendid one, the returns are carried.

The method on the Upper and Little Toad Veins is very similar, and only differs in the length of the hatchens, which are eighty yards in the former and sixty in the latter case.

The roof of the Great Vein is so bad that it is found advisable to carry the main roads in the Little Toad Vein, and to connect these roads with the Great Vein workings by drifts of 120 yards in length as occasion requires, the roads on the Great Vein being allowed to fall together.

The President said, he was sure they must all feel very much obliged to Dr. Saise for his very interesting paper. He thought they had better adjourn the discussion until the paper was in print, when, by referring to the plates, they would be better able to understand it. He begged to move a vote of thanks to Dr. Saise.

Mr. J. B. Simpson said, he had great pleasure in seconding the vote of thanks to Dr. Saise for his able paper, which would be a valuable addition to what is already known of this coal-field. It appeared to him, from the figures given by Dr. Saise, that the Bristol people need not be afraid of its being exhausted for several hundred years.

The motion was carried by acclamation.

The meeting then terminated, and the members proceeded to the Chemical Lecture Room of the College of Physical Science, where Professor Freire-Marreco exhibited the Grisoumetre of M. Coquillion in action.

[98]

[Plate VI. Sketch map of the Bristol coal-field;

Plate VII. Diagrammatic section of the Bristol coal-field;

Plate VIII. Vertical section of strata in Gloucestershire with pit sections arranged for comparison;

Plate IX. Method of working coal on the lower series at Kingswood;]

[99]

PROCEEDINGS.

GENERAL MEETING, SATURDAY, FEBRUARY 2, 1878, IN THE WOOD MEMORIAL HALL.

LINDSAY WOOD, Esq., President, in the Chair.

The Assistant-Secretary read the minutes of the last general meeting, which were confirmed and signed, and the proceedings of the Council Meetings were also read and agreed to.

With reference to the minutes of the Council appointing a Committee to report on the further development of the systems of Underground Haulage since the Report in 1868;

The President said, the reason why a Committee had been appointed to obtain more information on the Tail-rope system of Haulage was on account of the Council having received a communication from Mr. Bainbridge, in which he quoted three or four different systems which were now being worked in various parts of England, that were not mentioned in the former report of the Tail-rope Committee, and which were, he believed, considerable improvements on those existing at that time. The Council therefore thought it would be advisable for a small Committee to be appointed to obtain information as to what these different modes were, and to report to the Council whether it would be worth while to expend a sum of money in obtaining particulars in the same way as had been done with regard to the former report on tail-ropes.

The President laid on the table a copy of the new volume of "Lindley and Hutton's Illustrations of Fossil Plants," and said it was ready for publication, and any member could obtain copies from Mr. Reid, Printing Court Buildings, Newcastle, at 25s. each.

The Assistant-Secretary said there were no members for election, but the following were nominated for election at the next meeting:—

Ordinary Members—

Mr. J. Pease, West Cannock Colliery, Hednesford, Staffordshire.

Mr. Walter Topping, Messrs. Cross, Tetley, & Co.'s Collieries, Wigan.

Associate Members—

Mr. W. J. Greener, M.E., Pemberton Colliery, Wigan.

Mr. Corby S. Fennell, Bjuf Colliery, Helsingborg, Sweden.

Mr. W. B. Brown, Springfield, Victoria Park, Wavertree, Liverpool.

Mr. Thomas Winter, Messrs. Tangye Bros. and Steel, Swansea.

Students—

Mr. W. H. Pickering, Pemberton Colliery, Wigan.

Mr. W. C. Dowson, Belle Vue House, Escomb, near Bishop Auckland.

Mr. Philip Kirkup, Lofthouse Station Colliery, Wakefield.

Mr. Jos. S. Hudson, Cambois Colliery, Blyth.

Mr. Alex. Scott, Mining Pupil, Peases' West Colliery, by Darlington.

Mr. Alfred R. Oldham, Mining Pupil, Rockingham Colliery, near Barnsley.

The discussion of Mr. William Cockburn's paper, "On Cooke's Ventilating Machine," and Mr. William Cochrane's paper, "On the advantages of Centrifugal Action Machines for the Ventilation of Mines," was then proceeded with.

The President said, he was very sorry to find that Mr. Cockburn was so unwell as to be unable to attend the meeting. He was, however, glad to see that Mr. Cooke was present, and would like to know if he had anything further to add to his paper?

Mr. Cooke said, he had a few additional remarks to make, and he had written them down to save time. He read as follows:—

The machines described in Mr. Cockburn's paper are of excellent workmanship and design, such indeed as to yield results which perhaps may be considered unsurpassed. He had assisted at many of the experiments, and could vouch for their general accuracy; the very inconsistencies and deficiencies which have been cited by Mr. Cochrane had very early attracted his attention, and were the result of a mechanical defect in the attachment of the shutter which necessitated an alteration, if perfection was to be obtained.

The defect alluded to will be understood from the diagram, where the drum and casing described in the paper will be easily recognised.

The lower curved arrow in the wood cut (shown on the opposite page) represents the direction of the air from the mine, while that above shows its exit. But there is a straight arrow pointing downwards through the shaded part which unfortunately represents a large re-entry of air, which occurred in the earlier models, notwithstanding the geometrically perfect design of the machine.

[Diagram]

A much greater area of escape would be developed by increased deflection; but the shaded part fairly represents its average area, which left a clear opening for leakage, 3 inches wide, so favourably formed for free flow as to yield nearly the theoretical velocity of the air. This would give a leakage of 15,840 cubic feet at 1 inch water gauge, and of 28,000 cubic feet at 3¼ inch water gauge, which closely corresponds with the re-entries in the original machine; so much so at least as to indicate that the source of principal re-entry had been found. If this deflection could be dispensed with, much of the leakage which then took place would cease, and to effect this a modification has been made whereby the shutters, kept by the parallel movements at the same angles as before, are geometrically true under pressure, and practically independent of deflection. Each part producing the angular movement has been regulated in the same proportion, and the whole placed at an inclination harmonising with the movement of the shutter.

The length of the lever or spanner which serves to reciprocate the shutter, and that of the shutter itself were first made so as to give accurate results, regardless of the weight or deflection of the shutter. A reciprocating balance weight being objectionable, the shutters were made of great strength in the new machines, and what deflection remained was counteracted by a departure from the true geometric construction of the machine, which permits the shutter to touch the drum at 30 revolutions against a pressure of 2¼ inch water gauge, or about 15 cwts. on the whole area, and as this is about the working speed, the required amount of adjustment seems to have been reached.

Under these improved conditions, 250,000 cubic feet per minute, can be obtained with a Cooke's ventilator of one drum 20 feet diameter by 20 feet long, in round numbers, at any reasonable water gauge.

Displacement machines are more perfect than is supposed. For instance, Roots' Blower at Chilton Colliery has as little leakage at 8½ as at 3⅝ inches water gauge while on the mine, and if the separation

doors are open loses only 4 per cent. of its quantity at 6½ inches water gauge.

A useful qualification of a displacement machine should be mentioned, namely, that by reversing the engine the currents of air throughout the mine are also reversed. The cases are rare, and the rarer the better, where this can aid the ventilation of a mine, but by this means at North Brancepeth, the most satisfactory proof of the extent of pressure due to final velocity has been arrived at. There was a heavy pressure of the shutter against the drum when blowing, which thus acted as a brake and rendered the indicator diagrams useless, but the following results were obtained.

Exhaustion.	average water gauge.	speed of air measure.
28.3 Revolutions.	1.44	53.8 Feet per revolution.
Blowing. 27.66	1.73	49.1

The pits were idle. No regulator was changed, and the separation doors were fast. The upcast shaft was cleared in less than a minute, but the actual pressure was the same after eleven minutes' blowing.

This satisfactorily establishes the fact that with a displacement fan .31 inches say $\frac{3}{10}$ inches representing the final velocity does not appear within the mine unless the air is blown in instead of exhausted; this might be expected, for the airways, regulators, doors, and splits being in the same proportion, are calculated to develop the same friction of the air when passing one direction as the other. The subject wants further investigation but only as to minutiae.

It is intelligible enough that when all the air is before the fan, both that in the passages and that making its exit into the atmosphere, the pressure should be all shown on one gauge close to the ventilator, and within the mine: and equally clear is it that the pressure for overcoming the friction of the passages of the mine, is separated by the ventilator itself from the pressure for expelling the air therefrom when the action is reversed.

The application to Mr. Cochrane's diagram of the modifications shown in the annexed wood cut, will prove that this pressure does appear within the mine in centrifugal machines near the fan, and ought to be deducted when comparing

[Diagram]

[103]

them with a displacement machine, because it does not appear in the case of the latter. At the right hand of the diagram is the water supply; at the centre, an upright cylinder fixed so as to admit of the whirling of water within it. At the left hand is the outflow, not connected with the supply except through the cylinder. At the centre of the bottom of the cylinder is a pipe of such a size that the friction of the water exactly yields the required flow under the assumed head of the supply, and at the surface of the outflow are openings through which the flow is to be made. This shows that the parabola representing the conditions necessarily extends above the surface to the pointed rim, and deeper than the assumed head, and that this is occasioned by the adaptation of the whirling fluid to the inward and outward flow.

That there was $\frac{3}{10}$ inch difference of pressure within a very short distance of the fan at Crags Hall, has already been stated by Mr. Bell, Inspector of Mines, and it can be shown that the friction of the mine has very little to do with the difference.

Not understanding the great results said to have been obtained at Brandon, Mr. Heppell allowed him to ascertain for himself what they were by actual experiment. As he had suspected that some part of these results were due to what he ventured to call pseudo water gauge, he took very great care to ascertain that such a difference existed even at Brandon where the conditions of the mine were favourable, and where the shutter had been very carefully adjusted by Mr. D. P. Morison. The result was that, no doubt owing to the careful adjustment just mentioned, only .23 inches difference was noted notwithstanding the large volume of air, but the whole took place within the space of 7 feet; and any one sufficiently curious will be allowed by Mr. Heppell to verify this statement for himself. But more startling was it to find that the performance of the fan (reading the water gauge as usual) was :—Instead of as stated elsewhere,

							Efficiency.
167,778 cub. ft. per min. at 31.6 revolutions, and 1.10 water gauge							= 69.6 %
Only 147,180	„	42	„	1.535	„		= 45.916 „

and if the difference of pressure described as taking place, and supposed to be due to final velocity, is accepted, then 147,180 cubic feet per min., at 42 revolutions, and 1.305 water gauge = 39.032 %, which is the proper factor to compare with the result shown in Mr. Cockburn's paper as obtained by Cooke's ventilator.

[104]

From the upcast shaft to the Hutton Seam, the differences of pressure between the fan water gauge, and others in the shaft were:—

2' 0"	down	Difference	.04
7' 7"	„	„	.24
20' 9"	„	„	.22
33' 4"	„	„	.23
46' 5"	„	„	.22
58' 11"	„	„	.25
72' 5"	„	„	.24
85' 6"	„	„	.22

Hutton Seam	156' 0"	„	„	.23

The reading for the Hutton Seam allows 15° Fahr. excess of upcast temperature, as well as for the diminished density due to the partial vacuum.

No difference whatever can be observed in the Boyne shaft of the North Brancepeth Coal Co., thirty fathoms away from the Cooke's ventilator, and it is assumed that the final velocity which requires it, is all given off directly by the drum of the ventilator itself.

This being the case at Brandon, it diminishes the confidence which can be placed in some of the other results named.

To meet Mr. Morison's argument that the formula of friction accounts for any difference that may have been observed, take Hawksley's formula—

$h = b v^2 / 156{,}800\ d$ where h = head inches water.

v = feet per sec.

l = length in feet.

d = diam. shaft in feet.

Then $h = (5 + 32^2) / (156{,}800 + 10)$ at Brandon = about $\frac{1}{300}$ inch.

but a difference of .23" actually occurs.

The results from these formulas are quite inconsistent with actual measurements, and require revision.

Mr. Morison said, in reply to one or two of the remarks which Mr. Cooke had made, he would begin with the case of Brandon, which was mentioned last. He (Mr. M.) could only say that the experiments at Brandon were made by gentlemen whose reliability and impartiality were beyond suspicion. He himself had no part whatever either in the measurements or indications, and he believed that the results

were perfectly trustworthy. It was quite possible that the condition of the mine had changed since (the laying in of one seam favouring the suggestion), and that Mr. Cooke had found it had so changed. With reference to the remark as to the difference in reading of the water gauge, between the inlet of the fan, and the top of the shaft, or even down the shaft, he might say that he had made, on several occasions, very careful experiments on that point, and the result was, that the water gauge was hardly found to vary at all between the inlet of the fan and the top of the pit. In cases he had had, where the drift from the pit to the fan was of insufficient area with curves and sudden bends, a considerable amount of difference was detected; and whether with the varying capacity or the centrifugal system this would occur. The mode in which the pipe leading to the water gauge is placed in the drift, has also considerable influence on the reading. If the end of the pipe is turned towards the inlet, some two-tenths of an inch more water gauge (where the total water gauge is three inches) will be found than by turning the end of the pipe either at right angles to the current or facing it. Yesterday, he had some very careful experiments made by the kind permission of Mr. May, whose assistants conducted them most ably for him at the Harton and St. Hilda collieries, where a 50 feet Guibal is at work; and there a pipe was taken from the separation doors in the fan drift. They first took the pipe from the inlet to the fan, and turned it towards the fan. The water gauge thus observed was 3 inches and six-tenths. A second water gauge at the same place, the pipe being at right angles to the axis of the drift, only gave 3 inches and four-tenths, being a difference of two-tenths between the first and second. To test Mr. Cooke's argument, he (Mr. M.) had a pipe added to that of the second water gauge, and taken along the drift to a distance of 60 feet, and instead of 3.4, the average of four observations gave 3.37, only three-hundredths of an inch difference. They then carried the pipe to a distance of 120 feet along the drift, close to the top of the upcast, where they might have expected, according to Mr. Cooke's theory, to have got a difference of nearly an inch, but they there actually found 3.35 inches instead of 3.4. These figures spoke for themselves, and the apparatus was there and could be tested at any time. Referring now to Mr. Cockburn's paper on Mr. Cooke's ventilator, and to the remarks which Mr. Cooke had made, he might say, first of all, he was very glad that Mr. Cooke had to a certain extent surmounted the difficulty which he (Mr. M.) had always foreseen, viz., the very large re-entry of air. If by any alteration this re-entry could be practically avoided, in the way described by Mr. Cooke, he (Mr. M.) would be one of the first to congratulate him.

[106]

In Mr. Cockburn's paper, however, the capacity of the ventilator was given as 4,530 feet per revolution; while in nine experiments made at Upleatham, the following were the actual volumes observed:—

Upleatham Experiment		No. 1	4,399 cubic feet per revolution.		
Do.	do.	2	3,299	do.	do.
Do.	do.	3	4,111	do.	do.
Do.	do.	4	4,198	do.	do.
Do.	do.	5	3,978	do.	do.
Do.	do.	6	3,986	do.	do.
Do.	do.	7	3,992	do.	do.
Do.	do.	8	3,993	do.	do.
Do.	do.	9	3,990	do.	do.

Giving an average of 3,983 cubic feet per revolution, as against 4,530; or a loss by re-entry of 547 feet by revolution, or 12 per cent. of the duty. In No. 2 experiment (when the water gauge gave a high reading) the loss was 27 per cent.; and in No. 3 (with a low water gauge) the loss was 9 per cent. But, in curious contradiction, it will be observed that, with the 27 per cent. loss, the useful effect is represented to be 61.18 per cent.; while, with the better condition of only 9 per cent. loss, the useful effect is only claimed at 58.74 per cent. At Lofthouse, where the same capacity of ventilator exists (4,530 cubic feet per revolution), the average actual volume was 3,901; the loss being 629 cubic feet per revolution, or 13.88 per cent. Now, the outside speed at which he thought Mr. Cooke's machine could safely be run was 30 revolutions. He believed that was the highest speed it had been put to. According to the average obtained at Upleatham, the total volume which could be produced by the ventilator at this speed would only be 116,970 cubic feet per minute; whereas the average of three 40 feet Guibals (from results forwarded to him by the managers themselves—he not having experimented upon any of the three) gave per revolution 4,761 cubic feet; or at thirty revolutions an average of about 133,000 cubic feet per minute; and at 50 revolutions per minute, the speed at which they were actually running, an average of 223,050 cubic feet actual pit duty was obtained. These working volumes could be still further increased in cases of emergency by 50 per cent. At Cannock and Rugeley the working duty measured in the pit itself was 188,000 cubic feet, with 1.5 water gauge, at 35 revolutions of the fan. That, of course, was a very exceptional circumstance. At Pemberton colliery, with a 46 feet Guibal, they had produced 5,000 cubic feet per revolution, with a working duty of 200,000 cubic feet under 3 inches of water gauge at 40 revolutions. That had been at work without stopping, except for lining brasses, during five years. The following tabulated form will more fully explain the actual duties obtained:—

GUIBAL VENTILATORS.

[see in original text Summary of working duties.—January, 1878.]

In conclusion, he would submit that at collieries in this neighbourhood where, by the kind permission of the owners, the work of the fans might be verified by members desirous of doing so, the results were fully such as to justify the adoption of the centrifugal system. The fan at Hilda was doing remarkably well; and he was authorised to say that the colliery officials were amply satisfied with its performance. The "Guibal" had been put up at places where neither the "Lemielle," the "Cooke," nor any other displacement machine as at present constructed would be of the slightest service, and he was certain that if an investigation into the matter was made, either by a committee or by independent observers, and the first cost and duty taken into account, the result would be found to be largely in favour of the centrifugal system; and if this

comparison were made, and the two ventilators placed side by side, in these hard and depressed times, he would be very glad to have the difference in cost of stores and repairs between the two systems as a yearly stipend.

Mr. Nelson—In looking over the experiments given by Mr. Cooke, he had observed that a tone of accuracy was assumed that noted the tenth part of the revolution of an engine, or the 292nd part of a minute, which accuracy he was afraid was hardly maintained in other statements, wherein neither the water gauge, readings, quantities, or the revolutions of the same fan under the same circumstances seemed to bear any accountable relation the one to the other, and where a consumption of fuel of 6.07 lbs. at Upleatham is stated to be a saving of 35 per cent. over a consumption of 8.2 lbs. at Crags Hall, instead of, as it really is, a saving of only 28.9 per cent.

Mr. Cochrane said, he had very few remarks to make upon Mr. Cooke's paper, because his own paper upon the "Advantages of Centrifugal Action Machines," which was written with all the information before him, was already before the Members. With regard to the experiments quoted by Mr. Cooke, he would remark that they did not compare accurately within a reasonable margin, and some were quite anomalous. Such anomalies as Mr. Nelson had called attention to, were repeated over and over again. There was no proper relation, under the same conditions of the mine, between the volumes and the water gauges, and the speeds of the engines, which were reported. He hoped the variable capacity machine, whether Cooke's or any other system, might, in practice, do that which was claimed for it; but he could not help reminding Mr. Cooke of the original account given of the trial machine, in which, under the conditions of 6.34 inches water gauge, it was stated that an effective result of 85 per cent. of the power applied to the piston had been attained, which, having regard to the mode of transmitting the power by belting, indicated a realisation of more than 100 per cent. of useful effect. He desired to call their special attention to the new theory propounded by Mr. Cooke, that a Guibal fan working upon a mine produced a water gauge at a certain distance from it, which Mr. Cooke calls a pseudo water gauge, and acts in this respect in a different manner to Mr. Cooke's or any other ventilating machine. This was one of the most astounding theories he thought he had ever heard, and he could only say, that if Mr. Cooke had observed this variation in the water gauge at a certain distance from the outlet, in the case of a Guibal ventilator, and had placed his own, or any other ventilator there, under similar conditions, exactly the same effect would have been produced. Surely, one exhausting apparatus, no matter of what kind, drawing a certain volume

of air from a mine could not affect a water gauge at 50, 100, or 200 feet distance from it differently to any other exhausting apparatus—all conditions of the ventilation being the same, and the apparatus being similarly placed, the water gauge being the result of the particular volume of air passing along the particular airway. If such observations by Mr. Cooke are correct, there must be other reasons for this effect than the construction of the ventilator. As regarded the water flowing out of the vessel after assuming the curved surface of the parabola, if Mr. Cooke would place the outlet as he (Mr. Cochrane) had arranged it, as shown on the plan in the diagram, there would be the head to drive the water out, due to the centrifugal force even, although the level of the water were higher outside than inside of the vessel. As regards the mechanical details of Cooke's machine itself, he could only say, that the difficulty which Mr. Cooke pointed out as having arisen in a small ventilator at Upleatham, would, in his opinion, with a machine 20 feet diameter and 20 feet wide, be too great to be overcome. There would be, what in his paper he had called particular attention to—a huge mass of machinery to move, with a necessary clearance in the working parts, which would render it impossible to keep the joints tight, as in the case of a blast-engine blowing piston, where only small volumes of air have to be dealt with; but where large volumes of air require powerful machinery, the faults of the Lemielle ventilator must be perpetuated, and these will prevent the accuracy attainable in a small model from being maintained in practice; and the favourable result which, at a slow speed, a new machine might yield, is soon incapable of attainment by wear and tear. Mr. Cooke admitted, in fact, that in some cases instead of three-tenths of an inch he had 3 inches clearance between the shutter and the drums. He said, with the greatest confidence, that Mr. Cooke had got as good a machine from Messrs. Fowler as they could make; they had most accurate machinery and workmanship to produce it, and he knew that all concerned had exercised the greatest care to make it a success. But he did not care how carefully Mr. Cooke made that machine or any other, he would have a similar clearance after it had been in operation for some time. He drew this conclusion from the experience of similar machines working abroad. Mr. Cooke had informed them that at the Boyne colliery he did not find any difference in the water gauge at the inlet of the ventilator and in one at 30 fathoms away; from this it can only be inferred that the observation has not been sufficiently delicate, for a difference must exist; as already pointed out, a volume of air cannot travel through 30 fathoms of a drift without having its friction

[110]

duly recorded on the water gauge, even though it might be so extremely small that it could not be observed. There was a difference though Mr. Cooke had not been able to measure it.

Mr. Steavenson said, it would be in the recollection of many of the members that at the last meeting he was particularly anxious that they should have a committee appointed in order to investigate this question, and for several reasons. In the first place, it was very often supposed that to test a fan was a very simple matter. But it was in reality by no means so simple. It required the most strict care, and it was a most easy matter to get wrong. There might be, in the first place, errors, which he might call personal errors. Take half-a-dozen members of that Institute, and ask them to read a water gauge, and ask them to put down the result, without communicating with each other, and he undertook to say that no two of them would give the same. Then, again, there occurred many errors which he called practical errors. Two or three engineers wanted the speed of air, and they measured it. One gave 500, another 510, another 490 feet per minute. These he called practical errors, varying with the application and condition of the anemometer. In the next place, the results which were obtained were wrongly interpreted. He would allude to that more fully afterwards, but he would take that very instance which had been noticed already—the action of the water gauge. Suppose the reading of the water gauge was two inches, and the inlet was found to face the air. If the end of the pipe was turned away, probably the gauge marked 2½ inches, and so on. In the sixth volume of their Proceedings, Mr. Atkinson—a gentleman whose talents were undeniable, and whose loss was universally regretted— ascribed to the Fabry fan a useful effect of from 60 to 69 per cent. Mr. Cochrane, in the paper read before the Mechanical Engineers, said it would not exceed 35 per cent. Again, Mr. Atkinson gave the effect of the Struve fan at about 60 per cent.; Mr. Cochrane said it was from 40 to 45 per cent. He (Mr. S.) did not say that either of these gentlemen were wrong, but what he did say was that they did not agree. The Waddle fan was tested a few years ago by Mr. Evans and Mr. Atkinson, and the calculations still remained, if any gentleman would like to refer to them. Mr. Atkinson decided that it yielded 61 per cent. of useful effect, while Mr. Cochrane gave it in his paper read before the Mechanical Engineers at 39 per cent. Again, as to the Schiele fan, Mr. Willis, Mr. Morison, and Mr. Ramsay went over to Job's Hill, and they reported a useful effect of 62 per cent., while Mr. Cochrane told the Mechanical Engineers only 31 per cent. was obtained. Mons. Lemielle, in a tract published a short

time ago, claimed to have realised 90 per cent., where Mr. Cochrane, on the other hand, awarded only 35.50 per cent. A Roots' blower was lately stated to have given 96.8 per cent. of useful effect, when Mr. Cooke reported on it, and said it was 50.63 per cent. only. Mr. Guibal states in a document which is published by Mr. Cochrane, that he claims 75 per cent. of useful effect, whereas Messrs. Cockburn, Daniel, and Cooke, said it was not over 50 per cent. The battle of the fans was going on as now in 1869, when a letter was addressed to the Newcastle Chronicle, by a gentleman whom he was quite sure would do nothing but what he believed was right, asking "What is all this fight about the fans?" and stating that he had two small furnaces with a 12-feet upcast shaft, and obtained 250,000 cubic feet of air. Mr. Cochrane went over to examine for himself, and realized only 150,000; and so doctors differed. What he said was, that to some extent this was the effect of careless experiment; and the effect of careless experiments was known to nobody better than to the professors of our College of Science, and they would bear him out, he was sure, that not only was the greatest care and precision necessary, but that all such experiments should be conducted by independent authorities. In conclusion, he would give them an instance of a mistake made even in testing the Guibal fan. He went over to Framwellgate Moor about three months ago, to examine the effect of the fan there. As usual, the drift was divided so as to measure the air carefully. In order to effect this division, the fan had to be stopped for two hours, and during this time he took the opportunity of testing the natural ventilation. The fan when running gave rather better than 80,000 cubic feet; but after it had been standing for two hours, there was a natural ventilation of 15,000 cubic feet. If this 15,000 cubic feet was included in any of the results obtained they would be very far wrong. He went down to Cleveland to have an opportunity of testing a fan. There the seams were running into the hillside tolerably level; there was no upcast and no natural ventilation, and there he found that the most careful experiments made with the Guibal did not reach 47 per cent. He was quite prepared to go with any gentlemen and test the thing thoroughly, and have it settled once for all. He moved that a committee be appointed.

Mr. Cochrane said, did he understand Mr. Steavenson to say that he found 15,000 feet due to natural ventilation when the ventilator was not at work, which he thought should be deducted from the total volume of 80,000 before accurate results could be obtained?

Mr. Steavenson said, he would most certainly assume that, if he was

getting 15,000 from the heat of the shaft and the mine, it was not due to the Guibal ventilator, although he would not say that the whole of the quantity caused by the natural ventilation should be deducted—that would be a very different thing—but, at all events, he would say it should be taken into account in ascertaining the useful effect of the fan.

Mr. Cochrane said, in opposition to that view, that the total volume of air measured at the fan was the total work of the fan quite irrespective of the natural ventilation.

Mr. Steavenson entirely differed in this from Mr. Cochrane.

Mr. Daniel said, he thought the supporters of the different capacity principle of ventilation should be greatly obliged to Mr. Cochrane for his paper, for he had admitted in it that the principle of the different capacity ventilators was the best, in stating in his paper that he had obtained 86 per cent. of useful effect with a different capacity machine, and he (Mr. Daniel) did not find that any such percentage had ever been claimed for centrifugal machines. Mr. Cochrane seemed to make a great point of the fact that, if Cooke's fan was run under impossible conditions, no air would be discharged. For instance, he said, that if it was run to give a water gauge of 43.6 inches, there would be no air. But nobody ever wanted a water gauge of 43.6 inches. He (Mr. Daniel) might as well say that if you were to run a Guibal fan at a thousand revolutions per minute, it would fall to pieces. He thought the argument must hold as good in the one case as in the other. As to the difficulty of measuring the air, he quite concurred with all Mr. Cochrane had said. It was almost impossible to measure the air in the same mine, though under precisely similar conditions, and get the same results twice together. At Hilda Colliery, where Mr. Cochrane seemed to think the experiments were not carefully made, he could only state that those which he had quoted were made under Mr. Morison's supervision, and no complaint was made as to the manner in which the experiments were conducted till it was found that the results were not so good as had been anticipated. Mr. Cochrane also seemed to think that Cooke's fan could not be worked by an expansive engine, because there was no fly-wheel to it; but he (Mr. Daniel) maintained that the drums of Cooke's fan being perfectly balanced, make as good a fly-wheel as could be desired. Then they came to the wear of the brasses, and the wear of other parts of the machine, together with the relative consumption of stores. Since first Cooke's fan was put to work at Upleatham, about three years and a-half ago, the main brasses of the drum shaft had not been set up. He did not

suppose that though the fan had been working for three years and a-half, the brasses had worn the thirty-second of an inch, and nothing had been expended upon the maintenance of the fan except for painting; nor were the stores consumed in excess of those required by the Guibal fan. Mr. Cochrane seemed to think that in time the shutter would wear away from the drum, and that there would be considerable re-entry. He could say, in answer to that, that the shutter was as close to the drum now as it was when it started, and no amount of wear could affect the space between the shutter and the drum. He had in his paper made a remark as to the cost of the Guibal, which Mr. Cochrane seemed to dispute. The cost which he gave for a 36 feet fan was something like £7,000 or £8,000. Now, that was the cost given him by a gentleman who had put down a fan of that size, and included boilers, engines, and foundations. He could only say, in conclusion, that his experiments had been made solely with the view of trying to ascertain which was the best fan, and that, although he had made a great number of experiments with different fans, he had never yet found a Guibal which gave results equal to a Cooke's. He hoped that, if the suggestion which Mr. Steavenson had made that a committee should be appointed to investigate this matter was carried out, their report would not be confined to these two varieties, but would also include the Waddle fan, which he thought was a very good one, and any other which the committee might decide upon trying.

Professor Aldis said, there was just one remark which he would venture to intrude on this meeting in allusion to the illustration of the action of the Guibal fan by means of a parabolic curve and an opening at the side of a cylinder which contained water. The gentleman who read the paper at the beginning of the meeting, if he understood him rightly, attempted to meet Mr. Cochrane's argument by asserting that if the aperture were at the level of the top of the water, it would be difficult for the water to escape. He (the Professor) supposed that most of them would apprehend difficulty under these circumstances. Mr. Cochrane had answered that suggestion by saying that he would make his aperture below instead of at the level of the water. But the particular thing which he (the Professor) wanted to point out to that meeting was, that if he were defending the Guibal fan, he did not think that he would rest his defence of it upon this parabola. The existence of this parabolic curve depended upon three things; in the first place that the fluid in question, water, was incompressible; in the second place, that the axis round which the rotation took place was vertical; and in the third place, that the weight of the fluid rotating was the principal force acting upon it; and

these conditions were, as they saw, not satisfied by the Guibal fan. The fluid which was intended to be passed through the Guibal fan was air, which was an eminently compressible fluid, the axis of rotation of the Guibal fan was a horizontal axis, and the weight of the air which was made to rotate had very little to do with the efficiency of the fan. The theoretical explanation of the reason why air goes out from the Guibal fan was simply this: Suppose a closed cylinder containing air absolutely without any communication with the outside, and the air within that cylinder was made to rotate rapidly, there would be a great alteration in the density of the different parts of that air. The air would not long remain of uniform density throughout. There would be a great diminution of the density and consequently of the pressure at the centre, and a great increase of pressure at the circumference. It was a very simple mathematical formula which gave this rate of increase. The rate of increase was very large—larger he apprehended than the rate of increase of an incompressible fluid such as water rotating, as in Mr. Cochrane's diagram. Supposing that when the air had been reduced to a state of equilibrium within the cylinder, openings were made at the centre and the circumference, the pressure being less at the centre and greater at the circumference respectively than that of the external air, the effect will be that the air at the circumference will rush out, and that air from the outside will rush in to the centre. This process would be very much expedited by making the opening at the circumference sideways instead of leading directly out. Every particle of air as it comes round to this opening has a velocity in a tangential direction. If the opening were perpendicular to the direction of motion of the air, the velocity of egress would have to be produced by the pressure of the air inside, and no great amount of air would thus escape. If the opening were made tangential, the air can escape by travelling on in the direction of its present velocity produced by the rotation of the fluid, and is not sensibly prevented from escaping by the external pressure of the air. These were the only remarks he had to make on Mr. Cochrane's paper. The only other thing which occurred to him was this, that it had been objected to variable capacity machines, that after a time they would leak; and with the construction described in Mr. Cochrane's paper, it seemed to be inevitable that the tendency of the working of such a machine was an increased looseness; because during the whole of the operation the excess of pressure of the air on one side over that on the other, produced a continual strain on the shutter to keep it away from the revolving cylinder. In ordinary pumps the pressure of water or air tended to keep the valves tight; in this

[115]

machine it appeared to him that the tendency was to keep the valves loose from the difference of the pressure, and that looseness was an inevitable result of the construction.

Mr. Hall said, that in the previous discussion on this subject, he understood that Mr. Cochrane had stated that if by the side of a fan working at a certain number of revolutions a second were added, no more air and no higher water gauge would be obtained. This was in direct contradiction to the actual results from the use of a number of fans at Bickershaw Colliery, near Wigan. At that colliery there were four small fans working over the top of a drift, each drawing air through a small opening in the roof. When these fans were first put up two only were fixed; and they got 100,000 cubic feet of air per minute, with a water gauge of eight-tenths. Afterwards two more fans were fixed and they got 170,000 feet of air per minute and 1¾ inch water gauge. He could not say that these experiments were conducted with as much skill as some of the gentlemen present would have conducted them. They were made by Mr. Smith, the manager of the colliery. He (Mr. Hall) had no doubt they were made and given in good faith. If these experiments and these results were correct, they did not seem to bear out the fact which had been stated—that if one fan was placed alongside of another it did not increase the result at first obtained. These fans, which were doing this work, cost about £105 each. The engine which is working them cost about £400. It was working 45 revolutions, and driving the fans by straps at something like six to one. If a committee were appointed, he thought it would be well worth while to look at these fans, and he might say, for the manager, that he would be very glad to give them any help or assistance in his power. He had, with Mr. Smith, subsequently tested the fans referred to with the following results:—

Experiment made, February 11th, 1878.	Strokes of engine.	Revolutions of fan.	Water gauge.	Quantity of air per minute in cubic feet.
Two Fans Running	46	276	.85	73,000
Four Fans Running	46	276	1.85	111,100

The water gauge was taken at the door, which is midway between the upcast shaft and the fans.

The total quantities of air were less in these experiments than those stated above, owing to several causes, but the comparative increase with the additional fan is similar.

In reply to Mr. Cochrane, Mr. Hall stated that the fans were called Gunter's fans, they were 8 feet in diameter, and were all driven at precisely the same speed, both before and after the two last fans were added.

Professor Herschel said, that in immediately continuing the remarks which Professor Aldis had been good enough to offer on the theoretical point of view which the Committee would perhaps take of this subject, he would perhaps be allowed to detain the meeting for one moment to state that, so far as he himself was concerned, it had been of great interest to him to listen to the discussion, and he thought he should express the views of the Professors on a part of the proposal which Mr. Steavenson had submitted to the consideration of the meeting, namely, that it would give them the greatest possible pleasure to render any assistance in completing the examination and investigation of the actual and relative merits of fans or ventilators existing, or hereafter to exist, which might be desired of them. He could not help seeing that the enormous masses of experimental results which had been brought before them, and the able way in which they had been followed up, were of the highest interest scientifically as well as practically; and they would look forward with great interest to the issue of all the experiments which were being carried out. Mr. Cooke, Mr. Morison, and a great many other observers, had furnished them with observations of a variety of systems on a larger scale than any which could be made and recorded in laboratories, and which were, for this very reason, of a specially important and of a very valuable scientific bearing. He hoped that if such a committee as had been suggested was appointed, it would in some way be placed within the reach of the Professors to render it their assistance. He would like to be informed again by Mr. Cooke what results were obtained in working his ventilator backwards as compared with those found in working it forwards? This point, if it was satisfactorily determined, would be one of some interest, as it is one regarding which centrifugal ventilators, since they are not adapted to be worked in an opposite or reverse direction, cannot furnish us with any experimentally determined and recorded data.

Mr. Morison said, he would not have intruded further remarks upon Mr. Steavenson or the meeting, had it not been that the subject introduced by Mr. Hall was totally distinct from the preceding question. The four fans alluded to by that gentleman being small, as he understood, it necessarily followed they had small inlets. Perhaps Mr. Hall could tell them what was the exact diameter of the inlets of the

fans. It was quite possible that if the two fans which were originally put up were too small to exhaust the whole volume of air which the pit was giving out, under a certain water gauge produced upon the top of the pit, the whole air being still under the partial vacuum produced by these fans; then, by adding two fans, the increased capacity might exhaust all the air upon which already a certain partial vacuum had been produced by the two former fans. If the experiments were reliable at all—which he very much doubted, as the figures appeared erroneous—that was the only way in which he could account for it. If, as Mr. Hall said, they got 100,000 cubic feet of air with eight-tenths of an inch water gauge, it would have taken 3 inches water gauge (or nearly 3 inches) to have got 170,000; whereas they appeared to have been getting that volume with only an inch and three-quarters water gauge. So that not only were these fans cheaper in first cost, according to Mr. Hall's figures, but they were (on the extreme supposition of relying on the figures they had heard quoted) by far the most effective fans he had ever heard of; and he thought that Mr. Hall was quite right in his suggestion that the proposed Committee should go and inspect them.

Mr. Cooke said, that he had made a number of experiments on the relative effects upon the water gauge, of different angles of the pipe to the current of the air, because it was quite evident that without having that point settled any observation was useless; and the way in which he arrived at what, he thought, were accurate results on this point was, at Brandon colliery, in the Hutton seam, where they had an air-tight door put in so as to shut off the access to the shaft in such a way that they could get inside and outside the door as often as they liked. A Daglish's water gauge was applied so as to be read from each side of the door, and the small aperture was plugged so that the velocity of the air on the water gauge could not affect it when held in the shaft. Connection with the downcast air was made by a flexible tube placed against the closed door, and made tight with a union joint. It was held that the true water gauge in the shaft would by that means be ascertained, and would correspond with that at the door, and such was found to be the case. They then, when outside of the door, took the flexible tube connected through the door to the water gauge, and held it in the shaft against a current of 32 feet a second. When the water gauge on the door read 1.55 inches, the other water gauge connected to the pipe held pointing from the current read 1.75 inches, when it was held square to the current 1.75 inches, and with the pipe meeting the current, the water gauge read 1.45 inches. That experiment was made in the most careful manner, and could be relied

on. Taking this 32 feet per second as the basis in point of velocity, they would find that to put a pipe an inch in diameter against the current would reduce the reading one-tenth of an inch ; to put it square to the current would, on the other hand, increase the reading two-tenths of an inch, the same amount of difference would be experienced if the pipe pointed away from the current, and he could not help thinking that Mr. Cochrane's ideas about the vacuum existing inside of a Guibal had been derived from putting a pipe into the casing of a Guibal at its periphery, square to the enormous velocity developed against it, which had the effect of making a vacuum show upon the water gauge. This was the only experiment which he had got of any importance on the subject; and seeing that members were challenging it, and Mr. Steavenson and Mr. D. P. Morison had referred to it, he had thought it right to bring it forward. With regard to the lightness of the blowing machine, he considered the new one was practically as light as a centrifugal machine, the ends of the cylinders and the shutters were greased to reduce the friction, and were practically in contact. A machine on his principle, 20 feet by 20 feet, would deliver as much air as a Guibal 46 feet by 16 feet, and weigh considerably less.

Mr. Cochrane said, he was very much obliged to Professor Aldis for having amplified the explanation of the theory of action of the centrifugal ventilator. Mr. Cooke, in making his comparison, had considered the statistical and not the dynamical question, and had quite ignored the "Evase" outlet. In reply to the remarks made by Mr. Steavenson as to the widely-varying results stated to have been obtained upon various systems of ventilation, were they not rather attributable to the varying conditions under which the experiments were made than to erroneous observations? The same Guibal ventilator might be erected at one mine and yield a very high useful effect, as much as 75 per cent., and it might be erected at another mine and produce only 25 per cent. It entirely depended upon whether the mine afforded favourable conditions or otherwise for maximum useful effect. In the Belgian coal-field, where they generally had a high water gauge and a small volume, a low useful effect was the result. In other instances, where 70 or 80 per cent. was obtained, it was because there was a maximum volume, and the ventilation would circulate under a stipulated water gauge; therefore he did not consider there were the great anomalies suggested by Mr. Steavenson, for without imputing error on the part of the observers, all the experiments quoted might be perfectly consistent with the varying conditions under which they may have been made at different collieries. He would make one further observation respecting the merits of the two systems under

discussion: that the centrifugal system, as represented by the Guibal, has stood a very fair test in this country for something like fifteen years. Mr. Cooke's machine was very young indeed, and it could only be tested by becoming extensively applied to the object for which it was now brought before their notice. So far it seemed to be admitted by its supporters that the efficient machine had yet to be constructed. Its principle, like that of the blowing engine, may be good for some purposes, but under the peculiar circumstances, such as he had indicated, he considered that it was not satisfactorily applicable to mine ventilation; he hoped Mr. Daniel's prophecy might come true—that he would construct a machine to work with one thirty-second of an inch clearance, and to be capable of answering all the varying requirements of mine ventilation. What difficulties had arisen hitherto it was not for him to inquire, but it was exactly these apparently simple points in the variable-capacity type which had been the cause of the entire failure of that class of mine ventilators.

Mr. Cooke seconded the motion for the appointment of a committee.

Mr. Ramsay also thought it very desirable that a committee should be appointed.

Mr. G. B. Forster thought the question ought to be first reported on by the Council. It was rather a delicate subject for a committee to report upon; and he begged to move, as an amendment, that the question of the desirability of appointing a committee be referred to the Council.

Mr. Ramsay begged to second the amendment.

Mr. Steavenson said, that if it was the wish of the Council to deal with the matter, he had no objection to withdraw his motion.

The President said, it was desirable they should do so in order that they might come to some understanding as to what course of action the committee should pursue. If they were to report and come to a judgment as to which of the two systems was the best, it would be going beyond the province of the Institute; if they were simply to report facts, in the same way as the Tail Rope Committee did, it would be a useful and interesting report. The best plan would be to refer the matter to the Council, who would lay down for the committee such instructions as would keep their inquiry within the province of the Institute.

The amendment was then put to the meeting and carried.

Mr. Henry Hall, H.M. Inspector of Mines, read the following paper on "The Telephonic Ventilation Tell-tale:"—

[120]

[Plate XI. Diagram to illustrate Mr William Harle's paper on "Increased economy in the manufacture of coke by mechanical means";

Plate XII. Front elevation shewing mode of driving the belts and the elevator;

Plate XIII. Side elevation shewing the mode of driving the elevator;

Plate XIV. Plan shewing the mode of driving the elevator;]

[121]

THE TELEPHONIC VENTILATION TELL-TALE

By HENRY HALL.

Next in importance to the adoption of the best means of thoroughly ventilating a mine, is the introduction of some reliable test of the constant efficiency of such means, because the most perfect machinery and the most skilfully-planned air roads may fail at times.

With this object in view a great variety of anemometers or air-meters have been invented. A list of these, with a description of them, and an account of their comparative usefulness, will be found in the tenth volume of the Transactions of this Institute, in a most interesting paper contributed by Messrs. Atkinson and Daglish.

Since that time (1861) few, if any, improvements or novelties have been devised. Then, as now, the Biram anemometer appears to have given the most satisfaction of those of the revolving class, and the "Dickinson" of those of the pressure class.

In using each of these instruments to gauge the actual velocity of an air-current, certain additions require to be made for the friction of the bearings, and each separate instrument must be tested and regulated in this particular. But, for the everyday work of a mine, it is not actually necessary that this fact should be kept in view, so long as the same instrument is used, because comparative results are all that are needed. This being so, it would appear to be a more important consideration in the mechanism of an anemometer that the friction should continue a constant quantity, under wear and tear, rather than that it should be reduced to a minimum at the risk of more frequent variation.

When dealing with the same air-way, as much information is conveyed by entering the number of revolutions only as by working out the precise quantity of air passing.

Hitherto, in order to test the ventilation, it has been the practice to descend the mine, and at selected places make careful measurements of the air passing, and on returning to the surface enter such observations in the ventilation report book. At important collieries this is the daily practice, the duty being performed by a fireman, master wasteman, or

other official, and necessarily occupying much time. Indeed, at some large collieries the whole of one person's time is taken up for this purpose, and a serious expense incurred.

The "Ventilation Tell-tale," which is the subject of this paper, is an arrangement by means of which the quantities of air passing in the principal air-ways of coal and other mines, can be accurately measured at any moment in the Colliery Office, on the surface or elsewhere, without making a descent into the mine. The system is also applicable to the measurement of the ventilation of railway tunnels and sewers. This is effected as follows :—Having decided upon the point where the measurement of air is to be made in the mine. A "Robinson" or "Biram" anemometer is fixed permanently and firmly to an inch-round iron bar stretched across the air-way. The attachment is made with a small collar and screw, so that the instrument may vibrate as little as possible when the current plays upon it. The axes work in agate holes, and are calculated to wear a long time without repair.

Instead of the usual counting-dial a permanent bar magnet is attached to the anemometer, and on one pole of the magnet a small bobbin of insulated wire is fixed, similar to those used in a Bell's telephone; one end of this wire is connected to a line wire, and the other to earth in the same manner that telephones are usually connected up.

The pole on which the bobbin of wire is placed is made to project a short distance through the bobbin, and so arranged in front of the anemometer that at each tenth revolution of the vanes a small steel spring is caused to vibrate in close proximity to the pole.

The action that takes place is as follows:—At each vibration of the spring a current of electricity is induced in the coil of insulated wire from the fact of the vibrations of the spring having disturbed the magnetism of the permanent magnet on which the coil is wound.

The line wire from the anemometer, after being led up to the office on the surface is connected to one of Bell's telephones, and here the action that takes place is precisely the reverse of that which takes place with the anemometer, as the currents generated by the vibrations of the spring in passing round the coil of wire in the telephone affect the magnetism of the permanent magnet round which it is wound, either increasing or decreasing its magnetism in accordance with the direction of these currents, thus either attracting the diaphragm of the telephone or allowing it to recede further, and so setting up a series of vibrations in the air in its vicinity similar to the vibrations of the small spring of the anemometer. By this means the particular note which the spring makes is heard in the office.

The reason of every tenth revolution being chosen is that it would be impossible to count every revolution of the anemometer when running at a high speed, and for practical purposes every tenth revolution is found amply sufficient. The wires reaching from the anemometers to the bottom of the shaft are protected by half-inch iron pipes. Those in the shaft itself are carried on insulators fixed in the walling, and on the surface they are carried on posts from twelve to twenty feet high, or underground as may be desired. Improved "Robinson" and "Biram" anemometers have been selected as most suitable—the "Robinson" for currents exceeding 600 feet per minute, and the "Biram" for less velocities. The revolutions of the former, as compared with the actual velocity of the current, are as 1 to 3; and in the case of the latter the revolutions and actual velocity are nearly equal. The following remarks appear in the paper by Messrs. Atkinson and Daglish already referred to:—"The anemometer of W. Robinson is constructed on the assumption that the force of impact of the air, against hollow hemispherical cups, is twice as great on the concave as on the convex side of the cups, and that the vanes revolve at the rate of one-third of the velocity of the current, except in so far as the velocity of revolution is modified by friction. The mechanism of this instrument is very strong, and allows of the revolutions being recorded throughout a whole day; it would therefore be a very suitable anemometer to have near a furnace, or in the principal intake or return from a mine." And again, they say, "No. 10 series of experiments were made for the purpose of observing whether the action of Biram's anemometer varied much with the condition of the instrument, i.e., whether the same formula and constants were required for the same instrument when properly cleaned and oiled; and again, after being much used and in a dirty condition; and it is certainly satisfactory to find that the action of the same instrument is very little altered through these varied conditions." The writer hopes that this short description of the apparatus will enable members to form an idea of its practical utility.

It is not intended that the Tell-tale should only be used to register the total ventilation passing into or out of a mine; if it gave this alone it would be very valuable, but there is no reason why it should not be applied to each principal air-road, the wires being collected together and brought to the same point on the surface; indeed it would be quite practicable to take a wire into the face of the workings themselves, in the case of any special danger being apprehended.

However many anemometers may be fixed in a mine, one telephone only is required to make the observations, and Professor Bell undertakes

to supply and keep in working order telephones for this special purpose at the rate of 40s. per annum. The observations are entered on a diagram as frequently as their importance seems to demand.

The object of the introduction of the "Ventilation Tell-tale" is to afford those in charge of collieries an economical and reliable means of obtaining constant information of the quantities of air passing into and returning from the different districts of those collieries. It will also act as a most useful check on the operations of furnacemen and others in charge of ventilation.

The writer believes that in some instances insidious diminution of the ventilation of particular districts of mines has led to disaster, and that had there been a constant test within easy reach of the principal manager this might have been avoided.

He also believes that such an apparatus as the one proposed would be an encouragement to underlookers and others to make greater efforts to obtain good ventilation, because they would feel that their principles and employers were constantly cognisant of those efforts.

On the motion of the Chairman a unanimous vote of thanks was given to Mr. Hall for his paper, the discussion of which was reserved for another opportunity, and the meeting terminated.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, MARCH 2, 1878 IN THE WOOD MEMORIAL HALL.

E. F. BOYD, Esq., Vice-President, in the Chair.

The Assistant-Secretary read the minutes of the last General and Council Meetings.

The following gentlemen were elected members:—

Ordinary Members—

Mr. J. Pease, West Cannock Colliery, Hednesford, Staffordshire.

Mr. Walter Topping, Messrs. Cross, Tetley, and Co.'s Collieries, Wigan.

Associate Members—

Mr. W. J. Greener, ME., Pemberton Colliery, Wigan.

Mr. Corry S. Fennell, Bjuf Colliery, Helsingborg, Sweden.

W. E. Brown, Springfield, Victoria Park, Wavertree, Liverpool.

Mr. Thomas Winter, Messrs. Tangye Brothers and Steel, Swansea.

Students—

Mr. W. H. Pickering, Pemberton Colliery, Wigan.

Mr. W. C. Dowson, Belle Vue House, Escomb, near Bishop Auckland.

Mr. Philip Kirkup, Lofthouse Station Colliery, Wakefield.

Mr. Joseph S. Hudson, Cambois Colliery, Blyth.

Mr. Alexander Scott, Mining Pupil, Peases' West Collieries, by Darlington.

Mr. Alfred R. Oldham, Mining Pupil, Rockingham Colliery, near Barnsley.

The following were nominated for election at the next meeting:—

Students—

Mr. Walter Howard, Mining Pupil, Towneley and Stella Collieries, Blaydon-on-Tyne.

Mr. James B. Nelson, Mining Pupil, Seaton Delaval Colliery, Northumberland.

The Assistant-Secretary then read the following paper by Mr. W. Harle, "On Increased Economy in the Manufacture of Coke by Mechanical Means;"—

[blank page]

ON INCREASED ECONOMY IN THE MANUFACTURE OF COKE BY MECHANICAL MEANS

By WILLIAM HARLE.

The subject of the manufacture of coke has been frequently brought under the attention of this Institute, but it has always been treated with a view to the utilization of the products of the combustion of the coal, more than to the economy of the manufacture itself.

It is true that, incidentally, the Appolt and Anchor system, and the Belgian system, did treat of economy in drawing, but other circumstances connected with the working of them rendered them both failures, and the expense of manufacturing coke is as much now as in 1860, when the cost of making coke was first given to this Institute.

All the experience of the past years goes to prove that common Beehive ovens, with the heat utilized for boilers and cooled internally, are superior to every other system, and the writer claims, by a very simple arrangement, to effect a saving of 25 per cent.in the wages of the men that work them.

By reference to Plates Nos. XI., XII., XIII., and XIV. it will be seen that the scheme consists of a travelling belt passing in front of the doors of the ovens, which conveys the coke (when drawn) to a central into an elevator or species of Jacob's ladder, and is thus raised to a height position, where it falls sufficient for loading the truck, and, if necessary, passing over a screen. Any number of these elevators may be arranged in such position and in as many places as the circumstances require.

The arrangement at Page Bank, which is only of a temporary character, consists of a wooden frame with metal rollers, and a travelling belt of old rope on to which wooden cleats are bolted, driven by a small donkey engine. By this means the cost of filling, usually 3¼ d. per ton, has been entirely avoided, and the wages for drawing reduced 1¼ d. per ton. The usual time occupied by a drawer on the old system was two and a-half hours; of this half an hour was occupied for cooling, and the remaining

two hours for drawing and casting on to the bench. Since adopting the new arrangement the time occupied is half an hour for cooling and one hour for drawing.

In order to describe a complete arrangement it is necessary to assume a case. Take as an instance two double rows of 150 ovens each; by means of a twenty horse power engine a belt would be driven, from each end to the centre, where an elevator of sufficient width, actuated by the same engine, would deliver it into trucks. For the new arrangement, which is proposed at Browney Colliery, the frame would consist of cast metal sides and the travelling belt of one-eighth inch sheet iron, bolted together so as to form a chain.

The attendance would be one lad at 21s. per week for each outside row, and where the double row is face to face one lad could attend to both.

As the steam is supplied from the ovens no allowance need be made for that.

On the motion of the Vice-President, a unanimous vote of thanks was given to Mr. Harle for his useful and interesting paper, which was left open for discussion at the next meeting.

The Vice-President said, they would now take the discussion upon the paper by Messrs. T. Lindsay Galloway and C. Z. Bunning.

Mr. C. Z. Bunning said, that since the paper had been read before the Institute he had used the instrument in mines under the most difficult circumstances, and had found it to answer in all cases exceedingly well. If any gentleman had any remarks to make upon the subject he should be very happy to explain anything further.

The Vice-President asked if they found any difficulty in working it?

Mr. C. Z. Bunning said, not in any way.

The Vice-President said, it appeared to be a great improvement upon the old style.

Mr. C. Z. Bunning said, the instrument for mining purposes was a great improvement on the ordinary levelling instrument, as the time saved is very considerable owing to crooked passages and falls of stone not interfering in the least with the working of the instrument.

Mr. John Cooke asked what was the degree of accuracy obtained by this instrument?

Mr. Lindsay Galloway—The instrument in itself is perfectly accurate, as the liquid in the tubes will always come exactly to the same level. The only inaccuracy possible is in the reading off; but it is very easy to read the divisions to the one hundredth of a foot. In this respect there is no analogy with the telescopic level, in which the importance of an error becomes increased in proportion to the length of the sight. If it is very slightly out of adjustment there will be a considerable error in reading with the telescopic level at a distance of 50 or 100 yards from the staff; but with this instrument, the error, whatever it may be, is constant, and it cannot exceed the hundredth part of a foot. Mr. C. Z. Bunning had recently made a long underground levelling for comparison with the results got by the telescopic instrument, and the two were in almost perfect accordance.

The Vice-President asked if the instrument was convenient to carry?

Mr. Lindsay Galloway—It requires two men to carry and read the instrument, one of whom goes in front taking the fore sights, and the other following reads the back sights. A great advantage is found in levelling upon a sloped road, where the telescopic level is specially difficult to manage. Supposing that it was necessary to level up an incline of 4 inches per yard in a thin seam, and the ordinary instrument with a low stand was being used, it was frequently found that the front staff could not be placed more than two or three yards off, and that at so short a distance the telescope would not focus. In such cases the only way of getting a reading at all is to hold a dark object, such as a foot rule, across the staff, which can be seen, although the divisions of the scale cannot. The foot rule is then shifted up or down until it is opposite the wires of the telescope, and its position on the staff is afterwards read off. With the new apparatus there are no difficulties of this sort.

The Assistant-Secretary laid before the meeting a little instrument which Mr. Lebour had that morning left for inspection:—

Fig. 1 represents this extremely simple contrivance. It consists simply of two short glass tubes, A A, inserted into two pieces of common India-rubber tubing, B B. The whole is half-filled with coloured water. It can be folded and carried in any position in the pocket. When in use it must be held vertically, as shown in the figure, so that the level of the liquid in both glass tubes comes within the line sighted. The practical uses of the level for rough and rapid work in hilly districts, where approximate results only are required, will be very obvious.

[Diagrams of levelling instruments]

Fig. 2 shows a modification of the instrument, in which two closed glass tubes and only one piece of India-rubber tubing are employed, which, although consisting of three instead of four pieces, is scarcely so convenient to carry as the last, neither is it so readily filled.

The Assistant-Secretary then read the following paper, by Mr. Parkin, "On the Perran Iron Lode in Cornwall and the Mines in the District:"—

ON THE PERRAN IRON LODE IN CORNWALL AND THE MINES IN THE DISTRICT.

By CHARLES PARKIN.

The Perran iron lode may be traced for many miles, beginning at the coast in Perran Bay, in the parish of Perranzabuloe. The strata of the district is argillaceous clay slate, or blue "killas;" the bearing of the lode is about thirty degrees north of west, and south of east, with a southerly dip of 3 feet to 4 feet per fathom, this dip appearing to be quite independent of the "killas" beds on each wall.

At the outcrop in the bluff of the cliff on the coast, a very large "elvan" dyke is seen along the underside of this lode, which goes with it for some distance inland, after which it passes off from the lode in a direction nearly east and west; but, again, at the mines three and four miles east of this point, the ground abounds with elvan, and is found in close proximity to two lead ore lodes, which is considered a good indication of a rich deposit of lead ore in depth. Professor Warington Smyth, in a paper, says (in reference to this elvan dyke)— "I consider its concurrence with the iron lode in the cliff to be quite accidental, and that there is evidence to show that this lode (like most of the metalliferous veins of Cornwall) was formed posteriorly to the elvan, since fragmentary strips of that rock may be seen enveloped in the iron ore. Generally speaking, several feet in width of the iron lode is occupied by a breccia, which consists of fragments of slate, quartz, and elvan, which distinctly shows that the opening of the rent which received the lode, was accompanied by a very rough and violent fracturing of the 'killas' walls."

The dimensions of the lode vary from 10 feet to so much as 60 feet wide, and in the cliff on the coast it is plainly visible about 60 feet wide and 80 feet in height, at which point it becomes lost to view in the "blown sands" of the district. Numerous cross courses intersect and considerably deteriorate this lode, but when out of their influence it usually resumes its original course and character. A cubic fathom of the iron ore weighs about sixteen tons; so taking the lode at, say, six fathoms wide, it will yield for every fathom in height (or depth) and length, ninety-six tons of ore.

[132]

The ore from the lode is composed of white spathose, or grey carbonate, with a considerable overlie of brown hematite, which, to a depth of twenty to thirty fathoms, is of a very cellular nature, but in depth becomes quite close and compact, until at the depth of about forty fathoms it merges into the white spathose. In breaking a stone of this "cellular" brown hematite it is often found to contain a network of sparry cells full of small veins of galena, and sometimes phosphates of lead. The white spathic ore is compact and homogeneous, with a dull and lustreless fracture, similar to carboniferous limestone. Sometimes it is found in a more crystalline form, the crystals being of micaceous appearance.

Mr. Charles Smith sets forth, in a paper entitled "The Distribution of Spathic Iron Ore," "that in Cornwall hand specimens of chalybeate are common, but the perfection of the crystalline form of this mineral in Cornwall would militate against the probability of the discovery of ore in bulk, and that probably the deposits in this county are the 'backs' respectively of lead and copper lodes, rather than indications of greater deposits below."

The belief that this mass of iron is simply the "back" of a lead lode is shared by many, and the lead-bearing nature of the ground of the district gives additional strength to the supposition; although at the Duchy Peru Mine the iron has been proved seventy fathoms deep (this being about thirty fathoms below the datum line of high-water mark), without any indication of dying out, except that stones of lead ore are now and then met with in the lode.

The presence of magnesia renders this iron ore liable to fuse if much heated, therefore it is necessary to calcine it at as low a heat as possible. It takes about 3 cwts. of coal to calcine a ton of this ore in open clamp, but it could be done both cheaper and quicker if small kilns were erected, say built like an ordinary lime kiln, about 16 feet high and 8 feet in diameter, which would be equal to roasting upwards of thirty tons per diem per kiln. This size would be preferable to kilns of a larger description, owing to the ore being so liable to run together when over-heated, and which it would be more likely to do in going through a large kiln.

Mr. H. Bauerman states "that the proportions of manganese contained in the Cornish spathic ore, place it in an intermediate position with those of Styria and Seigen, the following being the average of the different districts:—

		Iron.	Manganese.
Styria	Raw	37.64	2.21
	Calcined	49.00	2.78
Cornish	Raw	38.03	6.64

Seigen	Calcined	41.00	9.01

[133]

Although this iron lode or deposit has for many years been known to exist, yet it has never been much worked upon until recently—former adventurers having only scratched about the surface, or sunk pits on it a few fathoms deep. From these shallow workings, however, large quantities of iron ore (mostly brown hematite) have been raised and sold, but owing to the heavy cost incurred by the mode of working, and the ore having to be carted at least nine miles to the ports for shipment, very small profits were realized.

In the year 1865, Parliament was applied to for powers to construct a line of railway from this district to the Port of New Quay, and within the last few years the Cornwall Minerals Railway Company have opened up a line from the very centre of the iron mines to the Ports of Par and Fowey on the south coast, and to New Quay on the north coast, and from this line convenient sidings are laid down for the loading of the ore into waggons at the Gravel Hill, Treamble, and Deer Park Mines.

At Fowey there is one of the finest land-locked harbours in England, accessible at all states of the tide to vessels of 1500 to 2000 tons burden.

In support of the bill for powers to construct this railway, Mr. Henry Bessemer gave evidence before a committee of the House of Commons to the following effect:—

1.—That he had personally inspected the Perran iron lode.

2.—That he was convinced there were millions of tons of Spathose ore.

3.—That it was specially adapted for making Bessemer steel.

4.—That it only wanted railway communication to develop it.

The lode has been opened up at various points, commencing at Gravel Hill on the coast, to the Deer Park Mines, a distance of nearly four miles east from the coast. (See Plate No. XV.) About nine miles further east another group of iron mines is situated, which mines are said to be working the same lode, but this needs confirmation, as a large tract of unexplored ground lies between.

It must not be inferred that the lode is regular in its width, as it is sometimes not more than a foot wide, but generally opens out again very soon; the cause of the contraction usually being the intersection of some cross lode or course.

The success of working this lode will of course depend on the output, and to get anything like a paying quantity will involve the opening up of the deposit at many more points than is done at present.

The iron masters have hitherto been prejudiced against the Cornish iron ore, doubtless to some extent from the fact that the ores sent off have been badly selected, and taken from near the surface where it is naturally very silicious.

[134]

The following analyses, by Mr. Edward Riley, give the metallic yield of the ores from this lode, the samples were taken at a depth of twenty fathoms:—

[see in original text Table of analysis of brown hematite]

2.—WHITE SPATHOSE.

Silicates		5.04
Protoxide of iron		47.43
Do. of manganese		6.42
Lime		.70
Magnesia		6.03
Sulphur		.23
Phosphorus		trace
Carbonic acid		33.70

Metallic iron (raw)	36.89	
Manganese „	4.97	41.86
Sulphur		.23
Loss by calcination		31.10
When calcined—Iron	53.40	
Manganese	7.20	60.60

The following is the analysis of pig iron made at the Monkland Iron Works, Scotland, by Mr. Wm. Wallace, F.R.S.E., and F.C.S., Glasgow, from ores sent from this lode:—

PIG IRON.

Iron	87.47
Manganese	3.24
Sulphur	.01
Phosphorus	1.20
Carbon, as graphite	2.12
Carbon combined	.97
Silicon	4.99
	100.00

[135]

The following is about the cost per ton of 20 cwts. of working the iron ore and delivering it in Wales (assuming the lode to be continuous):—

	Raw. s. d.	Calcined. s. d.
Raising and putting into railway waggons	4 0	5 4
Management and other charges	1 0	1 6
Calcining (coal and labour)	„ „	3 0
Royalty dues	6	8
Carriage to Port (New Quay)	2 6	2 6
Freight to Wales from Do	2 6	2 6
Total cost	10 6	15 6
Price per ton (1877)	15 0	17 6
Profit per ton	4 6	2 0

This cost for calcining is for ore roasted in open clamp. Undoubtedly, if kilns (like the style already described) were erected, it would bring the profit per ton about equal to that of the ore sold in the raw state.

The wages paid in the district are as follows:—

	£ s. d.	£ s. d.

Working iron ore	2 6	to	4 0	per ton.	
Deputies or pitmen	4 0 0	to	6 0 0	per month	
Underground labourers	2 0	to	3 0	per diem—8 Hours	
Surface do.	2 0	to	2 9	„	9 „
Enginemen	3 4	to	„ „	„	12 „
Smiths	2 6	to	3 6	„	9 „
Carpenters	2 6	to	4 0	„	

The miners (best men) average 3s. 4d. per shift of eight hours, after deducting all costs for candles, powder, etc. They also pay for having their tools sharpened, and for pick hilts.

Royalty dues on iron are from 6d. to 9d. per ton, and the dues on other minerals one-eighteenth to one-fifteenth of the price the mineral is sold for at the mine.

The following is a list of the mines working upon the lode, enumerated according to their geographical position, commencing at the sea coast; and in order to make the writer's remarks intelligible, a map of the Cornwall Minerals Railway is given (Plate No. XV.), showing its connection with the mines; also a sectional sketch of the workings at Nos. 1, 3, and 5 Mines, Plate No. XVI., and a sketch of the workings at No. 6 (Deer Park) Mine, Plate No. XVII.

1.—Gravel Hill.

2.—Mount.

3.—Preamble.

4.—Great Retallack.

5.—Duchy Peru.

6.—Deer Park.

[136]

1.—GRAVEL HILL.

Nearly the whole of the surface of this sett or royalty is covered with sandhills. A reference to the geological map of the district will show it marked "blown sands," which consist of the detritus of sea shells. Analysis shows them to contain from 80 to 85 per cent. of carbonate of lime and some phosphates. These sands are so light that they are blown for miles inland, and a Church, "St. Piran's," which was built in this district, was enveloped in sand to such an extent that about the year 1800 it was found necessary to pull it down and build it farther inland.

The workings consist of an adit (C), Plate No. XVI., which has been driven in from the base of the cliff (a few feet above high-water mark) by the side of the lode which intersects at about 60 fathoms in from the cliff. The bearings differ at this point from the general bearings of the lode, which has, together with other indications, led many to believe that this is either a distinct lode, or a branch from the main one. D is a shaft sunk down to this level, going through the brown hematite overlie, into a mixture of that ore and white spathose. E is "Borlase's" shaft. In the 13 fathom levels here is found the brown cellular ore, nine fathoms wide, and the analyses given are from ore taken from this level. Dynamite has been found far better than powder for blasting this "cellular" ore. F and G are also shafts sunk to prove the continuation of the lode.

The engine which is erected near "Borlase's" shaft is adapted both for pumping and winding. It draws the ore up a steep incline from the workings at the foot of the cliff to the summit, where a self-acting drum lowers the ore down the opposite side of the hill into railway waggons.

2.—MOUNT.

At this mine two or three openings have been made, from which many thousands of tons of iron ore have been raised, nearly the whole of which has been brown hematite, as the workings have not been deep enough yet to reach the white spathose.

There is nothing to notice here except that the openings have proved the continuation of the deposit or lode.

Analyses of ore from this mine, by Dr. Percy, give the following results:—

Metallic iron	52.91 per cent.
Do. manganese	2.36
Total	55.27

[137]

3.—TREAMBLE.

The lode has been worked away to a considerable extent here by means of an open quarry (H), Plate No. XVI., or cutting about ten fathoms deep. The brown hematite cropping out to the surface, and the white spathose plainly visible in the bottom.

I is a shaft worked by a water-wheel in the valley below at the bottom of which a lead lode was cut, from which a quantity of lead ore, highly productive in silver, was raised.

J is "Parkin's" shaft, at which a sixty-inch pumping engine is erected. The shaft is 20 fathoms deep.

K is "Berriman's" shaft and workings, where most of the ore sold from this mine was raised, and where the lode is larger than at any other point which has been opened up.

A kiln has been erected here for roasting the ore, but it is constructed in such a manner that it is very doubtful of its being equal to the work for which it is intended.

4.—GREAT RETALLACK.

The writer has not had the opportunity of personally inspecting this mine, but the owner of the royalty, Francis Retallack, Esq., has been kind enough to supply the following information, which goes to show that it is a very valuable mine. It has been worked for many years for iron, silver lead, and blende, more especially for the latter mineral. Upwards of £2,000 has been paid in royalty dues, which for so small a plot of ground is a considerable sum. The quantity of lead ore sold was very small, but it contained so much silver that it made a very high price, one parcel, it is understood, bringing the unusually high figure of nearly £300 per ton.

The pumping engine at the adjoining mine (Duchy Peru) drains the whole of this sett, which at present is being worked for blende only.

5.—DUCHY PERU.

Not only have many thousands of tons of iron ore been raised from this mine, but also quantities of copper, sulphur, mundi, and blende.

L is "Carter's" shaft (Plate No. XVI.) sunk down to the forty-fathom level, the brown hematite (of "cellular" character) from this point was unexceptionally good and free from all impurities; stones of white spathose were frequently met with towards the bottom of this shaft, enveloped in a shell of cellular brown ore of about an inch in thickness.

[138]

M is "Roebuck's" shaft, which is the most important one of all which have been sunk on the lode, proving, as it does, the existence of white spathose ore to a depth of nearly seventy fathoms, and thirty fathoms at least below the datum line of high-water mark. A sixty-inch cylinder pumping engine is erected here, which draws about 500 gallons of water per minute. This engine is draining the water from the next mine (Deer Park), a distance of about one and a-half miles.

N is "Vallance's" shaft sunk for winding purposes, and is fifty fathoms deep. An inclined tramway connects this mine with the Treamble Mines and the Cornwall Minerals Railway.

6.—DEER PARK.

This is the most easterly point at which the Perran iron lode has been opened, and is in close proximity to the celebrated East Wheal Rose and Shepherd's Lead Mines, the former having divided about £287,000 in twelve years, and the latter about £80,000 in sixteen years. See Plates XVI. and XVII.

In the Deer Park sett there are three lead lodes, and the iron lode discovered, and the writer will now give detailed particulars of the workings, which he thinks go to confirm the theory that this large deposit of iron is merely the "back," or gossan, of lead and copper lodes respectively.

No. 1 lead lode (Plate No. XVII.) is an east and west one, which was discovered by means of an adit taken up from the "Whipsey" Pit, about fifty fathoms west of the "Old Engine" shaft, and worked upon about fifty years ago. This adit was driven on the course of the lode, producing iron pyrites and lead ore. The result induced the company to put up steam power at the "Old Engine" shaft, which was sunk twenty-five fathoms below the adit, and levels were driven east and west on the lode eleven fathoms below it, which yielded about one ton of lead ore per fathom. From the bottom of the "Old Engine" shaft a quantity of white spathose iron was raised, but at this time, in the year 1832, there being no demand for Cornish iron ore, and the price for lead being only about £8 per ton, the mine was stopped. The iron ore has, however, been picked out of the burrows lately and sold. This lode (lead) is about 2½ feet wide, and is composed of floogen, decomposed elvan, spar, and small lead ore; it has been also cut about 100 fathoms east of the "Old Engine" shaft, and galena taken from it at this point, within ten fathoms from the surface, yielded about 70 per cent. of lead and upwards of 15 ounces of silver per ton.

At the "Whipsey" pit the lead lode comes in contact with the iron lode, and the latter is so impregnated with lead ore that it is found profitable

to stamp it by hand labour for the lead alone. If it were probable that this lead-bearing iron ore was to be found in any bulk in depth, proper stamps would be erected to crush it; but the writer is of opinion that the iron lode will die out in depth, and give place to the lead ore.

No. 2 lead lode, also an east and west one, was cut near "Barton's" shaft in the year 1875, and since that time several parcels of lead ore have been raised, yielding about 22 ounces of silver per ton, and it sold for about £18 a ton. These parcels were got within four fathoms of the surface.

"Barton's" shaft has now been sunk down to the eleven-fathom level "old workings," where the operations go to show that although large quantities of lead ore have been stored away, yet nothing has been done on the iron lode which is impregnated with lead here again. By sinking this shaft ten fathoms deeper the lead lode will be intersected in the shaft.

No. 8 lode is about 18 inches wide, producing stones of lead ore, which were analysed by Captain Champion, and found to contain 30 ounces of silver per ton and 80 per cent. of lead.

From the iron lode about 10,000 tons of iron ore have been raised by the late company who worked the mine, all of which has been quarried from openings of about three to four fathoms deep, but hundreds of tons of this quantity have been full of lead ore; in some cases stones of iron ore have contained so much as 40 per cent. of lead, and the percentage of lead in one cargo of iron sent away was 20 per cent. But taking the iron lode at the depths to which it has been proved to be productive at the various mines, it must yield a very large quantity of ore; and if in depth it should give place to either lead or copper, the latter deposits will no doubt be unusually rich ones from the fact of having such a rich "gossan" overlying them.

The Chairman said, they were all very much obliged to Mr. Parkin for the very interesting paper he had sent to them. It was peculiarly acceptable, because it was from a district of which they had not yet had any detailed account in a geological point of view. The point in the paper which seemed most to interest North Country people was the extraordinary production of such a variety of minerals. They had no idea of it in this part of the country. There was blend, copper, lead, iron, carbonate of iron, and silver, all combined together within a very short range of distance. The circumstance which struck him most particularly was, that the outside of these minerals—the external edge of

the nucleus which contained them—seemed almost invariably to be composed of carbonate of iron. It happened that in the county of Durham, as many of the members knew, the Weardale Iron Company were working a large quantity of a brown carbonate of iron (almost approaching to a hematite, in the Weardale district), and it generally formed (as is now described in this paper) the outside edge of the lead vein. They would observe that wherever Mr. Parkin had found a lead vein, he always found an outside edge of this carbonate of iron, which not only continued it to the perpendicular part of the lode, but also into the outlying parts of flatts of it which extended horizontally into the limestones; thus showing that the geological facts were synonymous in both districts. As to the cost of production and leading to the coast, these were points which would have to be very carefully tested at a future time; but he thought that as they had a favourable opinion on the subject, expressed by such a man as Mr. Bessemer, they might conclude there was something very valuable in the paper which they had just heard. He supposed that none of the members were sufficiently acquainted with Cornwall to be able to discuss the paper at the present time, but it would be open for discussion at a future meeting; and at any rate they had got an addition to their data. The meeting then terminated.

[Plate XV. Map of the system of the Cornwall Mineral Railway shewing its connection with the mines working the “Perran iron lode”;

Plate XVI. Longitudinal section of some workings of the Perran iron lode, Cornwall 1877;

Plate XVII. Deer Park Mines. Sketch of working plan, 1877;]

PROCEEDINGS.

GENERAL MEETING, SATURDAY, APRIL 13, 1878, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE

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

The minutes of the last General Meeting were read, and the minutes of the Council Meetings held on the 30th of March and the 13th of April were read and approved of.

The following gentlemen were then elected:—

Students—

Mr. Walter Howard, Mining Pupil, Towneley and Stella Collieries, Blaydon-on-Tyne.

Mr. James B. Nelson, Mining Student, Seaton Delaval Colliery, Northumberland.

The following gentlemen were nominated for election at the next meeting:—

Ordinary Members—

Mr. John Henry Harden, Department of Geology and Mining, Towne Scientific School, University of Pennsylvania, Philadelphia, U.S.A.

Mr. Thomas Gilchrist, M.E., Ovington Cottage, Prudhoe-on-Tyne.

Mr. Thomas Dacres, M.B., Dearham Colliery, Maryport.

Students —

Mr. David L. Evans, Gold Tops, Newport, Monmouthshire.

Mr. Amidee Vernes, 8, Claremont Place, Gateshead.

The Chairman stated that the expense of publishing the first part of the Sections and Borings had been so great that the Council had determined (as they had heard) to limit the issue in future to 500 copies, with the understanding that the publisher should stereotype the pages and deliver a further issue of 500 copies, if wanted, at a very much reduced price, and to charge for each part, of 200 pages or thereabouts, five shillings to members, and seven shillings and sixpence to non-members.

Mr. G. A. Lebour then read a paper, by Mr. Henry Laporte, entitled "A Geological Sketch of the Northern Coal-field of France:"—

[142]

[blank page]

[143]

A GEOLOGICAL SKETCH OF THE NORTHERN COAL-FIELD OF FRANCE.

By HENRY LAPORTE.

It is a difficult task to give a geological description of this coal-field, as, up to this time, it has been studied very little.

A few notes have been published, giving a general idea of the coal-field, with very few details. Monsieur Dormoy's book is the most important work published on the subject, but, in it, the author enunciates theories, the exactness of which are often doubtful, as they are not based upon material facts.

After reading some of these publications, including those of Messieurs Dormoy, Obry, and Gosselet, the writer has taken from them the following sketch of the northern coal-field of France:—

The northern coal-field of France (see Plate XVIII.) is the prolonged coal-field which is known and worked in Prussia and Belgium, at Aachen, Liege, Namur, Charleroy, and Mons. Its direction is from east to west. At the French frontier it turns a little southward, and reaches thus the towns of Valenciennes and Douai, then it again follows its former direction as far as Hardinghem and Ferques; beyond, it is impossible to trace it.

Its length is: From the Belgian frontier to its extreme known limits in the "Pas de Calais"	65 miles.
From this extremity to the " Hardinghem coal-field," the space under which coal is said, by the most competent men, to exist at a great depth	22 „
The length of the "Hardinghem or Boulonnais coal-field," which is the continuation of the former one, is	7 „
The probable total length of the northern basin is then	94 miles.

Its width is very irregular; for instance, it is about eleven miles near "Douchy," and it becomes only a little more than half a mile at "Fléchinelle" (Pas de Calais).

For a long time the "Boulonnais" basin was thought to belong to a special formation different from that of the large basin. This error

[144]

resulted from the fact that coal was lying between two beds of carboniferous limestone. It has been now well proved that the coal formation of Hardinghem is exactly the same as that of Valenciennes, the limestone having come upon the coal-measures by a geological accident, more details of which will be given later.

The French coal-field is everywhere covered by strata of recent formation, which are called in French "Morts Terrains" (dead strata), corresponding to the English word "cover." Their thickness increases from east to west, from forty-four to two hundred yards, but there are exceptional points where a much greater thickness of these "dead strata" is to be found.

Below this "cover" lies a series of beds, consisting of various shades of gray plastic clay, of argillaceous sand, or sandstone more or less consistent and of different colours, some of them being white, others yellow, reddish, or greenish.

These strata are very like the plastic clay found under the "London clay," and are called "Tertiary strata" (Terrains tertiaires). Fortunately, these strata are not very thick, for the marl, quicksand, as well as the water which they contain, make it a very difficult and dangerous matter to sink a pit in that country.

After the Tertiary strata comes the "Cretaceous stratum," which might mean, in English, "Chalky Limestone formation," and with which corresponding strata are to be seen along the English and Danish shores. This formation is sixty-six to eighty-eight yards thick.

It may be divided into two stages, an upper and a lower one. The upper one is formed of marl, gray chalk mixed with clay, green chalk, gray limestone, pure and soft chalk, blue argillaceous marl, (the first stratum reached, which is impervious to water), argillaceous chalk and marl, and finally, bluish compact clay called "Dièves."

The lower stage, which holds water very well, consists of a conglomerate, the elementary matter of which is limestone mixed with gray clay, containing, in some parts, a large quantity of silicate of iron.

Nevertheless this stage has no great thickness. It is only two or three yards thick. It is in Belgium, near the frontier, that its thickness increases to about eighty-eight yards. The "Walloons" call it "Tourtia."

Finally, there exists (but only over a small area of about five thousand acres between St. Waast, Denain, Oisy, and Prouvy,) other beds belonging to the lower cretaceous formation, which are called "torrents" by the French workmen, because of the quantity of water contained in them.

[145]

They are composed of sand, plastic clay with pyrites, different broken carboniferous stones, pieces of fossil wood and plants.

The carboniferous deposits in Prussia, Belgium, and France have been formed by the vegetation known under the name of "Sigillaria" and "Calamites," deposited upon carboniferous limestone, characterised by the large quantity of "productus" it contains.

This limestone itself lies upon a bed of "Devonian grits" ("gres Dévonien"), which contains "Spirifer Verneuili." It contains sometimes very good seams of coal, and such is the case in some parts of England, but this coal has been formed by a vegetation quite different from the former one, and called "Lycopodiacées" vegetation. Seams belonging to this stage exist in France, but they are unworkable.

The whole of these sediments have been deposited in a very long, low, and marshy region, extending from east to west, in Prussia, Belgium, north of France, and a part of southern England.

This sort of long valley was limited, to the north, by a higher country, which constituted a very important table-land composed of Silurian strata, and which existed northward from Liege, Namur, Ath, Tournay, Menin (Belgium), Saint-Omer Caffiers (France). The Belgians gave to it the name of the "Brabant" table-land, and this name is generally adopted.

The southern boundary of the marshy region was another table-land also composed of Silurian and Devonian beds, and nearly parallel to the former. It bears the name of "Table-land of the Ardennes."

A projecting crest of Silurian and Devonian formation (The "Condroz" Crest), following the whole length of the low country, divided it into two parts.

This crest crosses Belgium, the north of France, and probably England, where it separates the Devonian from the Bristol basin; the latter would then correspond to the Valenciennes coal-field.

On the continent, the two valleys which are on each side of the "Condroz" Crest, bear the following names:—The northern valley is called the "Basin of Namur;" the southern one, the "Basin of Dinant."

During the carboniferous and Devonian ages these basins were filled with sediments, which, enumerated according to age, are:—

The Silurian Sediments.

The Old Red Sandstone.

The Devonian Limestone.

The Devonian Sandstone "Psammites."

The Mountain Limestone.

[146]

At last, coal-measures were formed by the luxuriant vegetation which was growing in the middle of the marshes.

The coal period had scarcely finished when a great movement took place in this part of the world, which pushed the southern table-land to the north, while the "Brabant" table-land stood firm. In consequence of this, the sediments which had been deposited in the intermediate valleys, and which were originally horizontal, or nearly so, were thrown up, compressed, and folded, so that the section of the strata became very much like a more or less opened V. See Plate XXI.

Of course, the whole region being raised in consequence of the compression to which it had been submitted, ceased to be marshy, and fit for vegetation, and the coal formation was stopped.

Later on, the sea, by violently invading all these regions, reduced the surface completely to a level, and then covered it with cretaceous deposits.

In the so-called "Dinant basin," which is much larger than the other, only a few traces of coal-measures have been found. This basin exists under the Provinces of Cambresis, Artois, Picardie; under the English Channel, Devonshire, and Cornwall.

The Namur basin, i.e., the one which lies between the "Condroz " Crest and the "Brabant" table-land, is most important, as it contains the coal-fields of western Prussia, Belgium, northern France, Somerset, and South Wales.

The "Condroz" Crest, as before noticed, consists of a Silurian band, on which rested another and broader band of old red sandstone (the Pudding-stone of Burnot).

The result of the pressure exercised by the southern table-land against the intermediate beds has been, that an immense fissure was made all along the coal-field from Liege as far as Hardinghem, between the "Condroz " Crest and the Namur Basin.

This fissure, the name of which is "The Great Fault" (La Grande Faille) is inclined to the south, and is like a cleavage along which the "Condroz" Crest, while pushed to the north, has been slipped upwards so as to become a sloping prominence, covering coal-measures. This prominence, in many cases, sank down, and covered, to a great extent, the latter formation.

This fact explains how coal-measures are so often to be met with under Devonian rocks in Belgium, and in France, along the southern limits of the coal-field. As these limits are not quite in a rectilinear direction, some parts of the coal-measures were not reached by the fissure, while some parts were thrown up and washed away, and, in the latter case, it happened that

the "Condroz" Crest, by cutting away a part of the carboniferous beds, brought to the surface blocks of limestone which were left isolated, and which still cover at the present moment, throughout a certain area, different parts of the coal-field.

The French basin seems to have been composed at first of two declivities, as is also the case in the Belgian one. The northern declivity rested against the "Brabant" table-land, which, resisting the pressure, protected this declivity from being disturbed like the other.

This one, in fact, was thrown up, folded upside down upon the other half of the field, or the seams were twisted upon themselves like the pages of a book that one might close suddenly. In the whole length of the coal-field (at least, this is most probable), another fault was produced which is parallel to the Great Fault, and called "Cran de Retour."

The southern declivity is said in all the French books to have been slipped downwards along this fault, from the fact that bituminous coal is worked in the southern declivity at the same stage at which semi-bituminous coal is worked northward from the fault.

It seems difficult to understand how a downthrow of the seams could have happened in such circumstances as these. The "Cran de Retour" resulted, like the Great Fault, from a pressure from south to north. How could strata, which were pushed to the north, have been slipped downwards along a fault inclined to the south?

Probably the southern declivity was raised along the "Cran de Retour" in the same way as the "Condroz" Crest was raised along the Great Fault, forming a hill or mountain of coal-measures, which has been washed away by subsequent inundations. The seams of bituminous coal worked southward from the "Cran de Retour" might correspond to the seams worked in the northern concessions of the coal-field. A change of quality in seams of coal is not an impossible thing, for instances of it are observed in South Wales and Belgium.

Nevertheless, the southern declivity is known only from Anzin as far as Aniche; further west the northern declivity is the only one known, and this permits the supposition that, in this direction, the meridianal part of the basin might have been totally thrown up and washed away.

The seams are divided into three principal groups, very different from one another, and between which lie transitory groups.

The following is the succession of qualities in the northern declivity:— An anthracitic coal at the basis, bituminous coal in the middle, and at the upper part of coal-measures, intermediate qualities of more or less bituminous coal.

THE "BOULONNAIS" COAL-FIELD.

The first coal mines were started near Ferkes, and they became famous on account of the geological discussions which they provoked rather than on account of their importance.

Coal was lying between grits and shales, which were found between two beds of mountain limestone and in discordant stratification with the upper one. See Plates XIX. and XX.

Some geologists pretended that these two beds of limestone were of the same nature, and that the coal belonged to the limestone age.

Some others gave a more recent origin to the Upper Limestone, affirming that there was no difference between the coal-measure of Ferkes and those of Valenciennes.

Finally, grounding his opinion upon excellent reasons and upon material facts (amongst which the similarity of fossils), M. Gosselet, a French engineer, declared and showed that the existence of mountain limestone upon these coal-measures is the result of a geological accident, this coal formation being the same as that of Valenciennes.

The description of the "Boulonnais" coal-field is not a very easy one, for this reason: it has been furrowed by numerous and deep faults which cross in all directions, and these intersections of faults transformed coal-measures into a series of isolated blocks, which were allowed to move upwards or downwards between these faults.

Therefore, it is easy to understand how there remained such a strangely-composed surface, after this region, which was ploughed with projecting rocks and holes, had been levelled by the inundations. In some places a small square of the coal-measures will be seen everywhere bounded by faults, on the other side of which the Devonian formation will be found without any transition, and these Devonian strata themselves will perhaps be bounded by faults which separate them from the mountain limestone.

Yet, the northern declivity of the coal-field has resisted and is not disturbed; it enables the whole succession of strata to be traced again. This part of the basin, situated to the north of a big fault, which runs from Ferkes to Hardinghem, is very regular; but, unfortunately, there remains nearly nothing of the coal formation in this declivity. The following table shows the succession of strata:—

The Silurian Formation.

610 yards of Devonian formation	Red shales, with Pudding-stone and green "Psammites."
	Limestone
	Shales and dolomite.
	Limestone.
	Red shales and red grits.

[149]

Coal-Measures.	Carboniferous limestone, 366 yards	Limestone with "Productus Cora"
		Limestone with "Productus undatus"
		Limestone with "Productus giganteus"
	Coal formation	Hardinghem grits
		Lockinghem shales

The five Devonian beds may be observed to the north of the big fault, where they are inclined to the south. Southward, from the same accident, the upper part only of this formation is to be seen, in the middle of beds of limestone, from which it is separated by faults. Its inclination is to the south-east.

Coal-measures begin here with the dolomite; then come three beds of limestone, to which succeed the carboniferous grits and shales.

It is the same order of deposits as in Belgium, but, in this case, the inferior beds of the limestone stage fail.

There are six distinct bands of coal-measures in the "Boulonnais" coal-field.

I.—The "Ferkes" band is too narrow to be worked with any profit. The seams are inclined to the S.S.W.

II.—The "Haut-Banc" band is limited by three faults. The limestone, with "Productus Cora," forms here an arch, which plunges in all directions at an inclination of about 10 degrees.

III.—The "Leülinghen" band is bounded everywhere by faults, and is inclined to the east.

IV.—The band of "Les Combles" is inclined 13 degrees to the east, where it is stopped, at a fault, by Devonian strata.

V.—The "Lockinghem" band contains seams of coal which are worked to profit; their direction is from east to west, and they deepen to the north. They belong to the upper part of these coal-measures.

To reach them it is necessary to go through the mountain; limestone, which has nearly the same inclination as the coal-seams, but upon which, nevertheless, it reposes unconformably.

The presence there of limestone results from a geological accident.

M. Gosselet thinks that its position results from a very oblique fault, along which it may have slid.

VI.—The "Hardinghem" band, the ground of a great part of the plains, which extend westward from Hardinghem, is composed of carboniferous grits, very like the millstone grit. Coal was found in irregular

groups (nids) in this part of the country; all the beds are inclined to the south at the "Plaines" Pit, and to the north at "Des Verreries," so that the strata still form here a sort of arch between these two points.

The southern boundary of this band is a fault, on the other side of which lies limestone; and the fault being itself inclined to the south, coal-measures would be found under the mountain limestone.

In the following notice the writer simply intends giving the names and showing the importance of the different companies between whom the known coal-field of the North of France is divided. This will ensure economy of time to those of the members of the North of England Institute who wish to visit that part of France, for it will enable them to inspect those collieries which are the most worth seeing:—

There are twenty-three companies in the "Nord" and "Pas de Calais" coal-field, and one in the "Boulonnais" coal-field. A visit to seven or eight of these companies will be as profitable as an inspection of all the twenty-four. The total extent of the granted concessions in the Nord and Pas de Calais is about 220,000 acres. The extent of the "Boulonnais " concessions the writer is unable to give, but they are not important. Some companies have obtained concessions of immense size. For instance, "Anzin" has a field of 56,000 acres, and "Aniche" one of over 23,000 acres. These concessions are granted by the State, and the companies have to pay for them a fixed rent per acre, and so much per cent, of the profit, 5 per cent. being the probable maximum.

The great expense that has been incurred by the different companies, in order to increase the well-being, the instruction, and the morality of the working classes will form a subject well worthy the attention of the visitors. Numerous schools and churches have been established, so as to render it a very easy task for the parents to get their children instructed and educated under the best conditions. More than half the number of men, who are employed in collieries, live in the companies' comfortable houses, of which there are more than 13,000 in the two departments. "Anzin" spends, annually, more than £50,000 in subsidies of this kind for the workmen, and its example is imitated by all the other companies.

Most of the collieries have been established from twenty-two to twenty-five years, and they are generally well fitted. The pits are properly built and large, their diameter being between 13.5 to 15 feet. Wood tubbing is very often used, but in the new pits cast iron tubbing is preferred. The winding-engines are generally horizontal with two cylinders from 24 to 36

inches diameter and from 5 to 6 feet stroke. Steam brakes are everywhere applied. Flat hemp ropes are employed almost exclusively, except at Anzin, where flat iron ropes are used. The guides in the pits, and the trams or tubs, which contain from 8 to 10 cwts., are made of wood. No pumping-engines are to be seen, the water being wound up at night in wood or iron boxes. The men go down and come up in cages. Ventilation is generally effected by "Guibal's" fan, which is here considered as the best ventilating machine. Mechanical hauling has been established for three years in several collieries, and it gives very satisfactory results. The adopted systems are tail-rope and endless chain. Boring machines have also been successfully applied in several cases. Very good shipping places are to be seen at Lens, where coal is shipped by mechanical apparatus. It is the best place of the kind in France. It is not as complete nor as magnificent as the Cardiff shipping arrangements, but it is well applied to the special requirements of the district.

The production of coal in France is continually and rapidly increasing, and yet the importation of foreign coal—English, Prussian, and Belgian— increases. This proves that the extension of French collieries does not go on as rapidly as the consumption, and it disproves the opinion of those who say that the French market will soon succumb to English and Belgian competition.

As far as could be ascertained, the following are the mean prices at which coal was sold in 1875-76, per ton, at the undermentioned places:—

In 1875.	s.	d.	In 1876.	s.	d.
Aniche	12	9½	Aniche	12	0

Anzin	13	3½	Anzin	12 1
Escarpelle	12	8	Escarpelle	11 9

The following table shows the purposes for which coal has been used in France during the year 1872:—

Metallurgical and gas works, manufacturers	16,834,280 tons.
Domestic purposes	3,096,040 „
Transport industries	2,385,900 „
Mines and quarries	927,110 „
Total	23,243,330 „

During the same year French collieries had produced a total of sixteen million tons, and of the rest of the consumed quantity (i.e., seven millions and a-half), two millions came from England, five millions from Belgium, and half-a-million from Prussia.

[152]

The output of the northern coal-field has been:—

Name of Mine.	1875.	1876.	1877.
Dourges	119,478	123,454	163,000
Courrieres	435,933	380,119	370,475
Lens	715,097	670,089	627,643
Bully Grenay	288,676	415,969	425,004
Noeux	427,942	444,880	439,250
Bruay	252,728	270,064	309,023
Marles	232,595	269,114	301,156
Ferfay	166,704	162,865	156,433
Cauchy à la Tour	1,262		
Auchy au Bois	12,979	19,439	31,217
Fléchinelle	42,332	54,891	47,107

Vendin	35,100	41,034	50,516
Liévin	158,921	141,901	157,988
Meurchin	79,814	77,380	83,031
Carvin	149,880	117,827	126,513
Ostricourt	36,190	38,990	35,620
Hardinghem	77,953	94,273	87,651
Annoeullin			22,533
Courcelles			978
Anzin	2,025,873	2,063,931	2,032,535
Aniche	607,624	574,595	543,653
Douchy	207,963	173,910	157,225
Escarpelle	283,933	260,778	262,644
Azincourt	35,395	41,945	44,971
Annœulin		12,568	11,201
Vicoigne	134,878	124,388	121,216
Escaupont		63,457	55,600
Total	6,529,250	6,637,861	6,664,183

Some companies are separated here, which form one company; for instance, "Vicoigne" and "Noeux" belong to the same company, although their output is given separately.

LIST OF THE COMPANIES EXISTING IN THE NORTHERN COAL-FIELD OF FRANCE.

"Anzin."—This company was established in 1757, in the "Hermitage" Castle, near Condé, by Messieurs Desandrouin, Tassin, the Prince of Croy (a German nobleman), and the Marquis of Cernay.

Fifty-three pits are still utilised by the company, twenty-one of them being winding pits, six are temporarily idle, two in course of sinking, and the other twenty-four are used for ventilation.

[153]

The extent of the whole concession is very nearly sixty thousand acres; but it is composed of eight different properties, which the company obtained one by one, so as to form the immense field known under the name of "Anzin," more than eighteen miles long from east to west, and, on an average, more than six miles wide.

The names of these different properties, the limits of which are shown on the map, are: Fresnes, Anzin, Vieux Condé, Raismes, Saint Saulve, Denain, Odomez, Hasnon.

Throughout the whole extent of the field, the coal-measures are covered with more recently formed strata; alluvium, tertiary, and cretaceous; the basis of the latter being a bed of clay which hinders water from penetrating into the coal-measures.

The thickness of these covering strata increases pretty rapidly from east to west—for instance, they are only seven yards thick near Condé, but reach a thickness of twenty-seven yards at Vieux Condé, thirty-nine yards at Fresnes, one hundred and forty-four yards at the "Thiers" Pit, two hundred and sixty-six yards at Bruay, and so on.

The twenty-one winding pits give very different sorts of coal, the importance of each of which is shown by the following table of the output during the year 1875:—

Anthracitic coal	303,683 tons.
Slightly bituminous coal	19,287 „
A rather more bituminous coal	127,902 „
Semi-bituminous coal	769,641 „
Smithy and cannel coal	299,085 „
Total	1,519,598 „

The map shows whence these different kinds are taken. After deducting the quantities of coal worked out and lost by accidents, there remains, it is said, in Anzin more than three milliards tons of workable coal. The output has been for the last few years:—

In 1867	1,441,002 tons
1871	1,715,878 „
1874	2,058,037 „
1875	2,058,522 „
1876	2,136,877 „

This quantity represents one-third of the production of the departments of the north, and one-ninth of the production of France.

[154]

The following table shows the number of workmen, the wages and output per man during the years 1825, 1845, 1865, 1875:—[see in original text]

The colliers get coal, medical attendance, and instruction for their children gratis, and pay only a nominal rent for their cottages. These advantages, joined to a few others of minor importance, raise the annual wages of each collier to £49 9s. 2d.

At the present moment, the most interesting things to be visited at Anzin are:—First, at the "Thiers" Pit, mechanical underground hauling, by tail-rope system, two thousand yards long; second, underground hauling, by endless chain, at the "Reussite" Pit; third, air-compressing and boring machines at the three following pits:—"Enclos," "Thiers," and "Havelug." The "Renard " is worth seeing on account of its fine buildings, its general arrangements, and its winding engine of 450 horsepower. This engine is vertical, with two cylinders 39 inches diameter, 5 feet stroke, with "Guinotte's" expansion gear, flat steel ropes 4 inches wide and ⅕ inch thick, the weight of which is 19 lbs. per yard. The diameter of the drums is 19 feet. The pulleys are made of iron, and 20 feet diameter. The pit head frame is made of iron, and the weight of each steel cage is 1 ton 16 cwts.

A very large and interesting patent fuel manufactory is to be seen at St. Waast, where four presses, on the "Revollier" system, and two " Middleton" presses give 500 tons of patent fuel per day of twenty-four hours. The chief offices of the Company are at Anzin.

"Fresnes-Midi," "Crespin," "Marly," and "Douchy."—The author has been unable to give any details of these concessions.

"Aniche."—This company has existed since the 11th of November, 1773, but only began to prosper in 1845. Nine winding pits are actually at work, and two new pits will soon be ready to start.

The concession of Aniche is also very important for its extent, which is over twenty-four thousand acres. From Somain to Douai it is about ten miles long, and a little more than five miles wide.

[155]

As at Anzin, the coal-measures are covered by strata of recent formation, the thickness of which varies from 140 to 222 yards. They contain much water.

A group of sixteen seams is being worked at present; they give a sort of anthracitic coal, which contains from 13 to 18 per cent. of volatile matter. The total thickness of the group is 28 feet of pure coal, chiefly used for steam purposes. Another group of twenty-seven seams is being worked southward from the "Bernicourt" Pit. These seams are more recent than the latter ones, and give a bituminous coal, containing 18 to 28 per cent. of volatile matter, very good for coke and glass manufacturing. The thickness of the group is 57 feet. The pure anthracitic coal of the northern part of the concession is still untouched.

These collieries have produced the following quantities during the past twenty-five years:—

From 1850 to 1860	107,000 to 290,000 tons.
1860 to 1870	290,000 to 450,000 „
1870 to 1875	450,000 to 625,000 „

The quantities of coal produced per man, the number of workmen, and the mean wages, are given in the following table:—[see in original text]

The most important objects at the "Aniche" Collieries are:—First, the "Renaissance" Pit, with a completely closed pit-head frame, the pit being used both as a winding and ventilating pit; second, the underground hauling at "Sainte Marie" Pit; third, the two pits in course of sinking at "Roucourt," with cast-iron tubbings in six pieces, and an engine with variable expansion on the "Sultzer" patent.

It may be of some interest to know the value of a colliery, such as this one in France. The "Aniche" Company owns to a total expenditure of £832,000, the actual output being 611,000 tons of coal; but the partners have only had to pay £92,000, all the rest being covered by the profit. The chief offices are at Aniche.

[156]

"Azincourt."—Southward from Aniche is the "Azincourt" Mine. The company has two winding pits, and works some distorted seams near the limit of the coal-field.

"Escarpelle."—This company was founded the 4th of February, 1847, and is now amongst the best companies of the north of France, taking into consideration the profit obtained from its mines. Its concession has an area of about 9,500 acres, and it contains the same seams of coal as that at "Aniche." It is worked by five winding pits. The Nos. 1 and 2 pits work semi-bituminous coal; Nos. 3 and 4 pits, as well as No. 5, bituminous coal. The thickness of the seams varies from 1½ to 5 feet of pure coal.

The thickness of covering strata varies from 513 to 774 feet.

The production of coal has been:—

From 1850 to 1860	360,274 tons.
„ 1860 to 1870	1,158,006 „
„ 1870 to 1875	1,306,296 „
In 1875	283,933 „
„ 1876	265,122 „

In 1875 the production per hewer was 246 tons. The mean wage of the workmen of all descriptions was £43 17s. 7d.

In 1876 the production of each hewer was 221 tons, and the annual mean wage for workmen of all descriptions was £44 6s.

The No. 4 and No. 5 pits have been sunk by the Kind and Chaudron system. Seventy tons of water (15,625 gallons) came into each pit per minute, so that it was impossible to think of sinking pits there by any other system. These two pits are well fitted and worth seeing.

"Dourges."—At Hénin-Liétard, this company has rather large collieries, consisting of three winding pits, giving good bituminous coal. It is situated between "Courrières" and the "Escarpelle" colliery.

"Ostricourt."—This company's concession, situated to the north of "Dourges," is a small one, worked only by two pits, and containing nothing but a close-burning anthracitic coal.

"Courrières."—These collieries were established on the 5th of August, 1852. The company have obtained a concession, the area of which is 11,000 acres. As early as 1856 the mines were already developed and prosperous. There are five pits at work, and a sixth is in course of sinking. Borings made at Hénin-Liétard, Sallau, Harnes, and Courrières, show that the cover is, on an average, from 155 to 166 yards in thickness, and contains large quantities of water. The concession extends four miles in width from east to west, and more than six miles from north

[157]

to south. As regards the sorts of coal that it contains, the whole series may be found therein. In the northern part there are six seams of close-burning anthracitic coal, giving 9 to 13 per cent. of volatile matter; in the middle part, twelve seams of bituminous coal, but burning with a short flame, and giving 20 to 30 per cent. of volatile matter. This makes thirty-eight seams of coal, giving a total thickness of 105 feet of pure coal.

The production has been:—

From 1851 to 1860	15,000 to 70,000 tons.
„ 1861 to 1865	70,000 to 202,000 „
„ 1866 to 1868	230,000 to 280,000 „
„ 1869 to 1872	316,000 to 353,000 „
„ 1873 to 1875	372,000 to 435,000 „

This table shows how rapidly the output has been developed; it has been doubled in less than ten years (1866 to 1875). The value of the colliery is quoted at £346,400.

[see Table in original text]

The following places are the most worth seeing:—The shipping place, with a system of cranes (Chrétien's patent), No. 6 and No. 4 pits, and the Mericourt pit. The central offices are at "Billy Montigny."

"Liévin."—This company has existed since the year 1858, and the extent of its concession is 2,900 acres, which is worked by three winding pits. The concession extends over an area 5½ miles long and about 1 mile wide. The thickness of covering strata is about 143 to 166 yards; they are moderately aqueous.

The concession is remarkable, because of a fault running north-west to south-east, dipping 18 to 19 degrees to the south; the seams are quite disturbed and turned upside down on the southern side of this fault, while the northern part is very regular, with an inclination of 6 to 10 degrees.

The three winding pits give an output of:—

In 1860	4,068 tons.
1865	24,272 „
1870	80,457 „
1875	158,921

[158]

All the seams which are being worked at the present moment give bituminous coal.

In 1875, there were 914 workmen working below ground and 276 above ground. Hewers earned 4s. 3½ d. per day. Annual wage for workmen of all descriptions was £51 12s. 0d. Annual production per hewer was 202 tons.

The workmen have better wages here than in the other mines, but otherwise they do not get any particular advantages. All the pits have been sunk by the Kind and Chaudron system, and the deepest one is 1,434 feet.

If the members of the Institute pay a visit to the "Lievin" mines, they ought to see the screening arrangements (Briart's system) at Pit No. 1, as well as the compressing and boring machines, and the mechanical underground hauling by endless chain.

At the time of the writer's visit there was a pit in course of deepening by Lisbet's system, but he does not know whether this work is finished or not. Monsieur Lisbet's system consists in deepening a pit without interrupting the work. Monsieur Lisbet, who is a Belgian engineer, is the manager of the "Lievin" mines.

"Lens."—This company was formed in 1849; since that time the mines have become very important. They are worked by six winding pits. The concession is very large, as it includes nearly 14,000 acres. In this large field, the complete series of workable seams of the Northern Coal-field are to be met with, from anthracite to the richest in volatile matter, forty-two seams of coal, varying from 1½ to 9 feet, have been found. The "cover" is between 128 and 172 yards thick, and contains water.

The following table will show how rapidly the development of these mines has been pushed. The output has been:—

In 1853	223 tons.
1855	38,048 „
1860	99,897 „
1865	261,867 „
1870	408,234 „
1875	715,097 „

In 1870, 1,538 workmen were employed at the bottom and 566 at the surface—total 2,104; and in 1875, 2,816 workmen were employed at the bottom and 897 at the surface—total 3,713; so that each workman

represented 194 tons of coal during 1870, and 192 tons during 1875, the total output being nearly doubled. This shows that during and since the prosperous years the output per man has fallen off.

There are many things worthy of attention at Lens.

The Nos. 1, 2, 3, and 4 pits are well fitted, and very much like one another. Their respective depths are 280, 253, 331, and 280 yards; and their outputs in 1875 were as follows:—156,000, 173,000, 156,000, and 218,423 tons. The winding engines are the same at each pit—vertical, with two cylinders 26 inches diameter and 6 feet 7 inches stroke. At the first three pits there are 583, 700, and 558 workmen at the bottom; but the writer does not know how many there are in the No. 4 pit. At this latter pit there is a pumping engine on “Tangye's" patent, which is applied at a depth of 280 yards.

The No. 5 pit will be really a very remarkable one when completely finished. The horizontal winding engine, on the "Audemar" system, with two cylinders, 40 inches diameter and 6 feet stroke, is a beautiful one.

At the No. 6 pit there is a complete arrangement of boring machines, worked by compressed air; blowing apparatus ("Koerting's" patent) are used for the boiler fires at the same pit.

Finally, there is much to be seen at Lens; and every one must be astonished when thinking of the tremendous expense which has been incurred for these magnificent machines and buildings.

"Carvin."—This company's concession is to the north of Courrières. The concession contains only close-burning anthracitic coal, and is worked by two or three pits.

"Meurchin."—This company has only a small concession, with two winding pits, drawing close-burning anthracitic coal.

"Bully-Grenay."—This company's concession was granted on the 15th January, 1853; and it has at the present moment seven winding pits. The concession contains about 11,500 acres, and extends four miles from east to west and six miles from north to south. The thickness of the dead strata is from 150 to 170 yards. There have been fifty-five seams proved, which altogether give a thickness of 48 yards of pure coal. From the northern part of the field the company obtains a dry coal burning with a long flame, and giving 15 to 18 per cent. of volatile matter; further north, where close-burning anthracitic coal is likely to be found, no pits have been sunk. Nos. 2, 3, and 5 pits give coal with 28 to 34 per cent. of volatile matter; while to the south of the concession (at the No. 2 pit), long-flaming coal is worked, containing 34 to 40 per cent. of volatile matter. Finally, a boring, executed several

[160]

hundred yards from the southern limit, has discovered a seam of coal at 480 yards depth. These collieries have been developed very rapidly, too, as is shown by the following table. The output has been:—

In 1855	27,704 tons.
1865	185,962 „
1870	227,950 „
1875	288,676 „

[see Table in original text]

The No. 5 pit is the most worth visiting, as there is a good winding machine, boilers with reversed flames, ovens, air compressing machines, and boring machines on the "Darlington," "Blanzy," and "Warrington" patents. There is also a very strong winding engine (450 horse-power) at the Nos. 1 and 2 pits, fitted up with double-beat valves.

"Vicoigne-Noeux."—The two concessions which constitute this company's field are rather far from each other—"Vicoigne" is to the north of Anzin, and "Noeux" is westward from "Bully-Grenay." The extent of the "Vicoigne" concession is only 1,650 acres, and it is covered everywhere by 90 to 111 yards of dead strata. The four pits sunk here give close-burning anthracitic coal (8 per cen. of volatile matter), belonging to a group of fifteen seams forming a total of 10 yards of pure coal.

"Noeux" is much more important. Its extent is 20,000 acres, and five winding pits take out from this field four sorts of coal coming from four groups, the description of which is given in the following table:—

	ft. thick.	per cent.		per cent.

5 seams of semi-bituminous coal	10	8172 fix. carbon	18.28 vol. matter.
15 seams of bituminous coal, with) short flame)	30	74.22 "	25.78
13 seams of smithy coal	27	69.97 „	30.03 „
6 seams of dry, long-flaming coal	16	59.81 „	40.19 „

The output has been:—

In 1855	174,079 tons.
1865	267,766 „
1875	570,084 „

[161]

Some air-compressing machines at "Braquemont" pit, and a winding engine with Guinotte's expansion gear at No. 5 pit, are worth seeing.

"Bruay."—This company has existed since 1851. Its concession has an extent of about 8,000 acres. The coal-field is here in the very same condition as the neighbouring concessions. The covering strata are 111 to 170 yards thick. The company has only two winding pits, by which it is possible to work, at a depth of 1,000 feet, twenty-one seams, forming a total of 70 feet. The annual production has been:—

In 1871	1,622,019 tons
1873	2,425,084 „
1875	2,897,266 „

The No. 1 pit, with its winding-engines, is worth seeing.

"Marles."—This company obtained its concession in 1855, the area being 6,000 acres. Great difficulties were experienced in sinking the pits, two of which fell in, but three others have been successfully won by the company. The thickness of covering strata reaches 453 feet. They are nearly horizontal, with a slight inclination to the southwest. The upper seams, which give coal burning with a long flame, and containing 35 to 38 per cent. of volatile matter, are the only ones worked at Marles. Twenty-nine of these seams have been proved: ten containing from 3 to 4 feet of pure coal, three containing from 2½ to 3 feet of pure coal, eight are more than 2 feet thick, and the last eight more than 1 foot thick. The three winding pits (Nos. 3, 4, and 5) are very well fitted, and worth seeing. At the time of the author's visit, the company intended making a central screening place, to which the coal will be brought from the different pits by endless chains. The No. 5 pit is double. These two pits have been very successfully sunk by Messrs. Kind and Chaudron.

"Ferfay."—The concession was granted to the Ferfay Company in 1855, but in 1864 the "Cauchy à la Tour" concession was added to it, so that the total extent of the field reaches now 2,500 acres. Nos. 1, 2, 3, and 4 pits are at work, or in position to work. The works have proved the existence of twenty-six seams, representing a total thickness of 66 feet of pure coal. This coal is semi-bituminous, giving 27 to 34 per cent. of volatile matter, and 8 to 10 per cent. of ashes. The No. 3 pit is the most worth seeing. The winding-engine is on the "Quillacq" system. An underground hauling plane is worked by an endless rope coming from the surface. The annual output of these mines is about 180,000 tons. The number of workmen of all descriptions is 1,605. The central offices are at "Bois St. Pierre."

"Auchy-au-Bois," "Vendin," and "Fléchinelle."—These companies are working concessions in the far western end of the coal-field. Their mines are not developed, and it would be useless to visit them after having seen those already described.

"Rety," "Ferques", and "Hardinghem" form the only companies in the "Boulonnais" coal-field; they are not very important, but there are two pits at work, which give very good long-flaming coal.

The foregoing list comprises the names of all the companies existing in the northern coal-field of France.

Mr. Lebour stated that although a large portion of the communication contained a most interesting description of appliances, output, and wages of the several companies that at present existed in the districts of the Nord and the Pas-de-Calais, yet the geological portion of it was well worthy of consideration. The paper, as the members knew, was not his own, neither did it always represent his views, and he should avail himself of the opportunity afforded him of stating more particularly his opinion in the discussion, and showing where they differed from those of the author.

The Chairman said that Mr. Laporte's communication came at a most opportune moment, as the members were about to visit the districts and collieries that gentleman had so carefully described. This was also the first paper they had received written by a foreigner and communicated directly to them. He trusted such communications would be more frequent in future. He could not conclude his observations without complimenting Mr. Laporte on his intimate knowledge of the English language. He had great pleasure in proposing a vote of thanks to that gentleman.

Mr. Newall seconded the vote of thanks, which was unanimously carried.

[see in original text Statistical information on the coal-field of the North of France (translated by the Secretary from the French of Mons. E. Vuillemin). Names and dates of origin of the different companies]

[164]

[see in original text Table of market value of the capital employed in the collieries of the department of the Nord and of the Pas de Calai, in 1873]

[165]

[see in original text Table of market value of the capital employed in the collieries of the department of the Nord and of the Pas de Calai, in 1874]

[166]

[see in original text Table of coal in the departments of the Nord and the Pas de Calai]

[167]

[see in original text Table of Coal sent from the different stations of the North of France railway, and the cost of transport in the year 1873]

[168]

[see in original text Table of Wages of Workmen – from 1843 to 1877]

[169]

[see in original text Table value of the quantities extracted from the coal-fields of the departments of the Nord and the Pas-de-Calais, taken from the average price of the sales for the years 1843 to 1874]

[170]

Mr. T. Lindsay Galloway then read the following paper, "On the present condition of Mining in some of the principal Coal-producing Districts of the Continent:"—

[Plate XVIII. Map of the northern coal-field of France, shewing concessions, canals, railways, supposed limits of coal-field, pits, and some of the borings which have been made in that part of the country;

Plate XIX. Map of Hardinghem mine;

Plate XX. The Boulonnais coal-field;

Plate XXI. Section through the Valenciennes coal-field]

ON THE PRESENT CONDITION OF MINING IN SOME OF THE PRINCIPAL COAL-PRODUCING DISTRICTS OF THE CONTINENT.

By T. LINDSAY GALLOWAY, M.A., F.G.S., Assoc. Inst. C.E.

During the months of November, December, and January, 1877-8, the writer visited some of the principal European coal-mining districts, including various mines in the North of France, Belgium, Germany, and Austria. It has been suggested to him that some account of the state of mining in those countries might be of interest to the North of England Institute of Mining and Mechanical Engineers; and, in compliance with this suggestion, the following paper has been drawn up.

MINES OF THE NORTH OF FRANCE.

The coal-field first visited was that of the North of France, a district of great activity, and presenting features very distinct from the chief coal-fields of England. In this district are situated extensive mines, belonging to the companies of Aniche and Anzin, and it is proposed to give a short account of each of these collieries, commencing with that of Aniche.

Mines of Aniche.—The concession of the *Compagnie d'Aniche* lies to the east of the town of Douai, extending about nine miles along the margin of the coal-field. The workable seams of coal are eight or nine in number, and are very thin, being worked down to a thickness of 18 inches. They have an average inclination of about 30 degrees, but do not crop out to the surface, on account of the coal-measures being overspread by a layer of *morts terrains*, or barren ground, belonging to the cretaceous age—a cover which encloses much water, and can only be pierced with the greatest difficulty. The seams themselves are of various qualities, the upper beds being bituminous, and the lower anthracitic. The anthracitic coals are much used in the manufacture of glass, at the numerous glass works which abound in the northern parts of France; and the small from these coals is converted into artificial fuel at Somain, a

village in the vicinity. Towards the other extremity of the concession, near to Douai, dressing and washing machinery has been erected for the treatment of the small of the bituminous coals, which, after having been freed from rubbish, is made into coke. The total daily production of coal at this colliery is about 2,000 tons.

Shaft Arrangements.—In order to illustrate some of the details of working, we shall now speak more particularly of the Archevêque shaft, which is situated near to the village of Aniche. The output of this shaft is about 300 tons per day; it is 153 fathoms (280 metres) in depth, and 13 feet in diameter. It passes through 33 fathoms (60 metres) of water-bearing strata, and is protected by polygonal wood tubbing, in the manner which is most usual throughout the North of France and Belgium. The tubbing in the present case is nine inches in thickness, and is arranged in a polygon of sixteen sides. In connection with shaft arrangements, another interesting point of detail maybe mentioned, viz., that for the descent and ascent of workmen at this colliery, the ordinary cages are, at each change of shifts, detached, and replaced by parachutes, or safety cages; such cages, which are hardly if at all used in England, being much employed in all parts of the continent. Similarly, at the end of each day's work, the cages are removed, and large iron tanks substituted for them, for the purpose of drawing water during the night. These changes are accomplished by running a tram over the mouth of the shaft to receive the cage, which is then unhooked and wheeled away, while another tram, bearing the safety cage or tank, is brought forward in its place, and the new attachment is then made. The whole operation occupies only four minutes.

Of the seams of coal which are being worked from the Archevêque shaft, that which is called the *Conche du Nord*, the lowest bed of the series, has the following section:—

	Ft.	In.
Coal		8
Schist		4
Coal		8
Bad coal		4
	2	0

Other seams much thinner than this are worked, but, in the present depressed state of trade, the removal of the thinnest beds is not attempted.

Method of Working.—In speaking of the method of getting the coal, it may be advisable to premise that, in Northern France, and Belgium, there are three different systems of working employed in thin seams, of each of which there will be examples in the course

of this paper. The first is suitable for seams the inclination of which does not exceed 30 degrees; the second for those whose inclination ranges from that angle to 60 degrees; and the third is adopted in the *dressants*, or *rearing* seams of Mons and Liege, of which the inclination varies from 60 degrees upwards. At the mines of which we are now speaking, the first of these, which is called *tailles montantes*" or, as we should say, *rise work*" is the method employed. (Plate XXII., Fig. 1.) The coal is removed, in this case, by driving, from a principal level or rolleyway, towards the rise, a long series of little faces, succeeding one another in step-like order. Each face, which is 12 or 14 yards wide, communicates at first directly with the rolleyway, by means of a small self-acting inclined plane. When the faces, however, have advanced a certain distance, the inclines would become of an inconvenient length, and a new rolleyway, nearer to the faces, is then established in such a manner as to cut off all the longer inclines except one or two, which are retained as principal thoroughfares.

Meanwhile, the original level road is being continued along the strike of the seam, and is ever opening out new ground, and supplying fresh faces of work. The inclined planes, which are run with single ordinary tubs of 10 cwts., are cut up in the roof to a convenient height, and are strongly supported by pack-walling and timber. The faces of work are likewise timbered, and the goaves partially filled with rubbish and inferior coal.

Wages and Prices.—Five or six men work together in a company at each face, receiving in the *Conche du Nord*—the seam whose section has just been given—about 8½ d. per square metre, which is equivalent to about 1s. 5d. per ton, together with 5s. 10d. per yard for making the inclines. Each man can work about two square metres per day, and has, in addition, his share of the yard-work, which will bring up his daily wage to 2s. 6d. or 3s. The haulage underground is accomplished by means of horses; but at another pit, belonging also to the *Compagnie d'Aniche*, mechanical haulage by means of the tail-rope is employed.

Without adding further details with reference to this colliery, the writer will only mention the Bernicourt shaft, at which a new handsome winding engine, upon the Sulzer system of variable expansion, has been erected. This shaft has been sunk through the water-bearing strata by means of the apparatus of MM. Kind and Chaudron, after an unsuccessful attempt to sink it by the usual methods.

Mines of Anzin.—Leaving the mines of Aniche, and following the same seam of coals in an easterly direction, we reach the adjoining collieries of Anzin, near Valenciennes. These are unquestionably

among the most important coal mines in Europe. Their annual production is 2,000,000 tons; they give employment to some 12,000 men; and the extent of their concession is 69,000 acres. The seams worked comprise all the various qualities of anthracitic, semi-bituminous, and bituminous coal, which are employed for the several purposes of glass manufacture, steam raising, gas making, and household consumption. Coke is also made from small coal, consisting of a mixture of 70 per cent. of bituminous coal with 30 per cent. of semi-bituminous. Artificial fuel, which is largely used by the French navy, and begins to be introduced upon the railways, is made from various proportions of semi-bituminous and anthracitic coal.

One of the principal shafts at Anzin is the Thiers pit, which is named after the renowned statesman whom France has recently lost, and who was the chairman of this company. The Thiers pit was sunk in 1856, and is well mounted in every respect, being provided with mechanical haulage, and ventilation, and with rock-drilling machinery for driving the stone-mines. The shaft is tubbed with wood through 64 fathoms (118 metres) of water-bearing strata (*morts terrain*); its total depth is 246 fathoms (450 metres). It may be worthy of notice that the time required for running the cages from that depth is only 40 seconds, and no counterbalance is employed beyond that resulting from the use of flat hemp ropes.

Method of Working.—The method of working the coal belongs to the second of the three systems referred to above, which is called *tailles chassantes*, or level work. (Plate XXII., Fig. 2.) It consists in driving a succession of faces, still in step-like order, but driven in the direction of the strike of the seam, instead of going towards the rise. The inclination of the strata being about 45 degrees, it would be unsafe to drive up hill, on account of the liability of the masses of coal descending upon the miners during their work; and rise work, under such circumstances, is likewise found to be unprofitable, because the loosened coal, lying upon the thill, ever tends to slip downwards of its own weight, and portions become lost or mixed with rubbish. Under the level-course system, however, at the bottom of each face, (which is 20 yards long, measured up the slope, and worked at by four men,) there is a level road and tramway, at which the descending loosened coal is arrested, and is filled into tubs and led away. For their own convenience, the miners further regulate and control the descent of the coal along the face by means of pieces of board placed horizontally across the thill from prop to prop.

Inclines.—The various level roads lead into inclined planes by

which communication is made with the principal rolleyway. These inclined planes, one of which, 40 or 60 yards in length, serves two or three of the faces, are of a construction which is usually employed throughout the whole of the continent in the steeply-inclined formations. (Plate XXIII., Fig. 1.) They are laid with four rails, upon the outer pair of which there runs a sort of tram, having a horizontal platform which carries the tub. Upon the inner pair of rails there runs another tram, which is long, narrow, and heavy, and acts as a counterbalance, and the latter tram is made so low that it can pass underneath the former one at meetings. The two trams are attached to ropes, which are coiled upon a drum at the top of the incline; and while the weight of the full tubs descending raises the counterbalance, the latter, in turn, pulls up the empty tub.

In all very thin seams of coal the operations of shooting down top, timbering, and stowing, rank equal in importance with coal-getting itself. The following is the establishment of men at the Thiers pit:—

Hewers	400
Putters, etc	200
Stonemen, etc.	600
	1,200

Hours, Wages, and Prices.—The hewers and stonemen are divided into two shifts, who work from 4 a.m. till 2 p.m., and from 4 p.m. till 2 a.m., and each shift has its own district to work in, in such a manner that the fore shift of stonemen prepare the working places of the back shift of hewers, and the back shift of stonemen those of the fore shift of hewers. The thickness of the No. 2 seam is about 2 feet 4 inches, and the hewing price is 10d. per square metre of that thickness. Each hewer can obtain 2 to 2½ tons of coal, and gain an average wage of 3s. to 4s. per day. But at the time of the writer's visit many of the men were said to be making nearly 7s. per day, as they were working hard, in order to prepare themselves for the then approaching festival of St. Barbe—the patron saint of continental pitmen.

Fuel Works.—At the artificial-fuel works of the Anzin Company, which are known as the *Agglomerés de Saint Waast*, there is a daily production of about 260 tons of fuel. The coal, having been first passed between crushing rollers, is washed, by being carried over an iron sieve, through which water is violently injected upwards. The stones remain upon the sieve, while the coal is borne along with the stream, and is afterwards deposited in large tanks or basins. The washed coal is next more completely crushed, and being mixed with 10 per cent. of pitch, with which it is

heated in a steam-jacketed cylinder, the mixture is compressed into little blocks by hydraulic machinery, and is then ready for the market.

At the Haveluy pit there are several long stone mines, in course of being driven by means of the Dubois and Francois rock drill, slightly modified, and with the Sommeiller air-compressor, which is the most common upon the continent, being the original form of machine designed for the Mont Cenis Tunnel. The Renard Pit is remarkable for its handsome buildings and fittings, and not less for a powerful winding engine, upon the Guinotte system of expansion, the work of Messrs. Quillacq and Co., of Anzin.

MINES OF BELGIUM.

Passing from the northern coal-field of France to the immediately contiguous coal-field of Belgium, which, though really a prolongation of the former, is still more remarkable from an English point of view, not only for the large number and thinness of the seams worked, but for the extraordinary contortions which they have undergone. Geologically speaking, the coal-seams of Belgium have had an eventful history, in course of which, the strata upon the southern side of the basin, have been literally crumpled into folds, presenting now a regular succession of flats and rearers, or horizontal and vertical strata alternately. Under circumstances so unique there is great scope for the resources of the art of mining, and if it is added that much of the coal-field, like that of the North of France, is overlaid by barren measures containing much water, it will present no exaggerated picture of the difficulties which the Belgian miner has to meet.

Produits Mines.—In the vicinity of Mons, and near the village of Flenu, are situated the Produits Mines, a short account of which will illustrate several characteristic details. At this colliery there are both flat and vertical strata; but only the former are worked at the present time. The No. 12 or St. Louis shaft has a daily output of—

Coal	350 tons.
Stone	42 „
	392 „

It is sunk to a depth of 361 fathoms (661 metres), but at a point 261 fathoms (478 metres) from the surface, cross-measure drifts have been set away to cut the various seams. It is usual in all thin-coal districts thus to cut all the seams at the same level, by means of horizontal stone mines; and when the tracts so won have been worked away, a lower

winning is effected by driving new drifts from a lower point in the shaft. The establishment of men is as follows:—

Hewers	200
Putters, etc.	180
Stonemen, etc.	220
	600

Three seams are at work, of which the following are the names and sections:—

VEINE A LA PIERRE.

	Ft.	In.
Stone		1½
Coal	1	3
Kirving (bad coal)		3
Coal		2
	1	9½

GEORGES SEAM.

	Ft.	In.
Stone		2
Coal		10
Stone		11
Kirving (bad coal)		1½
Coal		4½

	2	5

PETIT FEUILLET SEAM.

	Ft.	In.
Stone		2½
Coal	1	2
Kirving (bad coal)		1
	1	5½

Of these seams only the best portions are sent to bank; the inferior coal is cast back into the goaf, along with the ramble and bands of stone. It is usual to make the kirving, or under-cut, of a depth of 2½ or 3 feet, and the coal is wedged out, without the use of gunpowder. The system of working employed is the first of the three methods above enumerated, viz., that which is applicable to seams of slight inclination, the slope of the workings here being only from 14 to 16 degrees. (Plate XXII., Fig. 1.)

Female Labour Underground. — The faces are fourteen yards long, and at each, five to seven men work together in a company, gaining an average wage of about 2s. 9d. per day. In attendance upon them are two young women, called respectively the *bouteur* and *chargeur*. The *bouteur*, who is generally quite a girl, collects the coal into a heap at the rail ends; and her companion, the *chargeur*, who is a young woman from fifteen to twenty-five years of age, fills it into

[178]

the tubs. These females are dressed in jackets and trousers, like the ordinary pitmen; the younger ones who work from 4 a.m. till 3 p.m., that is, the same shift as the hewers, receive a wage of 1s. 2d. per day; and the older ones who work from 5 a.m. till 6 p.m., that is, the same shift as the putters, receive on average 1s. 7d. per day. Females are so employed almost universally throughout the mines of Belgium; and young girls are also engaged, but to a smaller extent, in driving horses or trapping. The arduous work of putting is performed by young men, engaged under a contractor. These putters, who work twelve or thirteen hours daily for a wage of 2s. 9d., have to go along almost on all fours, dragging the tubs after them by means of a short chain, which is attached to a belt around the waist, while they support the fore part of the body upon two little staves about six inches in length, which they carry in the hands. The rolleyways and inclines are, of course, cut up to a height of about five feet to begin with, but they become gradually smaller, and it is contrived, as far as possible, not to have to rip them again, but always to have advanced a stage and established new roads by the time the old ones have become unserviceable.

Shafts.—The St. Felicité shaft, at the same colliery, has two working levels, viz., at 239 and 299 fathoms (438 and 547 metres) from the surface. In most of its details it resembles the St. Louis shaft, of which we have just spoken. The winding engines in both cases are equilibrated by the employment of flat hemp ropes, which are extremely common in Belgium. Arrangements are made at both pits, below ground, for the simultaneous loading and unloading of several tubs at a time; at the St. Louis pit two decks, at the St. Felicité pit four decks are simultaneously charged. The various platforms or stages communicate with each other by short counterbalance inclines. At the surface no provision is made for simultaneous discharge. The decks of the upper cage are brought in succession opposite one landing, while the bottom cage remains at rest.

Ventilators.—For the ventilation of the colliery there is a central establishment, provided with three ventilators of different types, a Guibal, a Lemielle, and a Letoret. Here at least it may be supposed that three rival systems have met upon equal terms. Experience has been most favourable to the centrifugal ventilators, and at the present time the Guibal and Letoret are doing all the work, while the Lemielle is only reserved as an auxiliary, in case of accident.

Coke-Ovens.—The coking arrangements at the Produits mines are very complete. There is about 30 per cen. of volatile matter in the coal, which, it is considered, renders it too bituminous for coking by the ordinary

process; but which, at the same time, makes it worth while to collect the products of distillation. The ovens themselves are similar to the Coppée ovens; they are loaded from the top and discharged by steam ram-engines; and the gases proceeding from them are collected and transmitted in iron pipes to an open-air or evaporative condenser. Those gases which remain uncondensed are returned in pipes to the front of the ovens, and are burnt underneath, thus supplying the heat necessary to carry on the process of coking; for the coke itself is not permitted to burn, the ovens being perfectly closed from the atmosphere. Those gases which have become condensed are afterwards re-distilled, the light and heavy oils, and ammoniacal liquor are separated, and a residue of pitch remains, which is used for the manufacture of artificial fuel.

Mines of L'Agrappe and Grisoeul.—The working of rearing seams, or *dressants* as they are called, is not carried on at the Produits mines, because there is an abundance of flat coal as yet, which can be more cheaply worked than the rearers. The writer will pass, therefore, now to the adjoining collieries of L'Agrappe and Grisoeul to see the Belgian method of working seams when they are nearly perpendicular.

Vertical Workings.—The manner in which the coal is wrought under such circumstances resembles what is called “overhand stoping” in the mining of metalliferous veins. The face of work, or *maintenage*, consists of a series of little steps, each 6 feet in height, and forming the working place of one man. (Plate XXIII., Fig. 2.) The steps are in reverse order, that is to say, the lower workmen are in advance of the higher, so that over each man is a ledge of coal, projecting a couple of yards, which secures him against the danger of anything falling down from above. Whatever stones or inferior coal proceed from the working, are cast behind the miners, and serve to fill up the goaf; but when there is any deficiency of such rubbish, the men have to work standing upon scaffolds, which are made by placing planks horizontally across the props. At the bottom of the face of work, which may consist of a dozen steps, there is a level road, to which the coals descend through little shafts or spouts called "chimneys," which are simply vertical openings, timbered through the goaf with square frames and longitudinal poles, and provided with a sort of sluice at the lower end. The miners fill their coal as it is hewn into the nearest chimney, and it is afterwards withdrawn by the putters from below, who load the tubs by bringing them underneath a spout and simply removing the sluice, and allowing the coal to rush in until the tub is filled. The timbering of the rearers is exceedingly difficult and expensive, especially on account of the beds

[180]

having been, in many cases, tilted completely over through more than a right angle, so that what are properly the *thills* of the natural beds have become the *hanging walls* of the rearers; and, as the thills are exceedingly friable, it is necessary to supplement the ordinary timber frames, not only with poles or lofting, but even with brushwood and wickerwood. The entire face of work has to be completely timbered, and this entire timbering is completely lost. It is hardly surprising, therefore, that the cost for timber should amount to 1s. 7d. per ton. The workings of the mines of L'Agrappe and Grisoeul have already attained a depth of 328 fathoms (600 metres). The No. 3 shaft is 251 fathoms (459 metres) deep, and within the workings there is a staple from that level to the lowest point. The staple is fitted with a compressed air winding-engine, which works expansively, the cylinder being kept warm by being encased in a sort of square box, in which quicklime is mixed from time to time. This cannot be a convenient method of keeping up the heat.

Air Compressors.—Great advances in the employment of compressed air have been made throughout Belgium and Germany, not so much with the object for which it is chiefly used in England, viz., mechanical haulage in the more distant workings, as for the driving of rock-drilling machinery. Numerous long stone mines or drifts are requisite for the winning and working of the many thin, and often highly inclined seams of coal, which occur especially in Belgium; and this circumstance would seem to have given an impetus to the development of drilling machinery, so much so that there are few leading collieries which are not provided with such apparatus. The form of compressor which is apparently in most common use is that of Sommeiller, in which the air is alternately drawn in and compressed by the fall and rise of vertical columns of water, which are acted upon by the reciprocating motion of a steam engine. This apparatus, however, is defective, in that it cannot conveniently be driven at a greater speed than twelve strokes per minute. There may also be found at collieries upon the continent, the form of compressor which is usual in England, consisting simply of ordinary cylinders, fitted with pistons, and jacketed with an envelope of cold water. But M. Cornet, engineer of the Levant du Flenu mines, claims to have recently effected a great improvement, by the injection of water as spray into the compressing cylinder, so as to prevent the heating of the air; and M. Cornet further proposes, by using a similar injection of spray into the cylinder of any engine or machine which the compressed air drives, to prevent the opposite effect, viz., excessive cooling of the air, and by such means to be able to employ it expansively. Undoubtedly, a considerable saving may be calculated

[181]

upon as the result of using more of the expansive force of the air; the exact amount, however, has not yet been determined satisfactorily, the apparatus being quite new.

Rock Drills.—Many forms of rock drills have been patented in Europe and America; but it would be outside the scope of this paper to discuss their several merits. In Belgium, where there has been a great deal of practical experience in their use, the Dubois and Francois drill continues to be much employed. A private trial was recently made of a number of the rival types, and the writer is informed that the Dubois and Francois drill excelled in economy the Dunn drill in speed, and the Ferroux drill in convenience for the drilling of horizontal holes.

Mines of Mariemont and Bascoup.—The mines of which the author will next speak are those of Mariemont and Bascoup, two united collieries situated some miles west of Charleroi. These collieries, as the head-quarters of many a mechanical invention, are deservedly well-known to the mining world. Their late principal owner, M. Warocqué, made great improvements upon the *fahrkunst*, or man-engine, producing an apparatus for the raising and lowering of workmen, now called the " Warocquère" in honour of its inventor, which is now exclusively used at the various shafts of these collieries, and has proved its own merits by the immunity from shaft accidents which it has afforded. M. Guinotte, the present General Director of the same company, has introduced a system of automatic variable expansion for winding-engines by a beautiful combination of the motions of several eccentrics; and the ingenuity with which the system has been devised, is only equalled by the skill and mathematical precision with which it has been carried into practice. Add to these two inventions, that of M. Briart, *Ingénieur en Chef*, for the mechanical screening of coal, which was first tried at Bascoup, and is now in operation upon an extensive scale, both there and at Mariemont, and enough will have been said to justify the reputation of these mines.

Mechanical Screens.—M. Briart's system has been described by himself,* so that it will be unnecessary to enter into a lengthy explanation of it; suffice it to say, that by the use of exceedingly flat screens, he avoids the breakage of the coal to a large extent, and, at the same time, insures its travelling along the screens, by making every alternate screen-bar moveable, and giving them a reciprocating motion by means of eccentrics. In the first screen, over which the coal passes, the bars are 3 or 4 inches apart, so that only fine large lumps are separated. The coal is then further

* See Publications de la Société des anciens Elèves de l'école du Hainault, Mars, 1873

classified into two, or in some cases three more sorts, by falling upon similar but closer sets of bars underneath; and finally, after having travelled round upon revolving tables or grills, and been picked free from stones by hand, it empties itself into the wagons. There are two great central screening depots, one for the pits of Mariemont, and one for those of Bascoup. The tubs are conveyed from the four or five pits belonging to each establishment along the surface by means of endless chains. Arriving all together at the screens, they are branched off in various directions by several short chains leading to the tumblers, where they are received by girls, and discharged. The empties are successively attached to the returning chains, by which they find their way back to the various pits, while their discharged loads of coals, gently travelling along the screen bars, become separated into classes and are borne to the several wagons quite automatically. Thus, under one roof, the screening of 1,000 tons per day is carried on with something like the regularity of clock work, exclusively by young girls, whose efforts, be it added however, are seconded by one or two good steam engines.

Surface Haulage.—In addition to the system of endless chains already described, branching out from the central screen sheds to the several pits, there are other branches likewise ramifying from the central screens to the timber-yard, store-houses, shops, and rubbish-heap. It will thus be seen that any one of these points can communicate by chain with any other; and thus, timber, fittings, or stones being placed in a tram, have only to be labelled with the name of the pit for which they are intended, and, passing through the central station, they will be sent out from thence to their proper destination, while similarly, coal, stones, or gear, coming from the pits, are respectively directed to, and delivered at the screens, the rubbish-heap, or the shops.

Underground Haulage.—The haulage below-ground is also, to a large extent, effected by means of endless chains, with this additional merit and peculiarity, that, except in a single instance, the entire system is self-acting, and the tubs find their way from the innermost workings to the shafts without the expenditure of a single foot-pound. The seams having in general a very considerable pitch, it will be readily understood, how, by husbanding the power gained by those branches which work from the rise, a sufficient surplus is obtained to drive those chains which proceed along the level course or strike. At the St. Arthur Pit, Mariemont, and at the St. Catherine and No. 5 Pits, Bascoup, this application of the endless chain has been carried out to an extent and with a degree of perfection which has never probably been attempted anywhere else.

The joint output of the collieries of Mariemont and Bascoup is about 3,000 tons per day. The largest output from an individual shaft is 700 tons. Two of the three systems of working coal above enumerated are in use, viz., those which are suited for flat and moderately steep measures. There being no *dressants* or rearers, the third method is not required; but bord and pillar has also been introduced, and is in use at certain of the pits.

Man-Engines.—We have already mentioned the "Warocquère," or man-engine, an apparatus which is exclusively used at all these pits for the ascent and descent of the miners. The apparatus is a modification of the well-known Fahrkunst, consisting of two vertical reciprocating rods or spears, near together, and each bearing a series of platforms. The rods or spears move alternately upwards and downwards, bringing the sets of platforms upon each road exactly opposite those on the other rod, at every stroke. The ascending or descending miners step at the proper instant from platform to platform, and thus wend their way upwards or downwards ten feet at each stroke, and at the rate of seven or eight strokes per minute. The platforms are railed round, and amply large enough to allow two men to pass each other, and thus a great portion of an entire pit's crew may be upon the " Warocquère " at the same instant, some ascending and some descending.

Pumping Engine.—It will be unnecessary to describe M. Guinotte's system of expansion, as it is well known and understood in this country as well as upon the continent, and has also been fully explained by M. Guinotte himself.* A new application of this system has just been made to a large and very handsome pumping engine, erected at the No. 5 Pit, Bascoup. This engine is rotative, fitted with an overhead beam, and controlled by a pair of heavy fly wheels. The degree of expansion employed is that of ten to one, and the actual useful effect, calculated upon the diagrams, is no less than 81 per cent. The pump rods are of round iron; the pumps themselves are of a novel construction, and nearly every detail of the engine presents some peculiarity. A sister engine is being set up by the side of the one which is now in use.

The workmen at these collieries are particularly well cared for, and their lives seem to have fallen in pleasant places; for there exists an *esprit de corps* among all connected with the establishment, which is not often to be found. These men have a park of their own, with arbours and kiosque for summer music, and a concert room for winter, where the pitman can even play his game at billiards and listen to the music of an excellent band, comprising eighty instruments.

* See Etude Générale sur la Détente variable, par Lucien Guinotte. Liege, 1872.

[184]

It will be unnecessary to enter into further detailed descriptions of other mines in Belgium. The writer visited the mines of Sacré Madame, at Charleroi, where a shaft, said to be the deepest in Belgium, has reached the depth of 437 fathoms (800 metres), and has been fitted up with winding machinery for that depth. Its present working level, however, is at 328 fathoms. He also visited the Braconier Pit, near Liège, Cockerills mines, and their gigantic iron and steel works, at Seraing, where 250 tons of Bessemer steel are produced per day; and the mines of Gosson Lagasse, Mariehaye, and Hazard, all of which are in the vicinity of Liege.

Electric Light.—At Gosson Lagasse, a new feature is presented in the employment of Gramme's electric light, for the illumination of the pit bank by night. Electric lighting has recently attracted much attention, both on the continent and in England, and promises, at least for some purposes, to supersede the use of gas. The Gramme machine is already in use at many workshops, such as Cockerill's, in Belgium, and Quillacq and Co.'s, in the North of France. It is also employed in front of the Grand Opera-house at Paris, and at various railway stations upon the continent. Each machine costs about £88, and can be driven by a force of 2½ horse-power. The working charge, inclusive of the necessary driving power, is about 4d. per hour; and one machine is sufficient to illuminate an area of from 350 to 600 square yards, according to the kind of work which has to be lighted up by it.

Hazard Pit.—This pit is one of the best-known and most active in Belgium. It has an output of 1,000 tons of coal and 200 tons of stone per day, and is fitted underground with mechanical haulage, by the endless chain, and with mechanical screening by the apparatus of M. Briart. There is also an apparatus for the manufacture of artificial fuel, upon the system of Bouriez, which seems to produce a very excellent article. 8 per cent. of pitch is the proportion which is mixed with the coal.

Workmen's Hotel.—This hotel, called the Hotel Louise, at the same colliery, is well worthy of a passing mention. It has been in operation for five years, and is said to be very successful, contains apartments for unmarried workmen to the number of 375. It is furnished with reading and concert rooms, baths, stoves, and a cafe. The fare consists of two breakfasts, dinner, and supper, which, with lodging and washing, costs only 1s. 2d. a day for the older, and 11½ d. a day for the younger men.

MINES OF SAARBRUCK.

The coal-mines of Saarbruck form one of the three principal coal-producing districts of Germany. The principal mines are under the immediate management of the Government; but there are also various private collieries of less importance.

Production.—The total annual production of the nine Royal mines is 4,500,000 tons, of which the Heinitz pits produce 750,000, and those of Reden, Sulzbach, Dudweiler, and Gerhard upwards of 500,000 tons each. Of this total production, about 1,000,000 tons are consumed around Saarbruck, 1,000,000 are sent to South Germany, 1,000,000 to Alsace and Lorraine, and nearly 1,000,000 to France and Switzerland. A portion of the coal is also made into coke. The coal-field of Saarbruck more nearly resembles our own than any of those which have just been described; the seams are of moderate thickness up to 12 feet, which is the thickness of the Blücher bed, and their inclination is generally not great, although in some places it attains as much as 30 or 40 degrees. The methods of getting the coals, also, are mostly of the types with which we are more generally familiar in this country, viz., those which are known as *strebbau,* or long-wall, and *pfeilerbau*, or bord and pillar, the only peculiarity being that, in the latter system, it is usual to make the pillars very much longer than is the practice in England.

Gerhard Mines.—The Gerhard-Prinz Wilhelm mines have a daily output of nearly 2,500 tons. There are various inlets to these mines, consisting of several shafts, and there is also a level drift of about 2,000 yards in length. The latter is worked by means of a hauling engine and tail-rope, to which are attached trains of eighty tubs of 10 cwts. each. The trains make their journey through the drift in ten or twelve minutes. The winding shafts are also well fitted up, and the cages are upon safety principles. Over the surface there is a very extensive system of tram-railway, upon which the tubs are dragged about in long trains by nine tiny locomotives.

The seam called the Maria Flötz is about 6 feet in thickness, and containing, as it does, very thick bands of stone, it is worked upon the system of long-wall. There is simply one long straight face of work, which is parallel to the line of strike. At right angles to this there are roads maintained through the goaf at distances of 25 yards from each other; and the inclination of the seam being 10 or 12 degrees, these roads are fitted as self-acting inclines. Owing to the abundance of stone, the goaf is practically all packed up, and scarcely any timber has to be employed,

with the exception of a few piles of chocks, to give extra security at the ends of the inclines. Each 25 yards of the face is let by contract to four men and a boy. Two men and the boy work by day, hewing, filling, and putting the coal; the other two men build pack-walls and stow during the night; and the company are paid 2s. 5d. per ton of coal produced, which includes all charges up to the delivery of the coal at the nearest horse station underground.

The Heinrich seam, which is 6½ feet in thickness, is worked by the method of bord and pillar: the pillars are about 100 yards long by 20 yards wide; the bords are driven directly towards the rise, and while in course of being driven, are ventilated either by building a pack-wall up the middle, or by an ordinary brattice, when there is a scarcity of packing materials. The pillars are afterwards removed in a series of slices, carried across from bord to bord.

Dudweiler Mines.—The No. 8 shaft belonging to this colliery is 164 fathoms (300 metres) in depth, and is stated to produce 1,500 tons of coal per 24 hours. Electric signals are employed from both top and bottom of the shaft to the engine-house, and seem to expedite the handling of the engine very considerably. The cages are only single-decked, containing two tubs; but they are manoeuvred smartly, and the time required for running and changing is only 53 seconds. Many horses are employed at this pit, and below-ground there is one long stable containing no less than 107 stalls.

The Blücher seam, as here worked, consists of three beds of coal, lying immediately over each other, but unseparated by any bands of stone. The following is its section:—

	Ft.	In.
Top bed	4	3
Middle	2	11
Bottom	4	11
	12	1

Method of Working.—This coal is of the best quality, and the small is suitable for coking. In working this Blücher seam, bords are first of all driven in the lower and middle beds, that is, of a height of 7 feet 10 inches, the top bed being in the first instance left above. The bords are driven along the strike, and not towards the rise, as they are at the Gerhard-Prinz Wilhelm mines. They are from a dozen to 16 yards apart, and are ventilated either by means of zinc tubes, or, where there is a sufficiency of stone, by a pack-wall brattice, and only at distances of 100 yards (unless the presence of large quantities

[187]

of gas renders such long bords impracticable) cross holings are made from bord to bord. When these workings have reached a fault, or any convenient artificial boundary, the pillars are wrought off in returning. The two lower beds are removed first, always several yards in advance, and the top bed is then easily dropped or shot down in the rear, the top coal hitherto remaining in the bords being recovered along with the rest. The price of working in the broken is about 1s. 2d. per ton, and each hewer can obtain 4½ tons per shift.

The new Camphausen pits, belonging also to the Colliery of Dudweiler, are being fitted up for a very extensive winning to the dip of the present shafts and levels. A winding shaft 328 fathoms (600 metres) in depth is already nearly finished; it is lined with sheet iron, instead of brick or stone, and is strengthened by large circular rings of wrought iron, which sustain the lining. It is intended ultimately to deepen this shaft to 438 fathoms (800 metres), and another winding shaft will be sunk alongside, forming part of the same scheme.

Counterbalance.—The system upon which the large winding engine, now being erected, is to be counterbalanced, although somewhat cumbrous, is deserving of a short description. The engine drives a cylindrical drum of 26 feet 3 inches in diameter, upon which are coiled the ordinary pit ropes. By the side of this drum, and linked to its shaft, is a conical drum of 32 feet 10 inches in diameter, the sole purpose of which is to effect the counterpoise. The rope upon this latter drum is continuous, passing from one side of the drum over the head-gear of a staple, round a pulley which suspends a balance-weight, back up the staple, and over the head-gear, to the other side of the conical drum. As the drum is turned the rope uncoils from one side and will be coiled up on the other; but, by reason of the conical form, the uncoiling, at the commencement, will go on more quickly than the coiling-in, and the balance weight will slowly descend in its staple. After the middle of each run, however, this state of things becomes reversed. The coiling-in then will take place more quickly than the uncoiling, and the balance-weight will be again slowly raised, in a manner which somewhat resembles the action of a differential pulley-block. It may be added that the depth of the counterbalance staple just mentioned is 44 fathoms, and that it is intended to draw the coals with three-decked cages, each cage containing two 10 cwt. tubs, side by side.

Iron Frames for Propping.—At several of the mines of Saarbruck, iron is beginning to be used with advantage underground, in lieu of timber

frames. The iron is of channel section, and is bent into the form either of arches or complete rings, each arch or ring being usually made in two pieces. These frames are placed along the main galleries, wherever the roof is bad, at distances of 3 feet 3 inches, and pieces of wood, in the form of poles or lofting, are placed close together longitudinally from frame to frame, so as to make as it were a complete vault of wood, sustained in position by the iron frames. This system is much less expensive than stone or brick arching, and has hitherto given the very greatest satisfaction. The cost per metre is approximately as follows:—

	£	s.	d.
One frame		14	0
Wooden poles		7	6
Labour		8	6
	1	10	0

The foregoing is equivalent to a cost of about £1 7s. per yard. Wrought iron sleepers are also pretty extensively used, and are made in some cases of double length so as each to serve two pairs of parallel rails.

Heinitz Colliery.—The colliery known as Heinitz Grube somewhat resembles those of the North of France. The seams of coal have a considerable inclination, especially near the outcrops where the inclination is at least 30 degrees; and stairs have been established in sloping drifts from the surface by which the workmen enter and leave the mine. The horses also have their stables above ground, and come to the surface at the end of each day's work. The method of getting the coal differs from that at Anzin only in that, a preliminary network of galleries is driven, which divides the seam into long pillars or blocks, the longer sides of which lie parallel to the strike. The removal of those pillars is however exactly similar to the method of working which is practised at the Thiers Pit, Anzin, and elsewhere, under the like circumstances. The price of the broken working is 1s. per ton, exclusive of putting. On account of a large number of seams being at work in this colliery, the ground is completely riddled in the most extraordinary fashion, with shafts, cross drifts, coal drifts, levels and inclines; and a model showing the actual state of the workings, presents the most complicated appearance. The mines being a long distance from the nearest villages, four Schlafhäuser, or workmen's hotels have been established, and are supported by the Government. They are sufficient for the accommodation of 1,000 men, and form a complete little colony; and although many of the miners have other houses of their own, they remain all the week at the mines, returning only from Saturday till Monday to their families and homes.

[189]

Hydraulic Pump.—At the collieries of Sulzbach-Altenwald, there is an underground pump of a peculiar construction. It is driven by the alternate rise and fall of two vertical columns of water contained in pipes which lead up the shaft to a steam engine upon the surface. The reciprocating action of the steam engine is communicated to the vertical columns, which in turn act upon the driving pistons of the pump, so that the water columns answer simply as transmitters of power. This arrangement is interesting, and perhaps suitable to the conditions in which it has been applied, where the want of shaft accommodation is said to have prevented the introduction of ordinary pumps; but it is by no means an economical arrangement, its efficiency being only something like 33 per cent., and the machine is now seldom worked, and only used as an auxiliary. It is capable of raising about 400 gallons per minute. At one of the pits of Sulzbach-Altenwald, there is also a rope counterbalance upon a system which has been recently applied in Westphalia, of which more will be said hereafter.

Mining Theodolites.—Nothing has hitherto been said regarding the subject of underground surveying upon the continent, but the mining theodolites which are in use at the mines of Saarbruck, and in other parts of Germany, seem to be so admirably adapted for underground work as to be well worthy of a passing mention. The telescope is short at the eye-piece end, and it can be raised to a great angle or turned over like an ordinary transit. The graduation is unexposed, except at the verniers, and little plates of ivory at those points are so placed as to throw a light down upon the divisions. The legs which support the instrument are each in two pieces, the lower of which can slide inwards or outwards with a motion like that of a ship's top-mast; and thus one or other leg may be readily lengthened or shortened at pleasure so as to suit the inclination of the workings and the position of the instrument. On the top of the legs there is a sort of circular table, having a hole 2½ or 3 inches in diameter in its centre. The theodolite is clamped to this table by means of a spindle passing down through the central hole; but there is a freedom of motion upon the table of an inch or two, horizontally, in any direction, so that after the stand has been set up as nearly under a given station as practicable, a closer approximation may be obtained by moving the theodolite about upon the table until its centre is exactly under a plumb-line before clamping it down. Even the plumblines are of an ingenious kind, and can be lengthened or shortened without any trouble. These adjustments would, no doubt, be altogether trifling in a survey above ground where the principal

base lines might be from one-half to several miles in length; but in underground work only short sights are generally obtainable, and in such circumstances any error in the position of the centre of the instrument becomes a matter of much greater consequence.

MINES OF UPPER SILESIA.

The coal mines of Upper Silesia differ from any that have gone before in illustrating the methods of working seams, the thickness of which ranges from 20 to 30 feet (6 to 9 metres.) The total production of the Silesian coal-fields is upwards of 10,000,000 tons per annum, which is partly consumed in the ironworks of Upper Silesia, partly in Breslau, and partly in Berlin. Indeed, the capital of the German Empire is chiefly supplied from this district. There are several deposits of coal here, but it is intended only to refer to those of Upper Silesia, and in particular to that deposit worked in the Royal mines, at the Königin Luise Gruben and the Königs Gruben, which latter greatly surpasses all the others in importance.

Königin Luise Mines.—These mines are situated near to the village of Zabrze, not far from the frontier of Poland. They have a concession of about 7,000 acres, and an annual output of 1,000,000 tons, which is obtained from three shafts producing each about 1,500 tons per day. The principal seam of coal is called the Schuckmann Flötz; it ranges from 19 feet to 26 feet in thickness, and at the Von Krug shaft, where the writer saw it in work, its thickness was 23 feet. It forms one solid bed, having no bands or partings, and is of anthracitic quality, and consequently unsuitable for coke-making.

The Method of Working.—This enormous seam is wrought by first of all dividing it into long blocks of 220 yards by 14, with the intermediate cross-holdings, which are necessary for the purpose of ventilation, by driving a preliminary network of galleries in the lower portion of the seam, that is, next the thill. Those galleries are made 8 feet square in cross-section; and the blocks or pillars lie with their longer sides parallel to the strike of the seam. (Plate XXIV., Fig. 1.) In this preliminary work the men are paid 4s. 7d. per yard of advancement; 10d. per ton for round coal, and 6d. per ton for small. Two or three men work together in each gallery, and each man can get about three tons in a shift of ten hours. There are also one or two boys who fill and put the coal for them. Those long blocks or pillars of coal, of 220 yards by 14, have next to be removed, an operation which is accomplished by taking a series of slices five yards wide at a time, right across the pillar, driving

towards the rise, and working the coal to its full height of 23 feet. The miners have to support themselves upon ladders, and the roof is sustained by means of long timber and lofting. (Plate XXIV., Fig. 2.) Grim is the appearance of these gigantic stalls, filled with a forest of pine trees, through which are scarcely seen the dim lights of the pitmen mounted high aloft, where they ply their perilous craft. When one of those stalls has advanced across a pillar, and holed into the gallery beyond, it is finished, and as much as possible of the timbering is then withdrawn, two lines of trees, however, are always left—one along the lower side of the stall, which is designed to protect workings coming from the dip against an influx of stones from the goaf, and one line up the near side of the stall, which is to afford protection for the next succeeding stall. For additional security, it is besides often necessary to leave ribs of coal several yards in thickness; so that the working of this thick bed is frequently attended with considerable loss; and the coal so left behind being liable to spontaneous combustion, the ventilating current must ever be kept clear of the goaves. The tonnage prices for the removal of pillars scarcely differ from those for the first working. The price for round coal is the same, viz., 10d., while for small coal it is 5d. per ton. Five hewers work together in each stall, each hewer getting about seven tons per day. It is part of their duty to set up the timbering, but they are attended by three boys, who separate the round and small coal by means of rakes, and fill it into the tubs and put it.

New Winning.—At the Poremba pits, which are designed to work the same royalty at a lower level, an extensive winning is now being effected. It is intended to fit up two underground steam-pumps on the rotative principle. The coal will be conveyed underground in cars of the American type, each car containing 2½ to 3 tons. The tare of such cars is 1 ton 10 cwts; the gauge is 36 inches; and the diameter of the wheels 20 inches. They will be hauled underground, in the American fashion, by means of small locomotive engines; and the cages will be made to carry two cars at a time, so that every full cage will bring up 5 or 6 tons of coal. Under the able direction of Herr Broja, all the other arrangements are designed upon a proportionately large scale, as well they may be, considering that within a depth of 210 fathoms (385 metres) there lies a thickness of 80 feet of coal, comprising seven seams, one of which is 25 and one 30 feet thick.

Königs Mines.—The royal mine, called Königs Grube, is situated at a distance of five or six miles from the Königin Luise Grube, almost in the angle where the frontiers of Germany, Poland, and Austria, intersect.

[192]

It possesses a still larger concession than the Königin Luise mines, and has a similarly large output, which is drawn from eight winding shafts. The Bahn shaft, 33 fathoms (60 metres) in depth, encounters a seam called the Sattel Flötz, of no less than 28 feet in thickness. This coal is very hard, but it is worked almost entirely by means of gunpowder, and the pick is but little used, so that about 50 per cent. is reduced to small. The system of working is similar to that which was last described, the pillars being made, however, only 9 yards wide. The coal is never all obtained; but a series of cross stalls are driven into the pillar, leaving safety ribs, and thus a sort of cellular structure of coal remains behind, which becomes ultimately crushed in the goaf. The proportion of coal so lost depends upon the thickness of the seam; thus, it is stated that in a seam of—

10 feet it would be	5 per cent.
20 „ „	15 „

30 „	„	30 „	to 35 per cent

So that practically not more than two-thirds of the Sattel seam can be got. The output of the Bahn shaft is 1,600 tons per 24 hours.

The Bismarck shafts, two in number, are 60 and 88 fathoms (110 and 160 metres) in depth respectively, and have a joint output of 750 tons. At these pits there are two screens, made after American models, each about 27 yards in length, which effect the separation of the coal into four different sorts.

MINES OF BOHEMIA.

Production.—In giving now a short account of the mines of Kladno, near Prague, it must be premised that the actual production of coal in Austria is very small in comparison with that of the other countries spoken of. The quantity of *Steinkohlen,* or fossil coal, produced in 1876, was scarcely 5,000,000 tons; but to this must be added about 7,000,000 of *Braunkohlen*, or lignite. Notwithstanding, there are at Kladno several large companies in the possession of collieries which are mounted in handsome style, and fitted with some of the newest and best machinery. The Royal and Imperial Austrian State Railway Company have four winding shafts, and produce 1,200 to 1,500 tons of coal per day, an output which the company themselves are able to consume. The Prague Iron Industry Company have also a colliery of the first rank, and consume their own produce in the iron-works at Kladno. There is only one seam of coal of any importance, but that has a thickness of from 23 to 37 feet.

Mines at Kladno.—The Engerth shaft of the Royal and Imperial Austrian State Railway Company is 218 fathoms (400 metres) in depth,

[193]

and has a daily output of about 500 tons. It is fitted with a horizontal engine for winding, by Quillacq and Co., of Anzin. The cages are suspended by flat hemp ropes, and are two-decked, and both decks are loaded and unloaded simultaneously at the surface and below ground, the two landings being provided with counterbalanced drops. In the first working of the thick coal, the method pursued resembles that which is in use in the mines of Upper Silesia.

Method of Working.—A preliminary network of galleries is driven in the lower portion of the seam, dividing it into a series of great blocks, which are disposed with their longer sides parallel to the strike, and the dimensions of which are from 60 to 100 yards long by 10 yards wide. There are two bands of stone in the seam, one at 3 feet and the other at 6 feet above the thill, and the preliminary galleries are driven of the height of the upper band, that is, 6 feet high. The process of removing the blocks or pillars is more intricate, but, perhaps, also more economical, than that which is practised in Upper Silesia. First of all, a stall of about 4 yards wide is driven across the pillar, under the higher band, that is, of the same height as the galleries, and not of the full height of the coal. (Plate XXV.) It is not driven immediately at the end of the pillar, but a safety rib, of two or three yards in width, is left towards the goaf. This stall is effectually timbered with stout 6 feet props. When it has crossed the pillar, it holes into the gallery beyond which is the goaf. The miners then commence retreating backwards to extract the safety rib, and to bring down the 20 or 30 feet of coal overhead by successively withdrawing the props with which the stall had been timbered. The Bohemian method of *drawing a jud* is altogether unique. When it is desired to bring down a quantity of the top coal, firemen come to the spot and place dynamite cartridges near to the tops of several of the trees. The safety fuses attached to these cartridges are lighted, and all hands retire to a safe distance. Presently, the dynamite explodes, the trees are blown out, and down comes the coal with a crash like subterraneous artillery. In this way it may easily be imagined how the hewers, who work in companies of two, having little more to do than fill the coal so brought down, can sometimes obtain as much as 15 or 20 tons per day.

Prices.—The prices of working are:—In whole work 8d. per ton, and 3s. to 4s. per yard; in broken working 7d. per ton; timbering and putting being in both cases included. Although the coal is so thick, and the prices so low, there must be considerable expense on account of stone-work, as in several places the seam very rapidly thins down until it disappears altogether, and the strata continue barren for a distance of many yards,

[194]

which has to be traversed by long stone mines before the coal can be again recovered. The inclination of the bed is variable, ranging up to 25 or 30 degrees, and counterbalance inclined planes, of the type already described, are employed.

The screening of the coal at this pit is done mechanically, upon the system introduced by M. Briart, at the collieries of Mariemont and Bascoup, and almost all the hand labour is done by women and girls. The other shafts are fitted up in a manner equal to that of the Engerth shaft. At one of them is a large and handsome compound pumping engine made by Quillacq and Co., of Anzin. The Prague Iron Industry Company have likewise first-rate fittings, and have just completed their Baron Maejrau shaft to a depth of 320 fathoms (280 lachter), which is walled throughout.

MINES OF WESTPHALIA

Production.—The last collieries which remain to be described are some of those of the great mining district of Westphalia, which is the principal centre of the coal-mining industry of Germany, having an annual production of 18,000,000 tons. To the coal proprietors in the North of England the mines around Dortmund have a special interest, on account of the trade rivalry which is springing up at the north western ports of Europe. A serious obstacle to the development of the Westphalian trade in that direction, however, is the heavy cost of land carriage, arising from the inland position of the collieries. The river Ruhr, which, flowing close by Dortmund, falls into the Rhine, is, to some extent, used as a waterway for the shipment of coal to Holland; but the droughts of summer and floods of winter both impede the successful navigation of this river.

The railway charges from Dortmund to several of the important markets are as follows:—

		s.	d.	
To Amsterdam	about	6	8	per ton
Bremen	„	6	0	„
Hamburg	„	7	8	„
Berlin	„	11	4	„

These may be defined as the northern limits of the Westphalian trade. In Bremen and Hamburg it is outmatched by the trade of England; in Berlin by that of Silesia. On the other hand a large quantity of Westphalian coal finds its way as far south as Alsace and Lorraine, where it falls into competition with the coal of Saarbruck; while about 25 per cent. of the produce remains in the district itself, being largely consumed in

[195]

iron, steel, and other works in the neighbourhood. A cross section of the coal-field shows it to consist of several very deep parallel troughs, almost like the letter V, and the seams have in consequence generally a very great inclination, approaching that of the rearers of Belgium.

Westphalia Company.—There are two adjoining shafts, almost within the town of Dortmund itself, which work the seams from two levels, viz., at 133 and 178 fathoms (243 and 326 metres). The output of the principal shaft is about 560 tons per day.

Method of Working.—The seams are numerous and of variable inclination, but at the points where the writer saw them at work the inclination was 70 degrees. A sort of bord and pillar system is employed in working the coal, a method which is quite different to what has been described in speaking of Belgium, but resembling the system which is pursued in working the edge seams of Mid-Lothian. The headways, as they may be called by analogy, are driven to the full rise, and are really more like shafts than ordinary headways. Three are driven near together and parallel to each other; the middle one is fitted as an incline, of the kind which has been before alluded to in connection with steep seams; and the other two are fitted with ladders, and are used as travelling ways. At right angles to the headways are the bords or principal working places, which are driven level-course or in the direction of the strike. Those horizontal galleries, of which a series of eight or ten may proceed from the same incline, are at distances of about a dozen yards apart, and are pushed onwards until some natural boundary, such as a fault or the limits of the district, are reached. It is then necessary, in working back towards the incline, to remove the blocks of coal, or pillars, as they may be called, which remain between the horizontal galleries. This is accomplished by leaving a protecting rib of coal of about a yard in thickness overhead, and working away all the rest of the pillar, either in a single face or in two steps. The pillars are removed in series, the higher workmen being in advance of the lower. It is, of course, necessary for the miners to stand upon scaffolds, which they form of planks thrown horizontally across the usual timbering.

The prices in a seam of 3 to 4 feet thick are as follows:—For driving the horizontal or main places which are 6 to 8 feet high, 1s. 8d. per ton, including putting, and 11d. per yard of advancement. Two men working together obtain 2½ to 3 tons per day. In the broken mine, three men working together (one of whom puts) are paid 1s. 1d. per ton, and obtain 7 to 9 tons as their joint production.

Rock Drill.—Before leaving this colliery, a new type of rock-drill in use there may be mentioned, which is the invention of Herr Pelzer,

[196]

engineer of the colliery. Its chief novelty consists in the injection of water into the bore-hole through a passage in the centre of the drill, or jumper, itself. The water is sent from the surface in the same pipes as the air, and finds its way into a receiver, upon which the drills are mounted. The pressure of the compressed air upon the surface of the water in this receiver forces it through the passages in the drills into the bore-holes, where its presence facilitates the work.

Coal Washing.—The Dortmund Mining Company, whose underground operations resemble those of the Westphalia Company, are chiefly distinguished for the possession of admirable screening and coal-washing machinery. M. Briart's apparatus is employed for the first operation, in which, by the use of screen bars about 3 inches apart, the largest pieces of coal are separated. The coal which has fallen through the Briart screens is next mounted aloft by a Jacob's ladder, and passing from thence through a large trommel, or revolving screen, it is sub-divided into two sizes. These are remounted by Jacob's ladders; the larger size is once more trommeled, divided into three, and then washed by jigging; the smaller size is permitted to fall in a stream of water, and being likewise divided into three sorts, by passing over a series of classifiers, similar to those which are used in ore-dressing; it is afterwards jigged along with small pieces of felspar. It is not necessary to describe the action of the jiggers, which are exactly similar to those which are used in the dressing of galena; but it should be explained that the use of the felspar is to form layers which lie upon sieves within the jiggers. The coal, on account of its comparative lightness, passes along the top of these layers; but the stones, being heavier, work their way downwards, by reason of the beating action of the water, and fall through the sieves. The speed of the larger jiggers is 35, and of the smaller ones about 200 strokes per minute. The water which has been used in these operations flows out into large sedimentary tanks or basins, and having there precipitated the particles with which it has become laden to blackness, it issues forth purified, and entering a centrifugal pump, is once more whirled up to the top of the washing-shed, and commences its work anew. By the foregoing process, about 6 per cent. of stone can be removed from the coal, and about 4 per cent. remains behind. The washed coal is sold for the purpose of coke manufacture, the company themselves having no coke ovens.

Rope Counterbalance.—Messrs. Krupp and Co., the makers of the well-known Krupp guns, have, at their Hanover Pit, a new style of winding-engine and counterbalance, the invention of their engineer, Herr Koepe, which deserve special notice. (Plate XXIII., Fig. 3.) Instead

[197]

of being provided with a drum, the shaft of this engine simply bears a large pulley, 24 feet in diameter, having a wooden rim, with a deep groove in it. Around the periphery, and lying in the groove is a steel rope, one and a-half inches in diameter, the two ends of which pass over the pit-head gear, and hanging down the shaft, suspend the cages. Below there is a similar rope, one end of which is attached to the bottom of each cage, while the rope itself simply hangs freely down the shaft in a great loop, which reaches about six feet into the sump. This is the counterbalance. This apparatus forms virtually an endless rope, interrupted only by the cages. Its upper loop passes over the head-gear and round the driving pulley; its lower loop hangs perfectly loose in the shaft, and the whole evidently remains in perfect equilibrium in any position. The engine driving the large pulley alternately in each direction raises and lowers the cages. The shaft, at which this apparatus is fitted up, is 128 fathoms (234 metres) deep, and the time of running is 35 seconds. This apparatus is the first of its kind; and it is proposed, in a new application, to modify the arrangement somewhat, (1) by placing the driving pulley and engine directly over the pit, and (2) to provide against breakage of the rope, by furnishing two parallel side ropes running over loose pulleys, which, in the event of the main or driving rope failing, will sustain the cages. In the present arrangement, if the rope broke, both cages would be liable to fall to the bottom. They are furnished with safety gear, as a provision against that casualty; but the action of safety cages at the proper moment is too precarious, and men do not at present ride at this pit. The placing of a winding-engine high overhead is scarcely in accordance with English ideas; but in some districts in Germany it is customary to erect such substantial castles above the mouths of the pits that the installation of an engine aloft would not be attended with danger or inconvenience.

New Winning by Messrs. Krupp and Company. — This company has recently effected a new winning at their Hannibal Colliery, which has been fitted up upon the most magnificent scale, at an outlay, it is said, of nearly £200,000. The arrangements for the comfort of the men are especially complete. Rooms heated by steam-pipes, and furnished with baths, are provided for all the officials, while for the workmen there is one gigantic bath, of which the entire pit's crew can avail themselves at the same time. The present output of the pit, which has been in operation four years, is only 250 tons, and one can hardly but regret that at so important a winning no better means of ventilation should have been provided than that of leading the upcast air into the boiler chimney.

[198]

Consolidation Mines.—These mines, Gelsenkirchen, are among the most active in the district. The output of the No. 1 shaft, per day of eight hours, is—

Coal	800 tons.
Stone	150 „
Total	950 „

It is unnecessary to describe the method of getting the coal, which in the steep seams is essentially the same throughout the whole coal-field; but at this colliery greater attention is paid to system than at some of the others, and the various seams, whose inclination is about 60 degrees, are laid out into districts of 300 yards in length, and 112 yards in width or height, each such district being served by a counterbalance incline, passing through its midst. The bords are sixteen yards apart, so that each district comprises seven bords. For the purpose of ventilation cross holings are made from bord to bord at every thirty yards; but few stoppings are used in order to force the air current in to the faces. In the working of the various seams, which are very numerous, there is a large quantity of timber lost; but this amount entirely depends upon the circumstances of each particular seam. In exceptionally good cases scarcely any is lost, in other cases none is recovered. The seams are of all thicknesses and qualities, and arrangements have just been made to extensively work large tracts of them. The price of working in the broken in the No. 21 seam is 10d. per ton for round, and 5d. per ton for small. Two men work together in each place, and obtain ten or twelve tons per shift.

Heinrich Gustav Colliery.—The Arnold Pit of the Colliery of Heinrich Gustav is the last which will be described. It has an output of 400 to 450 tons. per day of sixteen hours. The seams are partly steep and partly horizontal, but the writer visited the horizontal workings only. They are of the ordinary bord and pillar type, the pillars measuring 30 yards by 10, and lying with their longer sides parallel to the strike. At this place the inclination was 10 degrees, and self-acting inclines, running only one tub at a time, were established at intervals of 120 yards. In the broken working, the pillars are removed by taking a series of slices 6 or 7 yards wide across them uphill. The following is a section of the seam (No. 12) which is a smithy coal:—

	Ft.	In.
Stone		4
Coal	3	3
Stone	1	0
Coal	1	8
	6	3

[199]

The prices of working are as follows:— Whole mine 11d. per ton, and 11d. per yard of advancement; broken mine 7d. per ton. The tonnage cost for putting is 2½ d.

Underground Pump.—An underground pumping engine is being fitted up at this pit, and the means employed for protecting it against inundation are worthy of notice. The engine-house consists of a cylindrical chamber, securely lined with brick, and strengthened by circular wrought iron rings. It is connected with the surrounding workings by one passage, and there is also a staple by which it communicates with a higher stage above. In the former passage a place is prepared for a dam, and all the materials for one will be kept in readiness, so that should the engine ever break down, or be overpowered by any sudden outbreak of water, the dam can be inserted, the engine-house completely isolated from the lower part of the mine, and a means of communication still preserved from the higher level by the staple before-mentioned. The whole of the bottom workings would have to be flooded out, and the water to have risen about half-way up in the main shaft before the pumping engine would be in danger. At the same colliery there is a new installation of coal-washing apparatus similar to that of the Dortmund Mining Company, and a great number of Coppée coke-ovens.

Coke-Ovens.—In the vicinity, at the works of Messrs. Herbrez, there is another washing and coking establishment, which produces 250 to 300 tons of coke daily. This coke is chiefly sent to Luxemburg and Nancy. The coal, after being washed, by which operation it is freed from 6 per cent. of stone, while 4 per cent. of the coal itself is washed away, is completely reduced to powder by means of Carr's disintegrators. Those machines, which are very highly spoken of, are each capable of crushing 20 to 25 tons of coal per hour. They are driven at 400 revolutions per minute, and require a force of about 15 horse-power each. The screening is by trommels, and the washing by jiggers similar to those already mentioned. The coke-ovens are loaded from above and discharged by travelling steam rams. They are built upon the Coppée pattern, and are of two sizes, viz., those which burn for 24 hours at a time and are loaded with 2½ tons of coal, and those which burn for 48 hours and are loaded with 5 tons. Seventy per cent. of coke is obtained from the coal, but its quality is inferior to the best coke of the county of Durham, and notwithstanding the washing, it contains 9 per cent. of ash. The total cost of production, including washing and coking, is 1s. 2d. per ton.

Referring to what has gone before, it cannot fail to be remarked how variously the art of coal-mining has developed itself in its several branches in each country and district. Not only has nearly every coal-field methods of working peculiar to itself, and suited to its own special circumstances, but the progress which has been made in the employment of machinery, and the applications to which it has been turned, have been chiefly determined by certain ruling conditions. It may be observed how the general adoption of rock-drilling apparatus in the North of France and Belgium is to be accounted for by the amount of stone tunneling which is required in the winning of numerous thin and highly-inclined beds of coal, how the great depths to which many of the shafts have attained has proved an incentive to the study of expansive gear for winding engines, and of the best means of counteracting the weight of the ropes, and how the existence of thick water-bearing-strata in the same districts has given birth to several inventions, among them that of MM. Kind and Chaudron, for the piercing of such strata, without the use of pumps. Similarly, it may be remarked, why the large outputs of coal, which are obtained at some of the pits of Saarbruck and Upper Silesia, have necessitated the adoption of the best shaft-fittings and means of extraction known in England or America; and how, on the other hand, the very complete systems of coal-washing, which are in use in Westphalia, have been required on account of the great proportion of stone contained in the coal, which has to be got rid of before it is fit for the manufacture of coke.

ENGLISH AND FOREIGN MINES COMPARED.

If there is little to be said upon the subjects of ventilation and underground haulage, it is because no country on the continent can compete with England in these directions. The fiery mines, with the extensive and complicated workings in that country, have created a real necessity for the strictest attention to the subject of ventilation in all its details, and by the efforts of such men as John Buddle and Sir Humphrey Davy a comparative immunity from accidents has been attained, even in the midst of the greatest dangers. England is also the home of mechanical haulage, because, while the flatness and thickness of the seams of coal favoured the introduction of such means of transit, the high price of labour, the desire for large outputs, and the great areas generally worked from each shaft, rendered the adoption of machinery almost imperative. But although special circumstances will usually be found to account for marked progress in any given direction, it often happens that what was necessary in one situation may be usefully

[201]

adopted in others. In this manner all foreign nations have been more or less indebted to the mining experience of England; and those countries are most advanced in the art of mining who have kept themselves abreast of the progress that was being made elsewhere. England also may derive some benefit from a knowledge of the practice of her neighbours and competitors, and the writer will feel gratified if, in attempting to give some account of what is being done upon the continent, anything should have been suggested which may be of use to English mining engineers. It only remains for him to express his deep sense of obligation to all the managers and directors of mines with whom he came in contact, to whose kindness he is entirely indebted for whatever information he has been able to lay before the Institute.

Mr. Galloway, with reference to some remarks by the Chairman, said, that generally the ropes were taper, and made of hemp, that the parachute could be attached or removed from the cage at will, and was usually not put on more than three times a day, when the two shifts were lowered and brought to bank.

Mr. A. L. Steavenson proposed a vote of thanks to Mr. Galloway. He remarked that one of the principal functions of the Institute was to become the repository of the experience the members acquired in their travels, and he thought that few papers would add more to the usefulness of their Transactions as sources of reference and information than those they had just heard read.

The vote of thanks was seconded by the Chairman, and carried unanimously, and the meeting then separated.

[202]

[Plates XXII. to XXV illustrating the paper above]

[203]

PROCEEDINGS.

GENERAL MEETING, SATURDAY, MAY 4, 1878, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

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

The Secretary read the minutes of the last meeting and the minutes of the Council meetings.

The Chairman said, that the first business of the meeting was to elect the members who had been nominated; and as it was necessary to appoint a scrutineer to examine the voting papers, he moved that the Secretary be appointed to make the necessary examination.

The motion was seconded and carried by acclamation, and the following gentlemen were afterwards declared to have been duly elected:—

Ordinary Members—

Mr. Thomas Gilchrist, M.E., Ovington Cottage, Prudhoe-on-Tyne.

Mr. Thomas Dacres, M.E., Dearham Colliery, Maryport.

Mr. John W. Spencer, Steel Manufacturer, Newburn, near Newcastle-on-Tyne.

Students—

Mr. David L. Evans, Gold Tops, Newport, Monmouthshire.

Mr. Amidee Vernes, 8, Claremont Place, Gateshead.

The following were nominated for election at the next meeting:—

Ordinary Members—

Mr. Wm. Kellett, M.E., Wigan.

Mr. W. R. Ellis, M.E., F.G.S., Wigan.

Mr. Samuel Taylor Jones, Whitelea Colliery, County of Durham

Associate Members—

Mr. Richard A. Rylands, Bedford Colliery, Mold.

Mr. Ralph D. Cochrane, Hetton Colliery Office, Fence Houses.

Mr. G. G. C. Gambier, M.E., South Hetton Colliery, Fence Houses.

Mr. E. G. Hughes, Solway View, Whitehaven.

Students—

Mr. Samuel Powell, Westminster Chambers, Wrexham.

Mr. Arthur Stanley Douglas, West Lodge, Crook, Darlington

Mr. J. A. G. Ross then read the following paper "On Mechanical Stoking for Colliery Boilers," by Mr. Alexander Ross:—

MECHANICAL STOKING FOR COLLIERY BOILERS.

By ALEXANDER ROSS.

The dense black smoke emitted from the chimneys of furnaces burning bituminous coals has for many years excited the attention of engineers, who, attracted by the hope of destroying the nuisance, and of saving the lost carbon, brought numerous improvements in furnaces before the public. Economy in the consumption of fuel amounting to from 15 to 40 per cent. was frequently promised as an incentive to persons using these furnaces, and no doubt in many cases large saving was effected, although not in the way many supposed, for it has recently been established, on the authority of Mr. W. C. Estcourt, analyst for the city of Manchester, that the saving to be made by the perfect consumption of the smoke rarely exceeds 1 per cent.; in fact, there is not much more than 1 per cent. of the total quantity of the carbon of the coal being burnt there, to save. In the "Journal of Science and Arts," 1817, a description is given of a furnace patented by one Gregson, in which the coal is projected into the furnace by means of a lever moved by a cam, and air is supplied to the furnace from a shaft carried by the side of, and to the same height as the chimney. It seems that, according to Dalton and other authorities, the consumption of coal in this furnace was reduced 30 per cent. over the old one employed for the same purpose; that one pound of coal ought to evaporate from six to eight pounds of water; and that, in fact, in an ordinary furnace, one pound of Hartley coal did evaporate about five pounds eight ounces of water from a temperature of 212 degrees, and under a pressure of four inches of mercury. But Gregson's furnace actually evaporated seven pounds twelve ounces from the same temperature and pressure, whilst the temperature of the gases entering the chimney was reduced from 440 degrees to 250 degrees. The stream of invention has flowed on ever since, till the patents for the consumption of fuel have reached to several thousands, a slight description of them alone filling a thick volume. But all seem to have been laid aside from complication, liability to repair, and other reasons; and even at this very day the great majority of boilers are fired by hand.

In the year 1857, when an Act of Parliament came into force compelling the consumption of smoke in the vicinity of towns, the subject of

[206]

mechanical stoking became of much greater importance. Many persons considered that this Act could be complied with by careful hand-firing, and this view is perhaps correct when the coals are suitable, and other circumstances are favourable, although it is difficult to obtain firemen who are sufficiently skilled and attentive to do so; and as a rule, when hand-firing is practised, more or less smoke is evolved from the chimney tops. To avoid this, mechanical stokers have been adopted, and have obtained the desired object with more or less success, and generally with a certain amount of economy of fuel.

One of the earliest of these mechanical stokers that seems to have established itself permanently in public favour is the well-known Jukes' furnace, consisting of a series of short bars joined together after the manner of an endless chain, extending the whole width of the furnace, and revolving on two rollers, one outside and in front of the boiler, and the other underneath the boiler at the further end of the fire. These bars have a slow, continuous, and adjustable motion given to them by means of a donkey engine and suitable gear. A small pipe, about one inch in diameter, is carried from the steam chest of the boiler, terminating in a perforated copper pipe which crosses the far end of the bars, for the purpose of extinguishing those coals that are about to fall off after having passed through the furnace. These jets of steam also serve to clean the bars and increase the draught. This contrivance, properly arranged, may be relied on for burning the fuel economically without producing smoke, but great care and attention is required to prevent the rapid destruction of the bars.

The most important points to be attended to are:—

1.—Not to use too short bars, which should not be less than from 8 feet to 8 feet 6 inches long.

2.—The distance which the bars should be from the lower parts of the boiler is about 2 feet.

3.—The speed of the bars should be from 8 to 10 feet per hour.

These dimensions and speeds correspond very nearly with those of the eighteen boilers fitted with this apparatus at Monkwearmouth Colliery, where it has been long and successfully in use.

The proper speed at which these bars have to be driven must necessarily depend on actual experiment, and therefore a means for regulating it is provided in every case. It is important that the fuel should be completely consumed before it reaches the end of the bars, otherwise the draught and heat at that part would quickly destroy them; but when due care is given to ensure this, the bars will last under favourable circumstances for ten years, their average duration being about eight years. The use of these bars also seems to preserve the bottoms of the boilers;

[Plates XXVI. and XXVII. To illustrate Mr Ross's paper on "Mechanical stoking for colliery boilers"

on account of its not being necessary at any time to open the furnace doors, cold air is prevented from being periodically brought in contact with the hot plates, and much injurious contraction and expansion is prevented, and boilers thus fitted have been known to last for six or seven years with scarcely any expenditure for repairs, whereas the cost of repairing the bottoms and furnaces of hand-stoked boilers is always considerable.

The cost of Jukes' furnaces varies from £64 to £84, according to their size, but when they have been employed, the result usually shows that this expense has not been unnecessarily incurred.

It has been generally considered that an increased number of boilers is required when this stoker is introduced, but this is hardly the case when the bars are suitably proportioned. Of course, more steam can be raised by giving an increased speed to the bars, but economy will be sacrificed if this speed is increased beyond the limits indicated before. In fact, the fire being clearer and more uniformly fed than if stoked by hand, the production of steam is maintained if not increased by this apparatus.

Probably the next in importance amongst the mechanical stokers is Vicars', which has been in use about twelve years. The main difference between this and Jukes' furnace is, that the bars, instead of forming a revolving chain, are in one piece, and are so arranged that, by means of a rotatory motion given to cams acting on the bars, the whole number of these bars are made slowly to move towards the end of the furnace and carry the incandescent fuel with them; after this, they are brought back in groups of three, that is, the motion of the cams is so regulated that every third bar is in turn depressed slightly and moved forwards to its first position, until the whole of the bars have thus been brought forward, when they are all simultaneously pushed back again. By this arrangement, it will be seen that although the fuel is carried towards the end of the furnace by the simultaneous progression of the bars, it is not disturbed when the bars come forward in groups of three, for the fuel rests undisturbed on two-thirds of the bars which are at rest, while the other third being depressed pass out of contact with, and beneath it. The coal is, as in the Jukes' furnace, first placed in a hopper, at the bottom of which, in this case, is a couple of rams, one on each side of the furnace, which, push the coals on to a series of short fixed bars, which are substituted for the ordinary dead plate; as the coal accumulates here it ultimately gets pushed on to the moving bars, which carry it forward as described.

The back ends of the bars rest, when drawn forward, for about 3 inches on a cross-bearing plate about 10 inches wide, protected from burning by a 4-inch pipe in connection with the water in the boiler. The coal in its onward motion falls off the bars on to this plate, and the ends of the

bars, acting as plungers, break up the clinker, and ultimately push the remainder of the fire on to a small grate at the bottom of the flue.

The patentee claims for this second grate that it causes more uniformity of action on the boiler, and that the heat is better diffused than by the bridge plan, which limits the action of the heat to the upper part of the flue and produces irregular expansion in the boiler.

A simple arrangement is provided for regulating the speed of the feeding rams, and length of the stroke of the moving bars, which on an average is about 3 inches. This system is more complicated than that of Jukes', and also more costly, but it appears to have been successful in preventing smoke, and is said to save fuel. Its cost is from £90 to £98, according to size.

Butcher's mechanical stoker, introduced into this district some time ago, brings once more into operation one of the oldest of all the schemes for mechanically placing fuel on a furnace, namely, that of dropping small coal on a fan revolving at a high velocity, which projects it over the fire in minute particles. This principle, improved and combined with the practical arrangements made by Mr. Butcher, has been fairly successful at Seghill, Silksworth, and other collieries. Perhaps the most novel feature of the present form of the apparatus is the mode of conveying the coal to any number of boilers in a row by means of a worm working in a trough, which must necessarily save a considerable quantity of labour. Small coal, brought by trucks, is emptied in a hopper, to the bottom of which is conducted a worm a (Plate XXVI.), working in a trough b. This worm and trough run the full length of the whole range of boilers. Opposite each furnace there is a communication c made from the trough, into which a portion of coal falls in its passage from furnace to furnace. In this communication a feeder d works on the spindle h with a reciprocating motion, communicated to it from the shaft e, which also runs the whole length of the range. Particles of coal are thus pushed over the edge f of the communication and fall on to two fans gg, driven by means of cog wheels, as will be readily understood by reference to the Plate. The other details, with the exception of the mode of varying the feed, are sufficiently clearly illustrated and need no further description.

Plate XXVII., Figs. 1,2, 3, shows the mode of adjusting the feed; a, Fig. 1 is the worm, and b the trough described in the former Plate, k is the spindle on which the feeder d (see Plate XXVI., Fig. 2), is made to reciprocate. l is a lever attached to this spindle, which receives its motion from the rod m, the eccentric n, and the shaft e. The supports oo, which carry this spindle, are prolonged to pp, and are attached to two rods qq, the other ends of which are connected with two lugs x'x', cast on a guide piece v, attached to the eccentric strap s. Another rod mm, of the same

length as the rods qq, attaches the end y of the lever l to the lug t of the slider c which works in the guide piece v. It will be observed that the rods m and qq being of the same length, the centres of the lever l and the eccentric rod m will coincide with the centres pp of the supports oo and the corresponding centres of the rods qq, when the other centre t of the rod m is made to coincide with the centre u of the rods qq by means of the screw w and hand wheel x, in which case there will be no motion given to l; but as the rod is moved more and more in the direction in which it is shown in the Plate, more and more motion will be given to z and to the feeder d, and more and more fuel will be admitted to the fan.

It is needless to add that duff coal is the most suitable for this form of stoker, and that the smaller the coal supplied the better.

The fire bars are of the ordinary kind, and are made to rock at intervals by means of a lever within reach of the attendant, who in this case can scarcely be called a fireman, since he has nothing whatever to do with the manipulation of the coal.

Of course, an ordinary hopper can be supplied to each furnace instead of the worm and trough, although the latter is recommended where many boilers are together in a row. The bars appear to be durable, and the wear and tear could hardly be more than in other machines. There is almost a total absence of visible motion: the worm only requires a speed of twenty-five to thirty revolutions an hour to supply fourteen furnaces, and the only parts which require any speed are the fans, and every precaution is taken to preserve and lubricate them.

The cost of this apparatus is about £35 a furnace, which is much less than those of either Vicars' or Jukes'.

One advantage of the Butcher furnace is that it can be applied to any kind of boiler, whether a Cornish, or Lancashire, or an egg-ended boiler, for Jukes' and Vicars' can only be used to advantage under the latter kind.

These three methods of mechanical stoking seem to exhibit the most successful types of the various apparatus invented for this purpose, most of which are only (more or less) variations of one of the three; and the writer does not propose to continue his description further. Each type may be said fairly to fulfil the condition required, and each can be seen at work in this immediate neighbourhood.

The Chairman said, they were very much obliged to Mr. Ross for having prepared this interesting paper, and would be glad to have the subject discussed. In Lancashire he believed that mechanical stoking was much in vogue, and highly approved of for its economy of fuel, consumption of smoke, and saving in labour.

Mr. Lawrence stated that mechanical stoking had now been many years before the public, he recollected seeing it when a boy at the Chelsea water-works. He was pleased with the way in which the author had treated Jukes' furnaces, and fully concurred with him in all that he had said. At Monkwearmouth Colliery, he believed that there was not a single boiler that was not fired by one, and all the officials there were contented with them. Some of the bars there in use had lasted as long as nine years; he must, however, add that they must be put in the hands of those who took some interest in their preservation, or they would very soon receive injury; and if the manager from time to time found boilers off work from the apparatus being out of order, he might probably have them removed before, in fact, they had had a fair trial. He thought that Mr. Ross was in error respecting the jet pipe, for this was not included in Jukes' patent, but was patented afterwards by Mr. Coulson, not to keep down the fire at the far end of the furnace, but to increase the draught and keep the bars clean. He did not quite agree with the author about the speed of the bars; up to a certain point the efficiency of the boiler might be improved by an increase of speed, but that increase must in no case cause the coal to be carried unconsumed back to the bridge end of the bars, for if so, considerable waste would ensue. The proper speed of the bars was also dependent on the quality of the coals, and so in fact was the success of the entire apparatus, for when a coal is used that makes too much clinker, the bars were apt to become covered with a thick slag, and rendered immovable; but with proper coal and good management, he considered Jukes' furnaces the best stokers ever adapted to a boiler. These bars, however, were stated not to burn duff coal well, that is, the duff was apt to fall through the bars; but if it was damped a little, and a little straw put into the hopper, that difficulty was overcome. With Butcher's stoker, duff coal was probably the best to use, in fact large coal would have to be crushed to a certain size by a special set of rollers before it could be thrown from the fans with regularity on to the fire. Butcher's invention was not new, as the author had pointed out, being in fact that of Witham's and Stanley's in another form, and the contrivances of this class were all open to the objection that they always required a man occasionally to open the doors and push the fuel back, whereas in Jukes' furnaces, there was a continuous motion of the incandescent fuel, which rendered it perfectly unnecessary where proper coal was used to open the doors from one year's end to the other except for the purpose of lighting the fire; in fact, opening the door was detrimental to them, inasmuch as it kindled the coal lying close to the furnace mouth, and thereby destroyed the fittings. The very success of this furnace depending on the coal remaining cool at the furnace mouth, and becoming ignited by passing under a fire brick bridge already heated

by the fire. He did not consider Vicars' furnace so good as Jukes', for his experience was that they required considerable expense to keep in order.

In reply to the Chairman, Mr. Lawrence stated that neither Jukes' or Vicars' furnaces were so suitable for boilers having furnace tubes as they were for boilers which allowed them to be fixed underneath; and he thought Butcher's stoker would suit the former class better.

Mr. Clark said, that he had been taken quite by surprise on hearing that the author of the paper had brought Mr. Butcher's invention so prominently before the members, that gentleman was there and would be happy to give any further explanation that might be required.

The Chairman having asked Mr. Butcher to supplement the description of his invention by any remarks he might wish to make,

Mr. Butcher replied, that in the earlier forms of this class of stoker, hoppers were used instead of the worm, and, in fact, they had been so used at Seghill for about a year before the worm was substituted. The use of a hopper indeed was the most common method of supplying the fuel, and in Lancashire it gave the name to the apparatus which was called "a hopper." In speaking of this furnace, Mr. Lawrence had admitted that it was more suitable for adaptation to a fire tube than was Jukes', and that also it was more adapted to burn duff; but he had objected to it on account of the attendant having from time to time to open the fire door, and push the fire back towards the bridge. This was no doubt to a certain extent a defect; but was it a more serious defect than the one which was inherent in Jukes' and in all furnaces which carry the fuel forward from the fire doors towards the bridge at a regular pace? When the coal was first placed on the bars at the front of the fire, and commenced giving off gas, it required considerably more air than when it had arrived at the end of its course, and had given off the greater portion of its volatile constituents. The air, therefore, should be regulated to pass more abundantly through the front portion of the fuel newly added than through the back portion, but this can never be the case in Jukes' furnace, for the coal upon it, which is densely packed in front, only allows the minimum quantity of air to pass; whereas, when it is partially or almost wholly burnt away at the end, and the bars are only partly covered, large quantities of air are admitted. He contended that in the Butcher stoker the coal was placed in the furnace in small particles, subjected at first to the heat at a time when they were at considerable distances from each other, and freely surrounded with air; that these particles gave off their gases freely, and when at rest on the bars were in a state to require a regular and equable admission of air.

[212]

Mr. J. A. G. Ross stated that he had seen the Butcher stokers at work, and had been very much pleased with the fire they produced, and the results as to consumption of smoke and economy of fuel, which economy was rendered still greater from the processes being peculiarly suited to use up duff and other small coal. He quite agreed with all that had been said of Jukes' furnace, which at Sir William Armstrong's and other places had burnt fuel of a quality that it would have been impossible to have burnt by hand stoking. His experience with regard to the pipe at the back of the Jukes' furnace was that it was a mistake, and caused more repairs and trouble than it was worth. With regard to the application of Jukes' furnace to fire tubes, he had seen them so applied with success; but of course as the space in the tube was limited, this could only be done with tubes of a somewhat large size; but he thought that by having the bars in front of these tubes in a fire-brick chamber, and only allowing the products of combustion to enter the fire tubes, all difficulties would be avoided; or if the upper portion only of the fire bar chains were allowed to travel in the fire tube, and then descend at the back through an opening in the water space below, to be carried forwards outside the boiler, he thought Jukes' bars might be applied to any sized class of fire tube furnaces.

Mr. Butcher said, that they had hitherto mostly used duff coal, as the result obtained was almost as good as when small coal was used. Of course, if large coal were used, it would have to be passed through a crusher, and broken to a suitable size; but he found that rollers reduced too large a proportion of the coal to impalpable powder, which was not so effective even as the duff, and he in all cases recommended vertical crushers for this work.

Mr. A. Ross—As to the steam pipe, no doubt Mr. Lawrence was correct in stating that it was not included in the original patent of Jukes, but was added afterwards by another inventor; but the effect of it is most beneficial, as it increases the draught where it is deficient, keeps the bars clean, and tends materially to preserve the bars, the drums, and the whole apparatus. Neither did he agree with the remarks of Mr. J. A. G. Ross, as he had found that the cost of putting the pipe in and keeping it in repair was trifling, and, when in, it caused no trouble whatever.

The Chairman moved a vote of thanks to Mr. Ross for his interesting paper, which was seconded by Mr. Lawrence, and unanimously passed.

Mr. Lebour, then read the following paper, by Mr. Edwin Gilpin, M.A., F.G.S., on "Canadian Coals: their Composition and Uses."

[213]

CANADIAN COALS—THEIR COMPOSITION AND USES.

By EDWIN GILPIN, M.A., F.G.S.

The writer having been engaged during the past year in an extensive investigation into the properties of the chief Nova Scotian coals, thought that a brief description of the more typical seams would not be without interest to the members of the Institute; and as there is but little known of the coal deposits of the rest of the Dominion beyond the reports of the officers of the Geological Survey, the writer has added a brief notice of the more modern coals of the North West Territory and British Columbia, showing the value of the coal interests of a portion of the Dominion which is gradually becoming appreciated as a suitable field for emigration.

The writer takes this opportunity of acknowledging his obligations to Mr. Selwyn, Director of the Geological Survey, for information about the British Columbia coals, to the managers of several of the Cape Breton Collieries, and to Mr. E. G. Millidge, the gentleman in charge of the Public Works in Cape Breton.

The chief available information relative to the composition of the Nova Scotian coals is found in the reports of the geological survey and scattered analyses made by various chemists. Unfortunately the value of these reports for comparison is materially affected by the various methods of analysis employed, by it being frequently left in doubt as to whether the coals were coked by a slow or fast application of heat, and by the fact that in many cases samples of the best portions of the seams were analysed, and the results given as averages of the whole bed. In the following set of analyses the samples were averages selected either from the pit heaps, from cargoes, or from the working face.

The writer would not presume to claim any greater accuracy for his own analyses, but considers this their chief value, that as the same method of analysis was applied to all, a better comparison can be made not only between individual seams but also between those of various districts.

[214]

In the following analyses the method pursued in the Laboratory of the Pennsylvania State Survey has been adopted, and is briefly as follows.

The moisture is determined by heating at 212 degrees for one hour, or until the sample ceases to lose weight. The percentage of volatile ingredients by fast coking is got by heating the coal in a loosely-covered platinum crucible until the gas flame ceases to be visible, then a nearly white heat is applied for about five minutes. The percentage of volatile matter by slow coking is got by raising the heat very gradually, and finally applying a nearly white heat as before.

The total sulphur is estimated by fusing one gramme of the coal with ten of carbonate of sodium, and six of nitrate of potassium, dissolving the fused mass in water acidulated by hydrochloric acid, and then evaporating to dryness; re-dissolving the residue in dilute hydrochloric acid, adding water and precipitating the sulphur by chloride of barium from the filtered solution. The sulphur present as sulphate of calcium is got by boiling with carbonate of sodium, and deducted from the total amount, and the necessary corrections made, for the sulphuric acid present in the carbonate of sodium. The ashes are got by the usual process.

In this paper the ton is invariably the long one of 2,240 lbs. The localities of the various seams and collieries will be found marked on the maps accompanying the papers contributed by the writer on the Pictou Coal-field, and the submarine coal of Cape Breton. The calculations of the theoretical evaporative powers of the fixed carbon are, for comparison with the results of the British naval steam-coal trials, got by Regnault's formula, although later researches have somewhat modified the values determined by him.

The following analyses of the Cape Breton coals have been arranged in descending order, in conformity with the results arrived at by the officers of the Geological Survey. Although this arrangement of the horizons of the various seams differs somewhat from that proposed by the writer and others, he thinks that the results of a survey extending over several years form the most reliable guide.

The following table shows the arrangement of the seams analysed in their supposed equivalency:—

[see in original text Table of arrangements of the seams in the Cow Bay District, Glace Bay District and Sydney District.]

Hub Seam (of Little Glace Bay) —Although the land area of this seam is comparatively limited, it is accessible under a large sea area.

Section.	Ft.	in.
Coal, good		10
„ soft		3
„ good	5	6
„ splint		1
„ good	3	0

Total	9	8

Being unable to procure samples of this coal, which is justly considered one of the best of the Cape Breton coals, the following analysis, by an unknown authority, is given:—

Volatile matter	33.21
Fixed carbon	63.94
Ash	2.85
	100.00

This coal is more particularly used for gas making, its yield for this purpose being 9,500 cubic feet of 15 candle gas per ton, and a good coke.

[216]

The slack which forms about one-fifth of the coal mined is suitable for blacksmiths' work, and has been used to a small extent for coke making.

Harbour Seam (Stirling Pit) —This coal is also worked by the Little Glace Bay Co. The coal is laminated, with a pitchy lustre, some of the laminas being dull and heavy; much mineral charcoal on the deposition planes; little visible pyrites. Primary planes at right angles to deposition planes, with films of white carbonate of lime and iron. Secondary planes inclined irregularly to primary, and to deposition planes at angles of 60 to 65 degrees without films of spar.

Section.	Ft.	in.
Coal, coarse		3
„ good	1	6
„ soft		1
„ good	3	4
Total	5	2

Composition	slow coking.	fast coking
Moisture	.80	.80
Volatile combustible matter	27.85	29.40
Fixed carbon	67.05	65.50

Ashes	4.30	4.30
	100.00	100.00
Theoretical evaporative power	9.19	8.98
Injurious sulphur	2.327	—
Specific gravity	1.29	—

Coke vesicular, hard, and bright; ash very light red; powder of coal deep chocolate red.

At one point in the workings of this seam the pit water contains an unusual quantity of the sulphate of iron.

The following are the gas values of this coal as determined during the present year:—

Montreal New City Gas Company.		Halifax Gas Company.	
Gas, cubic feet per ton	9,268	Gas, cubic feet per ton	9,700
Candle power	15.00	Candle power	14.75
Coke (good) bushels	40	Coke (very good) bushels	39

The coals from the Hub and Harbour Seams were tested some years ago at Halifax, on behalf of the Admiralty, by the chief engineer of the flagship, "Duncan." He reported that they both light up quickly, raise steam fast, and give a very moderate amount of clinker and ash. The Hub Seam gave 80.9, and the Harbour 83.5 per cent. of carbon, and that they are well adapted for use in Her Majesty's Navy.

Block House Seam —Coal tolerably compact, with bright laminae, a few being brown and shaley; no calc-spar films or visible pyrites;

primary and secondary planes cut each other, and deposition planes at angles 70 to 75 degrees; very little mineral charcoal on deposition planes, which are quite smooth.

Section.	Ft.	in.
Coal, top	1	0
„ good	3	9
„ „ (holing)		3

„ good	4	2
Total	9	2

The top coal is left for a roof as it is rather coarse.

Composition	Slow Coking.	Fast Coking
Moisture	.600	.600
Volatile combustible matter	29.480	31.580
Fixed carbon	65.565	63.465
Ashes	4.355	4.355
	100.000	100.000
Theoretical evaporative power	8.99	8.97
Injurious sulphur	2.63	—
Specific gravity	1.292	—

Coke partly coherent and vesicular; ash dark brick red.

The following analysis, made in 1871 by the Manhattan (New York) Gas Co., and the results of their tests, will show its good gas qualities:—

Gas, cubic feet, standard yield	9,500
„ „ maximum „	10,316
Candle power, standard „	16.53
Coke (1,460 lbs.) bus:	40
Cubic feet purified by one bushel of lime	2,840

Analysis.

Volatile matter	39.00
Fixed carbon	57.50
Ash	3.50
	100.00

The ultimate analysis was made at Halifax on behalf of the Admiralty.

Carbon	82.60
Hydrogen	4.79
Nitrogen	1.20
Oxygen	4.10
Sulphur	2.51
Ash	4.80
	100.00

The coal was tried on board H.M.S. "Garnet," and found to raise steam fifteen minutes quicker than any coal that had been supplied to the ship.

[218]

When mixed with twice its weight of Tillery Elled Welsh coal a saving of 12 per cent. over the Welsh coal alone was reported. The percentage of ash and clinker was very small. The only objection to its use in war vessels is the large amount of dense smoke given off when the fires are pushed.

The mine water has a powerfully corrosive action on the pumps which had to be lined with wood. The following analysis of it is by Mr. C. Hoffman, of the Geological Survey:—

Constituents in 1,000 parts of the water.

Suspended matter	.1510
Consisting of ferric oxide	.1052
*Sulphuric acid and organic matter	.0458
In Solution.	
Iron (as per-salt)	.2426
Iron (as proto-salt)	.1168
Manganese	.0078
Aluminium	.0420
Calcium	.1498
Magnesium	.0618
Potassium	.0134

Sodium	.1884
Silica	.0116
Sulphuric acid	1.4808
Chlorine	.4100
Phosphoric acid	traces
Organic matter	.2844
	3.0046

Victoria Coal Seam

Section.	Ft. in.
Roof sandstone	
Coal, good	2 4
„ slatey	1
,, good	3 7
	6 0

Top-bench bright shining compact coal, primary and secondary planes irregularly inclined to each other, and to the deposition planes. Primary planes coated with a little calc-spar, deposition planes have a little mineral charcoal. The upper portion of the lower bench has a slightly splinty appearance, while the lower part resembles the upper bench, but is more lustrous, and has a cubical fracture. This coal contains a considerable amount of visible pyrites. In the more splinty portion of the seam it occurs in layers mixed with the mineral charcoal; and in the upper bench

* Combined with the ferric oxide as a basic sulphate of iron.

as small nodules. The whole appearance of the seam is very much in its favour; it is compact, and not liable to crumble. The coal has never been known to heat in cargo, but has done so when exposed in the slack heaps.

The specific gravity of the upper and lower benches is almost identical, the average being 1.290.

Composition.	slow coking	fast coking
Moisture	.28	.28

Volatile combustible matter	28.61	33.30
Fixed carbon	67.61	62.92
Ash	3.50	3.50
	100.00	100.00
Theoretical evaporative power	9.27	8.63
Injurious sulphur	2.84	—

Coke bright and vesicular; ash red, and inclined to form clinker.

The manager, Mr. J. Salter, writes—"We do not recommend the coal for gas, but find it well adapted for steam purposes." It has not been tried for coke, the slack sells readily for steam and smithy purposes.

Sydney Seam —Bright compact coal, breaking irregularly, owing to the want of persistence of the secondary planes; little mineral charcoal; and visible pyrites; the primary planes have numerous films of carbonate of lime holding much carbonate of iron, which gives the weathered coal a rusty appearance.

Section.	Ft.	in.
Roof, arenaceous shale	—	
Coal, good	4	3
„ soft		2
„ good	1	9
Total	6	2

Composition	slow coking	fast coking
Moisture	1.260	1.260
Volatile combustible matter	33.840	35.514
Fixed carbon	60.785	59.111
Ash	4.115	4.115
	100.000	100.000
Theoretical evaporative power	8.33	8.14

Injurious sulphur	1.705	—
Specific gravity	1.312	—

The average of four tests gave per ton—

Gas (cubic feet)	8,200
Candle power	8.00
Coke, good (lbs.)	1,295

[220]

The reputation of this coal is based chiefly on its suitableness for domestic purposes, and it commands a slightly higher price per ton than any other Cape Breton coals in the Halifax market. It is also used to some extent by the various steamers making Sydney a port of call. About one-eighth of the coal mined passes through a screen with bars three-quarters of an inch apart, and but little of it is saleable. After the coal has been banked out during the winter, one-fourth of it is in the state of slack.

The following is the result of a trial made of this coal by the American Government in 1844, and, as far as the writer is aware, it is the only practical trial that has been made of the evaporative power of any of the Cape Breton coals:—

Moisture	3.13	Lbs. of steam to one of coal from 212 degrees	7.90
Volatile combustible matter	23.81		
Fixed carbon	67.57	Ash and clinker per cent.	6.00
Ash	5.49	Theoretical evaporative power	9.25 *
	100.00		

From a comparison with the trials of Pictou coal made at the same place (see page 238), it will appear that the Pictou coals proved superior, although containing double the amount of ash.

The following table shows the composition of the ashes of the coals described above:—

	Block House.	Harbour.	Victoria.	Sydney†
Iron Peroxide	45.621	63.355	56.543	51.33
Alumina	3.250	8.280	6.456	4.84
Insoluble silicious residue	35.110	21.872	27.500	29.57
Manganese	—	—	1.930	—

Magnesia	1.100	trace.	.035	.23
Lime	5.425	4.640	2.598	3.05
Sulphate of lime	—	-	—	1098
Sulphuric acid	6.750	2.126	3.790	—
Phosphoric acid	1.900	.514	.691	trace.
‡ Alkalies	trace.	trace.	.150	trace.
Chlorine	—	trace.	—	trace.
	99.156	100.787	99.693	100.00

The second seam that is worked to any extent, and which may be distinguished as the Phelan Seam is also known as the McAulay and Lingan Main.

* Theoretical evaporative power from Regnault's formula.

† Analysis by Dr. H. How.

‡ In this and the following analyses the alkalies were estimated only when they appeared to be present in quantity.

[221]

McAulay Seam (of Cow Bay).—Coal black, with faint greyish tinge. On fresh surfaces the lustre is bright and pitchy, with very fine laminae of jet-like coal, and a good deal of mineral charcoal on the deposition planes. This coal sometimes exhibits four cleavage planes. The two primary ones are at right angles to each other and the deposition planes. The secondary planes are nearly at right angles to the deposition, and inclined to the primary planes at angles of 70 and 85 degrees. The primary planes have numerous films of calc-spar up to one-fourth of an inch thick; hardly any visible pyrites. Coal tolerably compact with nearly black powder.

Section.	Ft. in.
Roof, arenaceous shale	—
Coal (roof), coarse	6
„ good	1 0
„ soft, with considerable sulphur	6
„ good	9
„ splint	1

„ good	2	8
	5	6

Floor sandstone

The roof coal is stowed in the mine.

Composition	slow coking	fast coking
Moisture	.50	.50
Volatile combustible matter	28.13	31.41
Fixed carbon	66.01	62.73
Ash	5.36	5.36
	100.00	100.00
Theoretical evaporative power	9.05	8.62
Injurious sulphur	2.718	—
Specific gravity	1.310	

Coke partly coherent; ash purplish red.

This coal has been used lately chiefly for steam and domestic purposes, and has proved a fair gas coal. It lights readily, and forms an easily managed fire, having very little effect on furnace bars. It was for several years used in considerable quantity at some American copper works, and formed a satisfactory fuel. The water from this seam has a corrosive action on the pumps, and is said to be similar in composition to that already noticed as found in the workings of the Block House seam in the same district.

In the retorts of the New York Gas Co., this coal yielded per ton—

[222]

Gas (cubic feet)	9,000
Candle power	15.00
Coke, good (lbs)	1,230
Gas purified by one bushel of lime	2,100

Phelan Seam (Caledonian Colliery).—The coal on the west side of the pit is moderately compact, with bright pitchy lustre, much mineral charcoal, and no visible pyrites. The secondary planes are inclined to the primary and deposition planes at angles of 65 and 75 degrees, causing the coal to break in rhomboidal forms. The primary planes have abundant films of calc-spar, with carbonate of iron and sulphate of lime. The coal on the east side is not so bright, and has a little visible pyrites, but no calc-spar films.

Section.	Ft. in.	Ft. in.
Roof, fire-clay	8	—
Coal (roof), coarse	—	1 8
„ good	—	3 6
Fire-clay	—	2
Coal, good	—	1 6
		6 10

Floor, hard arenaceous fire-clay.

Composition of Coal from West Side of Pit.

	slow coking.	fast coking.
Moisture	.40	.40
Volatile combustible matter	27.16	28.85
Fixed carbon	62.62	61.03
Ash	9.82	9.72
	100.00	100.00
Theoretical evaporative power	8.58	8.49
Injurious sulphur	.785	—
Specific gravity	1.270	—

Coke partly coherent and soft; ash light grey.

Composition of Coal from East Side of Pit.

	slow coking.	fast coking.

Moisture	.921	.921
Volatile combustible matter	28.625	30.312
Fixed carbon	64.021	62.334
Ash	6.433	6.433
	100.000	100.000
Theoretical evaporative power	8.78	8.62
Injurious sulphur	1.105	—
Specific gravity	1.330	—

Coke vesicular and soft; ash greyish white.

[223]

This coal is exported to the New England States chiefly for gas and steam purposes.

During the present year it yielded, at the Montreal Gas Works, per ton—

Gas, cubic feet	8,900
Candle power	1.425
Coke, bushels (fair)	36

Reserve Colliery.—The Phelan seam, as worked at this colliery, presents no strong points of difference, except that some of the lamina are of a highly lustrous jet black colour, which makes it form one of the handsomest of the Cape Breton coals.

Section.	Ft.	in.
Roof, soft blue shale	—	
Coal roof	3	0
Soft blue shale		6
Coal, good	6	0
	9	6

Floor fire-clay.

Composition	slow coking.	fast coking.
Moisture	.52	.52
Volatile combustible matter	34.21	37.60
Fixed carbon	59.73	56.34
Ash	5.54	5.54
	100.00	100.00
Theoretical evaporative power	8.19	7.86
Injurious sulphur	1.252	—
Specific gravity	1.280	—

Coke vesicular; ashes light, and of greyish brown colour.

The following ultimate analysis of this coal was made at the Royal School of Mines, London:—

Carbon	77.41
Hydrogen	5.47
Oxygen, Nitrogen	9.30
Sulphur	2.47
Water	1.00
Ash	4.35
	100.00

The following is its gas yield in New York:—

Gas, cubic feet, per ton	9,500
Candle power	13.17
Coke, 40 bushels of 38 lbs.	1,520
Gas purified by one bushel of lime	2,380

Lingan Main Seam.—This coal is very similar in appearance to that worked at the Reserve Colliery, but is more compact, and with a considerable amount of visible pyrites.

Section.	Ft.	in.
Coal, good	1	2
„ pyritous		2
„ good		11
Fire-clay		1
Coal, good	5	8
	8	0

Composition	slow coking.	fast coking.
Moisture	.75	.75
Volatile combustible matter	34.61	37.26
Fixed carbon	61.39	58.74
Ash	3.25	3.25
	100.00	100.00
Theoretical evaporative power	8.42	8.00
Sulphur	1.356	—
Specific gravity	1.298	

Coke vesicular and hard; ashes light grey, with tinge of red.

This coal has been used chiefly for gas-making; it is also a fair house coal.

The following are its gas values in New York:—

Gas, cubic feet, per ton	9,520
Candle power	12.92
Coke (lbs.)	1,450
Gas purified by one bushel of lime	2,200

Its slack is well adapted for blacksmiths' work, and is said to have been successfully tried for coke.

The results of an analysis of the seams described above is shown in the subjoined table. [see in original text]

[225]

The following is the lowest of the seams worked to any extent. The coals from it have not been long enough in the market to acquire any decided status for gas, steam, etc.

South Head Steam (Cow Bay).—Coal compact and not very bright; laminated, with a splinty appearance, and a few very thin layers of soft shaley coal. No mineral charcoal on the deposition planes, which are quite smooth. A little visible pyrites.

Section.	Ft.	in.
Roof, strong shale	—	
Coal, good	1	8
Clay parting	0	1
Coal, good (two partings)	1	8
Coal, good	2	6
Coal, canneloid	1	10
	7	9

Floor, hard arenaceous fire clay.

Composition	slow coking.	fast coking.
Moisture	1.767	1.767
Volatile combustible matter	28.000	28.833
Fixed carbon	62.263	61.430
Ash	7.970	7.970
	100.000	100.000
Theoretical evaporative power	8.53	8.42
Injurious sulphur	2.641	—
Specific gravity, average	1.382	—

Coke firm and compact; ash bulky, light reddish grey.

The appearance and composition of this coal is in favour of its being a good steam coal, and it has never been known to heat in cargo. It makes a marketable coke, and is said to have yielded 8,000 cubic feet of sixteen candle gas per ton from sample cargo.

Ross Seam (Emery Colliery).—Coal compact, laminated and lustrous, with much mineral charcoal on the deposition planes. The primary and secondary planes cut each other at right angles, giving the broken coal a cubical form. The partings have no films of calc-spar, and the coal shows no pyrites.

Section.	Ft.	in.
Roof, hard grey sandstone	—	
Coal, good	1	2
Hard blue shale		0½
Coal, good	1	10
Hard, blue shale		0½
Coal, good	1	5
Floor, fire clay.	4	6

[226]

Composition	Slow Coking.	Fast Coking.
Moisture	.65	.65
Volatile combustible matter	32.21	34.80
Fixed carbon	63.49	60.90
Ash	3.65	3.65
	10O.00	100.00
Theoretical evaporative power	8.70	8.25
Injurious sulphur	2.41	—
Specific gravity	1.287	—

Coke hard and vesicular; ash purplish red.

The composition of the ash of this coal is as follows:—

Iron peroxide	38.764
Alumina	1.336
Silicious residue	50.673
Lime	4.200
Manganese	trace.
Magnesia	1.015
Sulphuric acid	4.030
Phosphoric acid	.012
Chlorine	decided trace.
Alkalies	decided trace
	100.030

On examining the ashes taken for the above analysis, two small rounded pear-shaped silicious pebbles were found, from one-fifth to one-third of an inch in diameter. When a quantity of the coal was roughly pulverised several more were found which appeared to be associated with a layer of the coal which presented a dull and shaley appearance.

The ultimate composition of this seam as worked at the Schooner Pond Colliery is—

Carbon	78.10
Hydrogen	5.48
Oxygen and Nitrogen	7.81
Sulphur	2.49
Water	2.67
Ash	3.45
	100.00

Collins Seam (Little Bras D'or).—This is a bright, tolerably compact coal, very similar to the Sydney seam in appearance, but has numerous very fine laminæ of slate.

Section.	Ft.	in.
Coal, top	2	6

„ good	2	4
	4	10

[227]

Composition.	slow coking.	fast coking.
Moisture	1.983	1.983
Volatile combustible matter	26.156	30.896
Fixed carbon	66.482	61.742
Ash	5.379	5.379
	100.000	100.000
Theoretical evaporative power	9.10	8.43
Injurious sulphur	4.248	—
Specific gravity	1.311	—

Coke dense and hard; ash purplish red.

The proprietors claim that this coal is equal to any found in the island for gas and steam purposes, but the writer is in possession of no positive information as to its qualities.

The foregoing analyses show that, theoretically speaking, there is a great uniformity in the composition of the coal seams of this district, and this is borne out in practice, the chief differences being in the yield of gas and their coking values. As far as can be ascertained, they are all about on a par as steam coals, and all yield a fair domestic fuel. It is to be regretted that with the exception of the Sydney main seam no systematic trials have ever been made of their evaporative powers.

At Port Hood, on the western shore of the island, where several seams are exposed, a small colliery has been recently opened on one of them, which, it is said, has a thickness of six feet.

Coal tolerably compact, lustre moderate; very much pyrites in bands, and small nodules; a little mineral charcoal, but no calc-spar; primary planes at right angles to bedding; secondary almost entirely wanting, giving the coal a smooth fracture one way, and an uneven one across.

Composition	slow coking.	fast coking.
Moisture	2.535	2.535
Volatile combustible matter	29.815	31.652
Fixed carbon	61.923	60.086
Ash	5.727	5.727

	100.000	100.000
Theoretical evaporative power	8.49	8.23
Sulphur	5.54	—
Specific gravity	1.277	—

Coke pulverulent; ash light red.

The writer is not aware that the coal possesses any special quality recommending it for the market, and the amount of sulphur present will prove a serious drawback.

[228]

At Broad Cove and Mabon there is an interesting exposure of the productive coal measures. The coals, although found in the regular or true coal-bearing strata, seem—from the large amount of moisture, and from their colouring action on a solution of potassium hydrate—to approach in character brown coals of a later age.

The following analysis is of a crop sample from one of the seams at Broad Cove, 5 feet 3 inches thick.

Coal tolerably compact, of a lustrous black colour, and laminated; primary and secondary planes irregular; with a little visible pyrites. When boiled in a solution of potassium hydrate it gives a brownish yellow colour. Powder blackish brown.

Composition.	slow coking.	fast coking.
Moisture	7.24	7.24
Volatile combustible matter	25.75	32.43
Fixed carbon	56.86	50.18
Ash	10.15	10.15
	100.00	100.00
Theoretical evaporative power	7.61	6.87
Sulphur	1.415	—
Specific gravity	1.290	—

Coke partly coherent; ash reddish brown.

The Report of the Geological Survey of Canada, dated May, 1873, gives analyses of several of the Broad Cove seams, from which it appears that they are fairly represented in the above analysis, except in the amount of ash, which is larger than that given in the report. In one of the seams layers of zinc blende were found, the first known instance of its occurrence in Nova Scotia coals.

As yet no openings of any amount have been made in these seams, and their practical values cannot yet be given.

The percentages of moisture are, however, a serious drawback. Taking the case of the coal analysed above, there would be no less than 162 lbs. of water in every ton. The results of this are that a large amount of carbon is diverted from its legitimate action on the water in the boiler to the task of evaporating the water contained in itself, and the weight of the fuel is increased in proportion to the percentage of efficient carbon.

THE PICTOU COAL-FIELD.

The Report of the Geological Survey of Canada for 1868, contains so full and careful a set of analyses of the Pictou coals, by the late Mr. Hartley, that the writer would not have added the following results, were it not that nearly ten years have elapsed since the report was published,

[229]

during which time fresh winnings have been opened out, and the faces of the old mines greatly advanced.

Pictou Main Seam.—As worked at the Foord pit of the Halifax Company.

Coal compact, bright, and somewhat irregularly laminated with uneven to sub-chonchoidal fracture; much mineral charcoal on deposition planes; primary planes well defined, with films of calc-spar; secondary planes generally not well defined, and inclined to primary and deposition planes at angles of 70 and 80 degrees; no visible pyrites.

No recent measurement of this seam being available, the section passed through during the sinking of the pit is given.

Section.	Ft.	in.
Coal, coarse	1	4
„ good	4	4
Ironstone band		2
„ good	20	6
„ coarse	8	4
	34	8

This section changes slightly in various parts of the workings. The thick coal has two partings of ironstone balls, from two to ten inches thick, to be noticed farther on. A carefully averaged sample gave:—

Composition.	slow coking.	fast coking.
Moisture	1.05	1.05
Volatile combustible matter	26.19	27.42
Fixed carbon	63.41	62.18
Ash	9.35	9.35
	100.00	100.00
Theoretical evaporative power	8.68	8.49
Injurious sulphur	1.480	—
Specific gravity	1.310	—

Coke hard and compact; ash light grey.

The coal from this seam has for many years been extensively used for gas-making at Boston and Halifax. The following is a recent report on gas values.

Gas, cubic feet, per ton	7,280
Candle power	15.00
Coke, lbs. (fair quality)	1,325

Coal, very free from sulphur and not liable to heat.

The coke from this seam has now been practically tested at the Londonderry Ironworks with satisfactory results. (See page 9 of my paper on Nova Scotia Iron Ores.)

Analyses of Coke—Main Seam.	I.*	II.
	1876.	1877.
Moisture	1.46	.55
Carbon	82.42	83.61
Sulphur	.62	.32

Phosphoric acid	—	.02
Ash	15.50	15.50
	100.00	100.00

The following analyses are of ironstone balls found in the main seam, and of a black band ironstone immediately overlying the deep seam, and occurring in bands having a thickness, it is stated, of two to five inches:—[see Table of analyses in original text]

Clay Ironstone.—Black and brown colour, with bands of dirty yellow; streak, yellowish brown; fracture, uneven; veins and masses of white calc-spar with iron; very little visible pyrites; exterior coating of one-fourth of an inch of bituminous shining coal, with films of white calc-spar.

Black Band.—Colour black, compact and laminated, the deposition planes being bright and smooth; slightly oolitic on fractured surfaces; streak,, liver brown.

Deep Seam (Halifax Co.)—The coal from this seam resembles that from the main seam, but is more compact and of a rather coarser appearance.

* Analysis made in London.

Section.	Ft.	In.
Coal, coarse		2
„ good	3	7
Ironstone	1	1½
Coal, very good	3	5½
„ shaley (holing)		8½
„ good	3	9
„ coarse		11½
„ good	3	4
„ coarse	5	10
	22	11

In the dip workings, to which operations are now confined, the bottom bench is of good quality.

Composition	slow coking.	fast coking.

Moisture	.75	.75
Volatile combustible matter	20.34	25.82
Fixed carbon	68.50	63.02
Ash	10.41	10.41
	100.00	100.00
Theoretical evaporative power	9.39	8.64
Sulphur	.945	—
Specific gravity	1.330	—

Coke pulverulent; ash fawn-coloured.

This coal has been found well adapted for steam and iron working, and when mixed with the coal from the Foord pit makes an admirable steam coal.

Acadia Seam.—This seam is considered by many to be the westward extension of the main seam, the continuity being broken by heavy faults.

The following section is from the Air pit at the Intercolonial Company's Colliery:—

Section.	Ft.	In.
Coal, good	5	9
Soft fireclay (holing)		3
Coal, good	5	6
„ hard grey		6
„ good	4	6
„ inferior	2	1
	18	7

In working 2 feet 6 inches of the top coal is left as a roof.

Coal compact, laminated and lustrous; deposition planes show much mineral charcoal; cleavage regular in two directions, giving the coal a cubical fracture; primary planes hold calc-spar and a few films of pyrites.

Composition.	slow coking.	fast coking.
Moisture	1.25	1.25
Volatile combustible matter	29.46	31.87
Fixed carbon	60.19	57.78
Ash	9.10	9.10
	100.00	100.00
Theoretical evaporative power	8.24	7.92
Sulphur	1.625	-
Specific gravity	1.330	—

Coke hard and compact; ash grey.

This coal has been largely exported to Montreal, and used for steam and domestic purposes, and also to some extent for gas. It is stated that the coal makes a marketable coke, but the writer has not seen any samples of it.

McBean Seam (Vale Colliery.)—This seam measures from seven to fourteen feet in thickness. At the point where the samples were selected it was 7 feet 2 inches thick, and perfectly free from any partings.

The coal is of a lustrous black colour, with a faint greyish tinge; laminae, fine and wavy; the primary and secondary planes intersect each other and the deposition planes a little obliquely, giving the broken coal a somewhat rhomboidal form; the primary planes have numerous films of white calc-spar with a trace of carbonate of iron; in one place films of selenite one-fourth inch thick occur; no visible pyrites; the whole of the coal is very compact in texture and uniform in appearance.

Composition	slow coking.	fast coking.
Moisture	.86	.86
Volatile combustible matter	22.95	25.87
Fixed carbon	62.95	60.03
Ash	13.24	13.24
	100.00	100.00
Theoretical evaporative power	8.90	8.23
Injurious sulphur	.85	—
Specific gravity	1.379	—

This coal is well adapted for steam and domestic purposes, as it is entirely without clinker, the bars of the colliery furnaces being practically unaltered after four years firing. It has not been used for gas or coke-making as it is a free burning coal.

There are several other seams in the Eastern basin of the Pictou Coal-field which belong to an upper group of seams, which, although not yet opened, promise to be of superior quality for steam and metallurgical purposes.

[233]

The following table gives the composition of the ashes of several of the Pictou seams:—[see in original text]

PRACTICAL TRIALS OF THE PICTOU COALS.

Two samples of coal from Pictou were tested at the American Navy trials in 1848. The coals must have been from the Albion Mines, working the main and deep seams, there being no others then opened, but it is not stated which seam they represented.

The results are from Mr. Walter Johnson's "Coal Trade of British America," page 134:—[see in original text]

A trial of the Acadia Company's coal on one of the Government locomotives, made under the direction of Sir W. Logan, gave 7.24 lbs. of water evaporated from 212 degrees by each pound of coal. A similar trial of this seam as worked by the Intercolonial Coal Company, made under the same direction, gave 7.69 lbs.

From the foregoing analyses it will be seen that the coals from the Pictou district differ from those in Cape Breton in being less bituminous, with a larger percentage of ash, and very much less sulphur. The Pictou coals kindle readily, burn with a moderately long flame, and give a not very dense smoke, and, in general terms, may all be considered suitable for steam and domestic purposes, and some of them adapted for coke-making.

THE SPRINGHILL COAL-FIELD.

Only one seam has yet been opened in this district, known as the "Black Seam of the Springhill Mining Co." Through the kindness of William Hall, Esq., the manager of their colliery, a complete sample

[234]

column of the seam was procured, from which the following set of analyses were made, forming an unusually full account of this very fine seam. The column was afterwards presented to the museum of the Geological Survey.

Section.	Ft.	in.
Top coal, a little coarse	1	7
Coal, good	1	2½
Fire-clay, parting		0½
Coal, good		8
„ „	1	6
Fire-clay, parting		6
Coal, a little coarse		9
„ good		11
Fire-clay, parting		1
Coal, good	2	2
„ „ with 1 inch soft coal		3
„ coarse		8½
	10	4½

Band, No. 1.—Bright compact coal of a deep black colour, with a few very thin bands of shaley coal, holding a little pyrites; a good deal of mineral charcoal, and very little calc-spar.

Band, No. 2.—Very similar to No. 1, with half-inch band of splint coal; in both these bands the primary and secondary planes are at right angles to the deposition planes, and inclined to each other at an angle of 70 degrees.

Band, No. 3.—Beautifully bright tender coal, very little visible pyrites; fracture hackly and uneven.

Band, No. 4.—- Coal bright, with uniform pitchy lustre, little mineral charcoal; lower half of band compact, top rather friable; fracture irregular; a few films of pyrites in the lower part; top has both calc-spar and pyrites.

Band, No. 5.—Tolerably bright, with a good deal of mineral charcoal and pyrites; primary planes inclined to deposition planes at an angle of 65 degrees; secondary planes inclined to primary at angles of 65 to 70 degrees, and at right angles to deposition planes.

Band, No. 6.—Similar to last band, and with same system of cleavage, but brighter, and with several small layers of shaley coal.

Band, No. 7.—Uniform well-compacted coal, with moderate lustre, and very slightly laminated; a few thin layers of splint coal; little mineral charcoal; primary planes inclined to deposition at angles of 60 to 65 degrees; secondary similarly inclined to deposition, and nearly at right angles to primary planes ; a few very thin films of pyrites on both planes.

[235]

Band, No. 8.-—Coal bright and rich, with much mineral charcoal; one inch band of soft charcoal and dirt in the centre, with thin threads of shale and pyrites; the rest of the band contains no pyrites.

Band, No. 9.—Coal a little coarse, with dull lustre; much pyrites with thin layers of pyritous shale efflorescing on exposure; cleavage irregular.

[see in original text Table of composition of Black Seam – bands 1 to 9]

Coke bright and tolerably compact; ash of average sample, grey with tinge of pink.

The following ultimate analysis of the coal is by Dr. Percy:—

Carbon	78.51
Hydrogen	5.19
Oxvaren Nitrogen	9.98
Sulphur	1.12
Ash	5.20
	100.00

One noticeable point in this seam is the irregular courses of the partings and the consequent heavy percentage of slack coal. The demand for this coal is so large that the colliery is unable to meet it. Its sales are confined to steam and domestic uses, for both of which it is admirably adapted, but, theoretically speaking, it should be a fair gas coal. It resembles in composition and appearance the Newcastle Hartley coals. It is stated that it has been practically tested for coke, but no positive information about the results is available.

NEW BRUNSWICK COAL

The productive coal-measures in this province extend over an area of no less than 1,900 square miles, but, unfortunately, there are only a few

[236]

thin seams known to exist in it, the thickest of which measures 22 inches. As the coal in many places lies quite horizontal and a few feet below the surface, it is won by stripping. The coal is of the fat bituminous coking variety, of excellent quality, and finds a ready market in the province.

At Lepieaux, twenty-five miles west of St. John, a bed of anthracite has been recently discovered in measures which belong, presumably, to the Devonian age. The coal has a very promising appearance, and finds a good market in St. John. Should it prove not to be merely a metamorphosed carbonaceous shale, with a varying percentage of ash but a persistent workable bed of coal, it will prove very valuable, as large quantities of anthracite are imported from the United States for heating houses and foundry purposes.

THE COALS OF THE NORTH-WEST TERRITORY AND BRITISH COLUMBIA.

An immense space, both geological and geographical, has to be passed over before coal is again met with, but from longitude 100 degrees to 117 degrees west, and from the International Boundary parallel to the 60 degrees of latitude, the officers of the Geological Survey have everywhere found lignite, and in the following sketch their reports have been largely used.

Along the International Boundary Line, and in the Qu'appelle River Valley, the lignites appear to be of Tertiary age. At the Dirt Hills Mr. R. Bell noticed, in one short section, the outcrops of four seams measuring six, four, three, and five feet respectively.

Some of the beds are made up of the carbonised trunks and branches of trees (mostly of coniferous species) and comminuted plant remains, without any visible mixture of other matter as sand or clay. In some beds there is much earthy impurity, and these show the forms of the plants much more clearly. Dr. Dawson remarks as follows, on one of the Dirt Hill seams:—"The material has the aspect of a compressed mass of roots, branches, and other vegetable fragments, with a little mineral charcoal and occasional pieces of yellow resin. The roots and branches are flattened in the state of lignite and mixed with vegetable debris as if accumulated in a swamp. The mineral charcoal shows a structure resembling that of cypress, sequoia, and thuja. Taken in connection with other collections it would appear that in the period of the Tertiary lignites the plains east of the Rocky Mountains bore dense forests of coniferous trees, some of them of types now found on the west coast, and enjoyed a more humid and equable climate than at present."

[237]

Analysis of coal from Dirt Hills, by Mr. C. Hoffmann. Coal rather friable; splits in laminae; colour almost black; fracture sub-conchoidal, and having a resinous lustre; streak almost black. The specimen was soiled with clay.

	slow coking.	fast coking.
Moisture	17.53	17.53
Volatile combustible matter	34.61	35.47
Fixed carbon	40.24	39.38
Ash	7.62	7.62
	100.00	100.00

Coke pulverulent; ash pale brownish grey.

"None of these lignites are as good as the brown coals from the Jaskatchewan, but resemble more closely those collected from the Jouris Valley by Mr. G. M. Dawson. On account of their rapid disintegration they should be used as soon as possible after being mixed."

Mr. Selwyn, Director of the Survey, speaking of his explorations in the North Jaskatchewan, says:—"There can be no doubt that in the region west of Edmonton, bounded on the north by the Arthabasca River, and on the south by the Red Deer River, there exists a vast coal-field, covering an area of not less than 25,000 square miles; and beneath a large portion of this area we may expect to find workable seams of coal, at depths seldom exceeding 300 feet, and often very favourably situated for working by levels from the surface." And he considers the lignites cropping for two hundred miles along the banks of the North Jaskatchewan as possibly of the Cretaceous age. The lignites form beds from six inches to twenty feet in thickness; some are quite compact and pure, others again are rendered valueless by partings of sand and clay. No work has yet been done to prove the regularity of the seams, a point which is so important in the development of the recent coals.

In this connection a few words on the coals worked in Colorado, Wyoming, and Utah, in the southern continuation of that vast and widespread coal-field extending "from the shores of the Arctic Ocean for thousands of miles along the Rocky Mountains" may not be out of place.

The largest of these coal-beds is in Bear River, Utah, and is 27 feet thick. These beds are remarkably free from impurities, there being frequently 10 feet of clean coal, of brilliant lustre, perfectly free from visible foreign matter. Iron pyrites is frequently present in thin films, but seldom to an injurious amount. The coals with few exceptions will not make a merchantable coke, and are liable to rapid disintegration on exposure to rain and sun. As shown by their analyses they hold

[238]

notable percentages of water, and hence are not suited to blacksmiths' work and furnaces. The coals answer well for locomotives and domestic use, kindling readily, and burning with a yellow flame and little smoke. The wonderful uniformity and persistence of these coals over so vast a region, and their superiority over the foreign varieties, known by the same name, would entitle them to a distinctive appellation. The containing measures and the seams show plainly their deposition on the shores of freshwater basins; consequently the seams are found of very irregular thickness, frequently in a few yards varying from a few inches to fifteen feet, and require the most enlightened systems of mining.

Composition of Lignites from the North Jaskatchewan:—

	slow coking.	fast coking.
Moisture	7.82	7.82
Volatile combustible matter	31.35	38.00
Fixed carbon	54.97	48.25

Ash (red)	5.86	5.86
	100.00	99.93

Coal bright black; fracture angular, compact; gives dark brown colour to solution of potassium hydrate.

Average of six samples from various seams on the same river, by slow coking:—

Moisture	10.34
Volatile combustible matter	29.90
Fixed carbon	53.27
Ash	6.49
	100.00

Passing to the province of British Columbia, a very abnormal development of coal-bearing measures is found.

The coal-fields of this district have been touched on first, by Mr. Bauerman, of the International Boundary Commission, and Dr. Hector;* also by Dr. Forbes and Messrs. Palmer, Bigbie, and Pemberton. Dr. Robert Brown also published a valuable paper on the Vancouver Island Coal Fields.†

On the main land there are beds of lignite at Quesnel Mouth, and Chilcotin, and the mouth of the Fraser River, in strata, probably of the Tertiary age. No detailed accounts of the extent or value of the beds has yet been published. There are many other places where

* Vide Proceedings London Geological Society.

† Vide Proceedings Edinburgh Geological Society. 1868-9.

coal is reported to be found, but practically the field is yet unexplored and unoccupied.

Passing to the eastern shore of Vancouver's Island, an extensive and valuable development of coal measures is found.

There are two chief districts—that of Comox, forty miles long and thirteen broad; and that of Naniano, sixteen miles long and six wide. There has, however, really been so little done to develop the extent of the coal-fields that the above estimates of Mr. Richardson are purposely made on the small side.

The following short section is from the area of the Union Coal Mining Company, near Comox Harbour.

	Ft.	In.

Drab and grey sandstones	45	0
Coal, good	4	6
Shales and sandstones	15	0
Coal, good	5	4
Grey sandstones	10	0
Coal, good	6	0
Grey and drab sandstones	3	10
Coal, good	10	0
	99	10

The gradual diminution of the thickness of the sandstones, and the corresponding increase of the coal beds in the above section is worthy of notice. There are many other seams exposed, but their relative positions are unknown.

Similar seams are met in the Naniano coal-field, and are worked to some extent for local use and exportation to the United States. The chief trouble met in working the seams of both districts is that they thin out, become unproductive, and form isolated masses, possibly owing to a drift origin. These seams are also met with at Fort Rupert on Queen Charlotte Sound, Quatsino Sound, and Koskeemo on the western shore.

American and Canadian paleontologists agree in referring these coal measures to the Chico or Upper Cretaceous group, or to the horizon nearly of the white chalk of the English series.*

The coals from these strata are not lignites, but true bituminous coals, frequently yielding a coke having a black powder, and scarcely colouring solutions of potassium hydrate.

* Geological Survey, Canada, 1872-3, p. 75. Geological Survey, California, Vol. II., preface, xiv.

[240]

Composition of Coal Union Mine, Comox, by Mr. C. Hoffmann. Geological Survey of Canada:—

	slow coking.	fast coking.
Moisture	1.70	1.70
Volatile combustible matter	27.17	32.36
Fixed carbon	68.27	63.08
Ash	2.86	2.86

	100.00	100.00

Coke compact and vesicular; ash light grey.

The following is the average composition of seven samples from the districts of Comox and Naniano:—

	slow coking.	fast coking.
Moisture	1.47	1.47
Volatile combustible matter	28.19	32.69
Fixed carbon	64.05	59.55
Ash	6.29	6.29
	100.00	100.00

Mr. R. Brown, in his paper on the North Pacific Coal-fields, gives eight ultimate analyses of Vancouver Island coals, of which the following is an average:—

Carbon	67.144
Hydrogen	5.530
Oxygen	10.623
Nitrogen	1.279
Sulphur	.843
Ash	14.642
	100.061

The same writer, speaking of this coal, says:—"The coal itself is light, tolerably compact, and not unlike some of the best varieties of English and Welsh coals in appearance. It is used by Her Majesty's ships, and all colonial and other steamers plying on the coast. It is highly valued as a domestic fuel in San Francisco, and gas of fair illuminating quality is manufactured from it in Victoria."

QUEEN CHARLOTTE ISLANDS.

The existence of coal in these islands has been known for a long time, and mines were opened at Congitz about twelve years ago. At this point the coal measures appear to occupy a strip of land on the shore twenty miles long and five broad. Coal seams have been found in other localities, but no work has yet been done to test their values. The coal seams vary in thickness from 2 feet 6 inches to 6 feet, but they appear to be subject

[241]

to the prevailing drawback of the modern coals of America, viz., a tendency to thin out or become replaced by carbonaceous shale.

The coal is all anthracite, and until recently was regarded as of Palaeozoic age. Mr. Richardson's discoveries, however, appear to have proved that it belongs to a horizon high up in the Jurassic, or low down in the Cretaceous.

Composition by fast coking of two samples from Skidgate:—

	i.	ii.
Moisture	1.60	1.89
Volatile combustible matter	5.02	4.77
Fixed carbon	83.09	85.77
Sulphur	1.53	.89
Ash	8.76	6.69
	100.00	100.01

The writer would have had much pleasure in extending his remarks on the coals of British Columbia and the North West Territory, but is afraid that he has already trespassed too much on the indulgence of his readers. The analyses, etc., of the Nova Scotian coals represent a good deal of work, but the writer will feel repaid if, through the valuable proceedings of the Institute, he is enabled to give any information about so important an item in the resources of England's nearest colony.

The Canadian Government are using every legitimate method of attracting desirable immigrants to the North West Territory, and in this connection, as well as that of the Pacific Railway, which is slowly advancing to the west, the existence of coal in such widespread deposits is of great importance.

In British Columbia there are indubitable signs of important deposits of iron, gold, and silver, so that her coal beds acquire a value for manufacturing and metallurgical purposes, in addition to their usefulness for marine and domestic fuels.

[242]

[blank page]

PROCEEDINGS.

GENERAL MEETING, SATURDAY, JUNE 1st, 1878, IN THE WOOD MEMORIAL HALL.

LINDSAY WOOD, Esq., President, in the Chair.

Mr. Lewin read the minutes of the previous meeting, and also the minutes of the Council meetings.

The following gentlemen were then elected:—

Ordinary Members—

Mr. John Henry Harden, Department of Geology and Mining, Towne Scientific School, University of Pennsylvania, Philadelphia, U.S.A.

Mr. Wm. Kellett, M.E., Wigan.

Mr. W. R. Ellis, M.E., F.G.S., Wigan.

Mr. Samuel Taylor Jones, Whitelea Colliery, Co. Durham.

Associates—

Mr. Richard A. Rylands, Bedford Colliery, Mold.

Mr. Ralph D. Cochrane, Hetton Colliery Offices, Fence Houses.

Mr. G. G. C. Gambier, M.E., South Hetton Colliery, Fence Houses.

Mr. E. G. Hughes, Solway View, Whitehaven.

Students—

Mr. Samuel Powell, Westminster Chambers, Wrexham.

Mr. Arthur Stanley Douglas, West Lodge, Crook, Darlington.

The following were nominated for election at the next meeting:—

Ordinary Members —

Mr. Robert Russell, M.E., Coltness Iron Works, Newmains, N.B.

Mr. J. S. Dixon, C. and M.E., Bent Colliery, Hamilton, N.B.

Associate—

Mr. Jos. Wm. Harrison, M.E. and Colliery Proprietor, Gildersome, near Leeds.

Students—

Mr. E. G. Kirkhouse, Medomsley, Newcastle-on-Tyne.

Mr. Alfred A. Atkinson, Assistant Manager, Chilton Moor, Fence Houses.

The balloting list for the annual election in August was read and agreed to.

The meeting then separated.

[244]

[blank page]

[245]

PROCEEDINGS.

GENERAL MEETING, TUESDAY, JUNE 4th, 1878, IN THE TOWN HALL, DOUAI, FRANCE.

LINDSAY WOOD, Esq., President, is the Chair.

On Tuesday, June 4th, about ninety of the members arrived by rail at Douai, at 3.35 in the afternoon. The station was tastefully decorated with flags, among which the Union Jack was conspicuous, and several French engineers were on the platform to give their visitors a hearty welcome. After dinner the members proceeded to the Hotel de Ville, at the doors of which building they were received by M. Vuillemin, Engineer and Director of the Mines of Aniche; M. De Quillacq, Director of the large Engine Works at Anzin; M. Dumont, General Engineer of the underground works at the Anzin Mines; M. Daburon, Engineer of the Lens Mines; M. Dombre, Engineer of the Aniche Mines; and a large number of the professional gentlemen of the district; and after mutual greetings the entire party entered one of the handsome rooms in the basement of the building, and inaugurated the first meeting the members of the Institute have ever held in a foreign land.

M. E. Vuillemin, Engineer and Director of the Mines at Aniche, then welcomed the English engineers to France in the following speech delivered in the French language, which was translated as follows by the Secretary:—

The Engineers of the Mines of the Departments of Le Nord and Le Pas de Calais have confided to me the agreeable task of giving you a hearty welcome to this district, and of telling you how much they feel flattered that you should have set apart some few days to view their works, and they also desire me to express to you their sentiments of brotherly esteem and respect. In fact, we are happy to receive you, and

[246]

to establish with you a useful, agreeable, and continued correspondence, and, if possible, to repay you the very excellent reception which a large number of us have received at your hands when they have visited your magnificent establishments in England.

Newcastle has the well merited reputation of having been the cradle of all the most important inventions relating to the extraction of coal, which have been to us as models and guides in the execution of our more modern erections.

Great Britain, possessing within herself enormous mineral resources, raises more coal than the whole of the rest of Europe, and, with that spirit of initiative invention which characterizes her people, they from the first applied machinery of the most ingenious nature and the best suited to the requirements of the trade; but we, less favourably situated with respect to the regularity and thickness of our seams, have been obliged to imitate them as far as possible, and to make the best of the difficult conditions under which we have had to work.

The discovery of coal in the North of France goes back to the year 1720, and those men who made the discovery gave proof of an energy of conception and a tenacious perseverance not only worthy of remark at that time, but which would excite admiration even if exhibited now. The problem was to find in France the prolongation of the Hainaut coal-field, which became then ceded to Austria, and which was hidden under a mass of recent formation of from 130 to 500 feet thick, full of water—and this with but very imperfect means of execution; but the task was successfully accomplished notwithstanding it was beset with difficulties of all kinds, and France is indebted to those hardy pioneers Desandrouin, Taffin, Traisnel, Mathieu, and others who were the veritable creators of immense sources of wealth, and whose names will pass down to posterity as true benefactors to their country.

However, until 1850 this coal-field was supposed not to extend further than Douai, and it was not until after this, that the presence of the coal measures in the Pas de Calais was determined by a series of researches, which rapidly and successfully gave to this latter department an amount of mineral wealth, equal if not superior to that which had been hitherto possessed only by Le Nord.

It can easily be understood that this vast field of mineral wealth, comprising an area of some 440 square miles, could not have been made available for the purposes of commerce, without the application of much perseverance, ingenuity and intelligence, together with a great expenditure of capital and a prolonged period of hard work. Indeed it was

[247]

necessary to overcome the difficulties of sinking pits through the prolific feeders of water in the chalk formation, to invent new means of sinking and tubbing, to improve the old tools, and to provide means for pumping enormous quantities of water.

When found, it is true the coal-bearing strata contained a large number of seams, but they were of but small thickness, and existed under circumstances that rendered them difficult to work by any but those who have been trained from boyhood to the exceptional circumstances of the district. At the present time there are in the mines of the North of France from 17 to 18 per cent. of lads between twelve and sixteen years of age who are serving their apprenticeship.

The distribution of the produce has also been very much limited by the want of proper means of transport, which has not kept pace with the requirements of the country, and which is still far from being so complete as in England—a country above all possessing an immense outlet by means of its maritime resources, enabling it to send coal cheaply to all parts of the habitable world.

Lastly, an immense capital has been required to win collieries in this neighbourhood, which will be understood when I state that an expenditure of between £120,000 and £160,000 has been found necessary to raise 100,000 tons of coal yearly.

These few words of explanation will enable you to appreciate the difficult conditions under which we have laboured, and the inferior position, in an economic point of view, in which we find ourselves when we compare our costs with those of your more favoured country; nevertheless, the production of Le Nord and Le Pas de Calais, although much below that of Northumberland and Durham, forms one-fifth part of the total production of coal in France, and the new winnings lately made will make it possible to double this quantity.

These results, gained under the circumstances which I have just described, are due to the intelligence and activity displayed by our engineers, to the perseverance of the administrators of our Companies, to the public, who have trusted us with enormous capital, and who have had the good sense and foresight to defer the full enjoyment of their success, preferring to lay by a large portion of their profits for the successful development of their property, and to the goodwill of the miners themselves, who have always shown themselves mindful of the sacrifices that have been made to ameliorate their condition and to extend to their children the blessings of a liberal education.

In conclusion, I must add that we have, to some extent, a pride in

showing what we have done to our friends, who have so long and so successfully directed similar works in their own country, for we see in them the persons best capable of appreciating our works and the difficulties which have attended their construction; and for this reason alone we would hail with pleasure their advent among us: but added to this, we have indeed a pleasure in seeing those who, working for the same end as ourselves, have rendered themselves so famous as engineers, and we trust that they will appreciate our feeling, and carry back to England some friendly recollection of their voyage, which we trust will be the means of consolidating sentiments of respect and cordiality between us, and tempting them more frequently to avail themselves of the facilities they may have of repeating their visit.

Mr. W. Cochrane—M. Vuillemin, allow me, in the first place, on behalf of the President and the members of our Institute, to thank you and your friends for the very cordial reception which you have given us this evening, in your town of Douai, and to express to you the very great pleasure we all feel in meeting you, our brother engineers of France and Belgium, here this evening. I can assure you we reciprocate those feelings of cordiality and friendship which M. Vuillemin has expressed, and we appreciate the praise he has been pleased to bestow on our professional efforts. We are well aware of the advantages we possess in the thickness and character of our coal seams, and that we have, by means of these advantages, been able to extend our workings more readily than you; and we know that the natural difficulties you have laboured under, have caused you to have recourse to systems and mechanical arrangements which, although not in use in our coal-fields, are every day becoming more and more necessary among us as our difficulties increase. Already have we had to abandon sinkings from excess of water, after expending large sums of money and years of anxious responsibility; but the adoption of a foreign system, that of M. Chaudron, has encouraged us to believe in ultimate success. I know not if M. Chaudron is French or Belgian.

M. Vuillemin—Great men are of all countries.

Mr. Cochrane—That is true; and if I enumerate the number of foreign inventions that we have adopted in England, it is only following the liberal remarks of M. Vuillemin, who has so kindly insisted that our models have served as guides to French construction; and it is with a view of proving that, as our difficulties increase, we may be obliged to adopt still more those special and ingenious discoveries of yours to enable us to overcome them. Notably, in two instances, have your inventions been

already of great use to us ; first, the process of M. Chaudron, which, as I have before said, is enabling us to continue sinkings through water bearing strata formerly abandoned; and secondly, the system of mechanical ventilation, the invention of M. Guibal. Fifteen years ago a furnace was almost the sole means we employed for the ventilation of our mines, and, although great efficiency was attained by this system, still much more was to be desired, and it was reserved to the process of mechanical ventilation to place at our disposal a more perfect means. Again, the increased cost of fuel has obliged us to copy from you new forms of winding and pumping engines; and I see here among you a gentleman, M. de Quillacq, who has largely contributed to the improvements we have adopted, and who supplied to me, from his Anzin works, two engines, which have for many years given me the utmost satisfaction. Our visits, therefore, to your district will prove, we are sure, of immense use to us, for we are not forgetful of the fact that the time is not far distant when we shall have to seek our coal at greater depths, and shall have to develop thinner seams after encountering ever-increasing difficulties. In conclusion, I thank you most heartily for your very kind and courteous reception, and for the very patient way in which you have listened to me whilst endeavouring to explain myself in your language.

The President said, the next business before the meeting was the reading of M. Laporte's paper—"A Geological Sketch of the Northern Coal-field of France." As every member had been furnished with a copy, it would not be necessary to occupy the time of the evening in reading it. He would, however, ask M. Laporte if he had any addition to make to his paper, more especially with regard to the places which the members were going to visit during the next few days.

M. Laporte said, he had nothing to add upon the subject of his paper; but he wished to thank the President for the very kind and encouraging words in which he spoke of him when the paper was read in Newcastle.

Mr. Cochrane asked M. Laporte if he would kindly point out the two lines of fault running east and west which he had spoken of as dividing the field into two parts.

M. Laporte—These faults were shown on the map printed in the Transactions, but were not shown in the diagram exhibited at the meeting. They were called the northern and southern Crans de Retour.

M. Vuillemin asked Professor Gosselet, of the Faculty of Science, of Lille, to make some remarks on a subject he had so completely studied.

Professor Gosselet—M. Laporte, in his paper, has explained to you the geology of this basin, with a perfect knowledge of its details, derived from an extended study of much that has been written on the subject, and he (M. G.) would be glad to add a few words in explanation of his views of the configuration of the country, and this explanation he would more particularly confine to the probable extent of the coal-bearing strata here and their connection with others in distant places. [Professor Gosselet made a sketch on the black-board to illustrate his views, and this has been reproduced in Plate XXVIII.]

Many theories as to the origin and extent of this northern coal-field have been hazarded, which possibly may be considered premature until a correct appreciation of its peculiarities and of the discoveries which are daily being made has been arrived at. It is only recently that any precise idea has been formed of the extent of this basin; indeed, twelve years ago, when a party of engineers visited the district, there was a very great want of information on the subject. It was thought then that the Great Fault (Grande Faille) I., Plate XXVIII., was the southern limit of the field, for, on the south of the Great Fault, the red sandstone appeared, which was considered a convincing proof that beyond this no coal would be found. Red sandstone is found from Auchy to Houdain; from thence, cropping out to the day, it follows a line which passes north of Lievin to Mericourt south of Douai, then it reappears close to Azincourt south of Douchy and Valenciennes, and at Crespin, where it crosses the frontier and extends into Belgium as far as Liege.

This line, the limits of which have been pointed out, was generally supposed to mark the limit beyond which no coal could be found; but for the last ten years the red beds have been passed, and coal has been found under the Devonian.

Where, then, will be its limit? That was a question he could not answer. Perhaps M. Vuillemin knew; but if he did, he had not told him (Mr. G.)

Every day fresh discoveries are made, and every day the limits of the coal-field have had to extend themselves before the skill and enterprise of modern engineers.

What is principally required to obtain a correct opinion on these matters is an accurate study of the Great Fault. The coal beds dip to the south; at the northern extremity the Great Fault rests on carboniferous limestone (Calcaire de Tournay); and on the south on red beds of the Devonian age. The seams to the north are regular, that is, they are all roof above and floor below; but on the south the seams are often

reversed and contorted. Then come the Devonian rocks, resting over the coal measures.

What is this Devonian? Is it Upper Devonian? He must confess he, as well as others, had for a long time thought that this was so, and that there had been a general reversal of the beds, and that the coal measures had been reversed with the coal they contained.

There were many difficulties in the way of this explication, and it was these difficulties that led him (M. G.) to infer, that a correct knowledge of the basin could not be obtained without studying the Devonian formation far into Belgium; and he had followed the Red Sandstone from Liege to the French frontier, during the whole of which distance it forms a zone 3,000 yards thick.

It was only after many years of study that he began somewhat to understand these red formations.

He divided them into three groups—the Gedinnien, the Middle, and the Upper, in which conglomerate or "Poudingue" is to be found. It is not the last, but the Gedinnien which is met with on the south of the Great Fault.

What he had shown was, that to the south of the Great Fault the strata are all rightly placed, that is they are not reversed; that the French Dinan basin has risen on to and covers that of Namur, and that in thus mounting, it has carried with it the lower deposits of the Dinan basin, has pushed them back, and has finally placed them over the coal beds, but in an irregular manner. Sometimes the Upper Devonian is above as at Douai, sometimes the Carboniferous Limestone as at Courrières, and sometimes the lower coal measures, as he had elsewhere remarked.

It is thus that but a short time ago a bore-hole near Denain revealed carboniferous limestone 160 yards below the surface—that marine lower carboniferous, of which the fauna is so well known through the excellent work of Roemer.

It is therefore possible that one might find above these coal measures traces of more ancient stratification pushed upon and transported by the convulsions of the soil which produced the Great Fault, and the great question is to know how far the coal stretches beneath the Devonian, and how far to go to find it. The dislocations which have disturbed the soil in the post palaeozoic age have sometimes been very considerable; and the coal measures are sometimes found underlying the carboniferous limestone ; in fact, the patch of carboniferous limestone may have been pushed so far as to abut against the northern limestone, and thus carboniferous beds might be found between two limestones.

[252]

This, he hoped and believed, would be the case, in fact lately they had found coal seams between two distinct carboniferous limestones.

The coal-field, the direction of which has just been pointed out, extends from Liege to the Boulonais, and is incontestably the prolongation of that of Westphalia, and under the Channel into England, where it forms the Bristol coal-field.

There was one question still that interested English engineers considerably; it was the trend of this coal, as to whether it runs under, or to the north of London. It has been stated that the Devonian strata have been found in the neighbourhood of London,* and if it be true, that this Devonian, with its characteristic fossils, has really been found there, there is no doubt that it belongs to the Namur coal-field, and is evidence that the continuation of that coal-field passed to the south of London.

It had been thought that this coal-field had been deflected in the Pas de Calais, where the carboniferous limestones have been found by a recent sinking at a depth of 154 yards, and that then they suddenly disappear; but he considered, on the contrary, that this was a Jurassic or Cretaceous limestone that had been found, and he thought that no reliance could be placed upon this boring, which has been so often alluded to when considering the out-crop of this field. It would be remarked without doubt that much that he had had the honour to submit to the members was theoretical, but he trusted they would consider his deductions were those which were most in conformity with the facts.

M. Vuillemin asked if there were not any French engineers who had been personally interested in this subject who could give some further information—M. Dumont, for example.

M. Dumont replied that he was not prepared to add anything to the remarks of M. Gosselet.

The members were then conducted by their French friends into a magnificent suite of rooms, where they were most handsomely entertained. The excellent band of the Municipality performed the English National Anthem and a select programme of music.

M. Dombre proposed "Success to the Coal Trade of England and France," which was responded to by Mr. Bunning; and the members separated highly gratified with the cordial reception that had been given them and with the profuse hospitality of their hosts.

* In the recent boring at Meux's brewery.

[253]

FIRST DAY'S EXCURSION, WEDNESDAY, 5th JUNE, 1878.

PROGRAMME OF VISITS.

The Gayant Coke Ovens and Pit.

The Bernicourt Pits, in the concession of Aniche.

The Escarpelle Pits, Nos. 4 and 5, in the Escarpelle concession.

The Patent Fuel Manufactory at Somain, the property of Camille and Albert Dehaynin & Co.

The Renaissance Pit, belonging to the Aniche concession.

The Steel and Iron Works at Denain.

THE ANICHE COMPANY.

The Aniche Company was established on the 11th November, 1773, by the Marquis de Traisnel.

The area of royalty granted to this Company is very large, as it includes over twenty-nine thousand acres. The concession extends ten miles in length, from Somain to Douai, and a little more than five miles in width from north to south.

The coals in the Aniche measures are covered with more recently-formed strata, Tertiary and Cretaceous, the basis of the latter being a bed of clay which is impervious to water. The thickness of these covering strata varies from 130 to 180 yards. The amount of water they contain makes it a very difficult matter to sink a pit, as from 1,500 to 1,800 gallons per minute have been frequently encountered. Wood or cast-iron tubbing is usually employed. Seven pits are actually at work, four are temporarily idle or used for ventilation, and two are in course of sinking.

As regards the varieties of coal contained in the large Aniche coalfield, the whole series, from anthracite to the richest in volatile matter, may be found therein. In the northern part there are many seams of close-burning anthracitic coal still untouched. In the middle part there is a group of sixteen seams of semi-bituminous coal, giving from 12 to 18 per cent. of volatile matter, and chiefly used for steam purposes. These are

[254]

being worked by the Pits St. Louis, Fénélon, la Renaissance, Archevèque, Traisnel, and St. Marie. The total thickness of the group is 28 feet of pure coal. Another group of thirty-two seams is being worked by the Pits Gayant, Bernicourt, Notre-Dame, Dechy, and St. René. These seams are more recent than the latter ones, and give a bituminous coal containing from 18 to 28 per cent. of volatile matter very good for coke and glass manufacturing. The total thickness of the group is 65 feet.

Southward, seams of long-flaming coal will be soon worked at the Roucourt pit, which is in course of sinking.

The pits are well finished, and from 10 feet to 13 feet 6 inches in diameter. Flat hemp ropes are exclusively employed for winding purposes. The workmen go down and come up in safety cages. No pumping engines are to be seen, the water being wound up at night in wooden boxes. With respect to the ventilation, furnaces and fans (Guibal's or Lemielle's) are used. Inflammable gas has never been seen in the Aniche Collieries.

The production of coal by the Aniche Company is continually and rapidly increasing. The output has been for the last few years:—

In 1850	107,583 tons
In 1855	219,950 „
In 1860	289,473 „
In 1865	438,532 „
In 1870	447,679 „
In 1875	613,760 „

There are in all 3,479 workmen at present attached to the mines, of whom 2,843 are employed below ground, and 502 at the surface, while 134 are on the sick list. The mean wage of hewers is 3s. 8d. per day of eight hours. The colliers receive coal, medical attendance, and instruction for their children gratis, and pay only a nominal rent for their cottages.

The Aniche Company owns to a total expenditure of £832,000. The partners have had to pay only £92,000, all the rest being covered by profit. 3,112 shares are issued.

THE GAYANT COKE OVENS AND PIT.

The small coal is purified by means of four washing apparatus. Three of these are on the Berard and the other is on the Coppée system.

There are 56 Coppée ovens, giving 112 tons a-day; duration of process, twenty-four hours (the waste heat from these being applied to the boilers); and 112 coke ovens on the Belgian system, giving 130 tons a-day, but the process requires forty-eight hours. A full description of the

Coppée Oven (from which the Belgian differs but slightly) is given in Mr. Emerson Bainbridge's paper, Volume XXII., p. 81. When large coal is used it is crushed by rollers of the usual type.

THE BERNICOURT PIT.

This pit has been sunk by the Kind-Chaudron system. Depth of cast-iron tubing, 100 yards; total depth of the pit, 355 yards; diameter, 11 feet. The engine is horizontal, with two cylinders 30 inches diameter, 5½ feet stroke, and variable expansion on the Sulzer-Martin patent. The ropes are of flat hemp, 9½ inches wide at one end, 6½ inches at the other, and 1⅛ in. thick; and the weight is, on an average, 15 lbs. per yard. The pit-head frame is made of wood, and is 53 feet high. The weight of each cage is 1 ton 4 cwts.; and the weight of each wooden tub, 4 cwts.; capacity, 8 cwts. of coal.

THE ESCARPELLE PITS.

The No. 5 pit is being put down by the Kind-Chaudron process. The diameter of the inside of the tubbing is 14 feet, and the depth of the shaft, 184 fathoms, 64 fathoms of which is lined with cast-iron tubbing. Several members were allowed to descend the shaft and examine the tubbing.

No. 4 pit was next visited. The shaft is 385 yards in depth. There are thirty-five seams, of which nine are being worked. The inclination of the seams averages about 30 degrees, but in some cases it is as much as 60 degrees. The system of working differs from that at Aniche, and is known as *tailles chassantes* (see Mr. T. Lindsay Galloway's paper, Vol. XXVII., p. 174), which is pursued under every amount of inclination. There are two advantages in this system; in the first place, the coal is not liable to slide down and become mixed with the rubbish, as it is under the rise system; in the next place, supervision is much more easy, consequently, the discipline is better, and better coal is produced, the coal being larger in size with less rubbish. The output is 600 tons a-day of ten hours. The percentage of small is about 60, the bars of the screens being four-fifths of an inch apart. The quantity of stone is 8 per cent. The quality of the coal is bituminous, and there is about 25 per cent. of volatile matter. The small is used for coking and for glass manufactories, and the large for sugar refineries and other industries, and also for household purposes. The workmen descend by ladders, but are drawn by safety cages, which are substituted for the ordinary cages at the end of each day's work, and the water is drawn in tanks during the night.

PATENT FUEL WORKS AT SOMAIN.

This newly established plant is remarkable for its simplicity. It can produce 220 tons of fuel in 24 hours, with 50 workmen, under the control of a clerk, a weighman, and a fireman. All the workmen live in houses belonging to the Company, for which they each pay 3s. 3d. a month. Two per cent. of their wages is kept off for sickness, medical attendance, etc., and the employers engage that, if the funds fail, the sick allowance shall never be less than half the usual pay.

The factory is situated about three-quarters of a mile from the Somain Station, on the line of the Paris, Douai, Valenciennes and Brussels Railway, and is on the Aniche concession, justly celebrated for the richness and purity of its coals, which contain about 13 or 14 per cent. of volatile matter, and give but little smoke when burned. The annual consumption of material is 70,000 tons of small Aniche coal, and 5,000 tons of English pitch. The machinery is driven by a 50 horse-power engine, and there are also two coal-washers, a Carr's disintegrator, two centrifugal drying machines and a press on the Bouriez system.

The coal, brought into the works in wagons, is emptied into a large funnel, from whence it is elevated by a Jacob's ladder to a rotating screening apparatus. The very fine coal is not washed, but only the larger size. The refuse is sold.

The washing apparatus is on the Berard system, of large size, with a case composed entirely of cast-iron. The coal after being washed is not heaped and left to dry by the ordinary slow process, but is taken direct to a rotatory drying apparatus on the Hanrez system. This is composed of a perforated cylinder, revolving at about 300 revolutions per minute, and a screw which nearly fills it travels at a speed of 305 revolutions per minute. This screw forces the coal which comes in at the top towards the surface of the cylinder, and also causes it to descend gradually to the bottom, and ultimately pushes it out. The washing takes two minutes and the drying one minute. The water which is thrown out by the centrifugal force of the machine is returned for fresh use, and the dried coal is emptied into a pit, where it is mixed with the small coal which has not been washed; the whole is then taken up by a Jacob's ladder to a large conical cistern where the two are mixed, the mixer revolving at about 250 turns per minute. The pitch properly broken up is now measured by a system of cylinders, the speed of which can be regulated at will. The material falls into a second pit, where another Jacob's ladder lifts it into a vertical wrought-iron cylinder, where it is mixed and heated; the heating being effected by the waste steam. The

mixture is then forced on to a turning platform and carried to four presses which are horizontal rectangular cylinders, with rams at one end. Their tops are half pressed down upon the lower part by a long lever and weight. The rams are actuated by two cranks driven from the main engine, and the product, which is introduced into the cylinder by a port on the top side, receives the friction produced by the pressure from the lever before mentioned. The friction is so regulated that the issuing product is of the right consistency for being formed into bricks. It is delivered in one continuous piece, and is taken off by hand in lengths indicated by each motion of the ram; and these lengths or bricks are taken forward by an endless band running alongside a series of railway wagons, into which they are laid by hand. The fuel is very hard, and has sometimes stood for six years in stock without becoming disintegrated, and it stows in a much smaller space than any other form of fuel. The present selling price of the fuel is 18 francs per ton, and the whole production is consumed in France.

THE RENAISSANCE PIT.

The pit-head frame is completely closed in, the pit being used both for winding and ventilation. The total depth of the shaft is 385 yards, and the diameter 18 feet. The fan is on the Lemielle system; height, 12 feet; diameter, 10 feet. The quantity of air circulating in the upcast shaft is about 22,000 cubic feet per minute. Plate XXIX. shows the general arrangement of this pit.

„

THE IRON AND STEEL WORKS AT DENAIN.

The blast furnaces, steel works, and forges at Denain and Anzin are owned by a Limited Liability Company, and consist of—

1.—The Bessemer Steel Works at Denain, built in 1873 and 1874 (see Plate XXX.)

2.—The Iron Works at Denain which were built in 1834, and are situated close to the steel works, the Denain and Lourches Railway, and the River Escaut. These works, with two blast furnaces making 100 tons a day, and thirty puddling furnaces, with the necessary steam hammers and mills, are making from 20,000 to 22,000 tons of rolled iron, boiler plates, etc., per annum.

These two sections were visited by the members under the guidance of M. Martelet, the managing director.

3.—The Iron Works at Anzin, near Valenciennes, which were started forty years ago, near to the Mons and Valenciennes Railway and the Escaut. They comprise two blast furnaces, making 100 tons a-day, thirty-six puddling furnaces, and the necessary plant for a yearly production of 25,000 tons of rolled iron plates, rails, and beams.

258]

The chief offices of the Company are at No. 56, Rue de Provence, Paris, and the resident manager is M. Chadeffaud.

No. 1.—The two blast furnaces at the Bessemer Steel Works, making 120 tons of steel in twenty-four hours, with a consumption of one ton of coke for each ton of iron, are completely enclosed by an iron plate casing. The hearth and boshes are cooled by cold water running continually down the outside of the casing, and by twelve water boxes passing through twelve openings in the casing at the height of the beginning of the boshes. These water boxes fill the place of fire lumps, and have their full length. They are intended to maintain the inside shape of the furnace.

The blast, at a pressure of eight inches of mercury, is heated to 1,100 or 1,300 degrees Fahr., by eight of Whitwell's hot blast stoves, and enters the furnaces through five tuyers of welded iron plates.

The dimensions of the furnaces are:—

	Ft.	In.
Diameter at bottom of hearth	5	8
„ at tuyers	6	7
„ at beginning of boshes	8	0
„ at largest part of boshes	17	2

„ at the top of furnace			11	2
Height of tuyers from bottom of hearth			2	11½
„ beginning of boshes	8	5		
„ largest part of boshes	23	2		
„ top of furnace	58	8		

The top is closed by the ordinary cup and cone, but about three feet above these is fastened a smaller cone, which spreads the charges equally into the cup. The four-wheeled barrows, holding about two tons, are carried on rails, and brought over the top of the small cone on which they pour their contents through their moveable bottoms. The furnace-lift is worked by two hydraulic cylinders, with pulleys and chains; the two cages slide between three high columns, which act also as supports for the furnace bridge. These columns are cylindrical, two feet in diameter, and are made of iron plates and angles.

The furnaces are tapped into a ladle mounted on a small four-wheeled wagon. When full, the ladle is carried over a weigh-bridge and lifted by a hydraulic lift up to the converters' level, and its charge is poured into the latter by means of a moveable spout.

The Bessemer hall contains two ten-ton converters, the casting pit with the ordinary casting crane, and two strong twenty-five-ton turning cranes for handling ingots and moulds, and also for changing the converter

[259]

bottoms. All the motions of these cranes are worked by hydraulic pistons, and are easily handled by a boy. When a bottom has to be changed the converter is turned upside down, and the whole of the bottom half of the converter is taken off by the crane and set on a special wagon. A newly re-lined half-converter is then brought forward on its wagon and mounted by the crane. The joint is generally made from the inside.

The refractory lining is built up with unburnt fire-bricks, the bottom only around the twelve tuyers is made of "Voiron" sand; each tuyer has eight holes of from ⅜ to ½ inch diameter. One of these bottoms will make an average of forty blows, but some of them have made up to sixty blows.

The metal is hot and bears generally from 10 to 15 per cent. scraps; it contains from 3 to 4 per cent. manganese, and can be converted into very mild steel without any addition of spiegel or ferro manganese.

In ordinary working for rail ingots the blow is stopped at the exact moment when the metal is of the required hardness, and no spiegel iron is added. At the present time from fourteen to sixteen blows are made every twenty-four hours, and the whole of the steel produced is rolled into rails. The ingot moulds are square with rounded corners, and have hinged bottoms. The ingots when still red are laid on wagons and immediately carried to the rolling mill. This latter consists of four sets of rollers—two three-roller roughing sets, and two finishing sets. The diameter of the rolls is 2 feet 1¾ inches. A strong horizontal engine coupled direct to the mill, is capable of driving three sets of rolls at the same time. The engine is 41¼ inches diameter, and 5 feet stroke, with condensation and Mayer's variable expansion gear; the fly-wheel is 26 feet 5 inches diameter, weighs forty tons, and makes from sixty to sixty-five revolutions per minute. Every set of rolls has its elevators worked by hydraulic cylinders.

The re-heating furnaces are worked with blast under the grates, and over them are the horizontal steam boilers. Each furnace takes fourteen ingots for rails 26 feet 6 inches long, and makes six charges in twelve hours. The average production of the mill is 160 tons of rails of 63 lbs. to the yard per twenty-four hours.

The rails are finished in a long shop, which contains one double-straightening press, four machines for trimming the ends, four double-drilling machines, one double-notching press, etc. All the blowing machinery and pumps stand in the same building, and were all made by the Creusot Company. The two blast furnace blowing engines are of the vertical "Seraing" pattern, improved by the "Creusot." The dimensions are: diameter of blast cylinders, 87 inches; diameter of steam cylinder,

[260]

35½ inches; stroke, 5 feet 7 inches; diameter of air-pump, 1 foot 9 inches; stroke, 2 feet 9 inches; average revolutions per minute, 18; steam pressure, 75 lbs.; vacuum in condenser, 27 inches mercury; blast pressure, 8 inches mercury. The introduction and escape of the steam is effected by brass double-beat valves; the steam is cut off at one-sixth of the stroke. The Bessemer blowing engine is a pair of coupled horizontal engines, also with double-beat valves worked by cams; the inlet cams have steps, and may be shifted by a screw to vary the expansion. The dimensions are: diameter of steam cylinder, 48 inches; diameter of blast cylinders, 60 inches; stroke, 6 feet; steam pressure, 75 lbs.; blast pressure, 56 inches mercury; vacuum in condenser (a separated condensing engine), 26½ inches mercury; steam cut off from two-tenths to four-tenths of the stroke; maximum revolutions, 28 per minute; horse-power—maximum, 1,000; diameter of fly wheel, 26 feet 6 inches; weight, 4-5 tons. The blast cylinders are water jacketed, and have India-rubber inlet and escape valves. All the packings of the blast pistons are made of small blocks of "lignum-vitae," breaking joints, pressed against the cylinder by small flat springs, and lubricated by plumbago. The fourteen steam boilers heated by coals are of a mixed type, half inside flue and half multitubular; the other ten, heated by the blast furnace gas, are plain cylindrical boilers, with one "bouilleur."

The Pernot Furnace Hall contains two steel melting furnaces of this new type. These furnaces are like the ordinary Siemens-Martin furnaces, with their gas producers and regenerators; but the bottom, instead of being made fast in the furnace is made to revolve, is mounted on a wagon, and can be pulled out of the furnace for re-lining. The casing of this bottom is a cylindrical iron tub, 11 feet 2 inches diameter, and 2 feet in height; the lining of silica bricks is 19¾ inches thick on the sides, and 8 inches on the bottom. The tub which rotates in a plane 7 degrees out of the horizontal, is carried by four conical rollers running between it and the top of the wagon, and is maintained by a central pivot. A small two-horse vertical steam engine, with two pairs of toothed conical wheels cause it to rotate at the rate of from three to four revolutions per minute.

The make of one of these stoves is four heats of 5½ tons = 22 tons in twenty-four hours. The bottom requires re-lining every twenty-five heats; but the roof, also made of silica bricks, stands up to three hundred heats without any repairs.

Charges are generally composed of one-fifth of pig iron and four-fifths of steel scraps. The pig iron and one half of the steel scraps are first charged cold, and when this is melted, the remainder of the scraps heated

[261]

in an ordinary re-heating furnace, is added hot. The average consumption of coal is from half a ton to a ton of ingots. The casting and handling of ingots is done by a ladle mounted on a wagon, and two fifteen-ton hydraulic cranes similar to those of the Bessemer pit. These furnaces are chiefly producing ingots for steel plates, which are rolled in the plate mills of the iron works.

Only those ores which are nearly free from phosphorus are used; and they are chiefly procured from Mokta-el-Hadid, Milianah, Camerata, Tafna, in Africa, and Bilbao in Spain. The Bilbao and Mokta ores are the most used.

The mean composition of the blast-furnace charges is—

Silica	0.0640
Alumina	0.0156
Lime	0.0246
Magnesia	traces
Iron	0.5205
Manganese	0.0174
Sulphur	0.0010
Phosphorus	0.00007

Mean yield = 55 per cent.

The flux used is the white chalk of the country containing 0.0002 phosphorus and no sulphur. The coke is supplied by the Aniche and Anzin Companies; it contains 10 to 12 per cent. ashes, and is of the following composition:—

Silica	0.0546

Alumina	0.0419
Lime	0.0035
Sulphur	0.0018
Phosphor	0.0004
Combustible matter	0.8978
	1.0000

The iron ores contain very little manganese, but the converter slag is very rich in it, and is very regularly charged into the blast furnaces. The iron produced contains 3 to 4 per cent. of manganese, 3½ carbon, and from 1 1½ to 2 of silicon. This large amount of manganese allows the converters to turn out extra mild steel without the addition of either spiegel or ferro manganese; it is true that it is necessary to make a trial of the metal before it is formed into the ingot, but that is a precaution which it is always well to take if it is desired to work the converter with the same regularity as the Martin furnace.

[262]

The steel contains—

Manganese from 0.0040 to 0.0060

Phosphorus 0.0005 — 0.0006; only traces of sulphur.

Silicon 0.0000— 0.0020, according to the way in which the steel has been blown, and variable amounts of carbon, according to the required hardness of the steel.

These qualities are classed by numbers from 4 to 8, according to the resistances they give to a blow after having been hardened when red hot in cold water.

No. 4. —Contains about 0.0075 of carbon; easily broken after being hardened; too hard for rails.

No. 4½.—0.0060 to 0.0065 of carbon; fragile after hardening; a strip ¾ x ⅜, not hardened, breaks before it has been set to an angle of 90 degrees by blows from a hammer.

No. 5. —0.0050 of carbon; mild after hardening; a strip ¾ x ⅜, not hardened, will bend, cold, to 90 degrees, without breaking.

No. 5½ —0.0035 to 0.0040; does not break easily after hardening; fracture with large grains; a strip ¾ x ⅜ does not break at 90 degrees.

No. 6. —0.0025 to 0.0030; difficult to break after hardening.

No. 6½ —A strip ¾ x ⅜ when hard bends a little before breaking.

No. 7. —A strip ¾ x ⅜ hardened, only breaks at 90 degrees.

No. 7½ —A strip ¾ x ⅜ hardened, does not break, but can be doubled.

No. 8. —Extra mild.

The steel of every blow is tested by a hardening test, by a chemical analysis, and by a weight falling on a test-piece about ¾ inch square; and for resistance and elongation on a test-piece 4 inches long and ⅝ inch in diameter.

The following table gives the mean result of a great number of tests for elongation and resistance:—
[see in original text]

During the visit to the steel works the members were most hospitably entertained by the Company, M. Martelet conducting them to an elegant luncheon set out in one of the workshops.

[263]

M. Martelet, in a few words, thanked the gentlemen present for the honour they had done the Company, and proposed the health of Mr. Lindsay Wood, the President, and the success of the Institute.

The President replied by thanking his host for his great kindness and hospitality, and proposing the success of the Denain Iron and Steel Works, and the health of the courteous manager, M. Martelet, who had shown them everything without reserve, and who had treated them with every kindness.

[264]

SECOND DAY'S EXCURSION, THURSDAY, JUNE 6th, 1878.

PROGRAMME OF VISITS.

The Chabaud Latour Pits.

The Thiers Pit.

The Engine Works of M. de Quillacq.

The Haveluy Pits and Coke Ovens.

The Renard Pits.

The Engine Works of MM. Cail et Compagnie.

This morning the members proceeded to visit the works of the Anzin Company, leaving Douai by special train at 7.25 a.m. They were received at Somain by M. de Marsilly, the Managing Director of the Anzin Company, and by M. de Quillacq, the Managing Director of the large and well-known Engine Works at Anzin.

They went first to the Chabaud Latour Mine, situated almost at the outcrop and close upon the Belgian frontier, when M. de Marsilly explained that during the whole of the time since the train had left Somain, the visitors had been travelling over the concession of this large Company. They had now arrived at the extreme boundary, which was close to the Belgian frontier and to a place where the seams nearly cropped to the surface. Chabaud Latour was in fact only from 100 to 200 yards inside the outcrop. This was the district where the coal was found which most nearly approached the anthracite. He added that in the afternoon they would visit a district at the Thiers pit, where the Company were working coal at a depth of from 600 to 1,600 feet; and in that district the coals were more bituminous; in the afternoon they would visit the Renard pit at Denain, towards the other extremity of the concession, where the coal was much deeper.

[265]

HISTORY OF THE ANZIN MINES.

When the conquest of Louis XIV. had separated Hainaut into two parts, the French and Imperial (Treaty of Ruyswick, 20th September, 1697), there were no coal mines in that portion belonging to France.

For twenty years a useless search was made for the prolongation of the Belgian coal-field, and on the 1st July, 1716, Jacques, Vicomte Desandrouin, and Taffin, in partnership with others, obtained a grant from the king, and commenced operations in the neighbourhood of Fresnes.

Coal was discovered on February 3rd, 1720, but it was only fit for burning lime and making bricks, and another search was made to find smiths' coals, which ended after much delay in manufacturing coal being found at Anzin on the 24th of June, 1734.

After having so far successfully overcome all difficulties, obstacles of a new but formidable nature connected with the ownership of the soil under the feudal tenure had to be met, and on the 19th November, 1757, a compromise was effected, and Desandrouin, Taffin, le Prince de Croy, and the Marquis de Cernay commenced a partnership, which was in fact the Anzin Company.

This Company had numerous pits at Anzin, Fresnes and Vieux-Condé, and was in a very prosperous condition, when the revolution broke out and completely changed the aspect of things. The war destroyed the works and warehouses, the chief partners emigrated, and in 1795 the works were almost abandoned. However, comparative quiet having been established, new pits were sunk, and in 1805 the mines had already began to pay again, but, on account of the wars of the Empire, did not attain their former prosperity until the year 1818. Since then the Company has constantly progressed, and at present it holds eight different concessions obtained at different times, the extent of which is given at page 163 of the present volume.

The number of pits that have been sunk in the different concessions since 1716 is 214; namely, 118 for raising coal, 46 for pumping or ventilating, and 50, which either became unproductive or never reached the coal. For further information see Mr. Laporte's paper, page 152.

The most varied descriptions of coal are raised in these concessions, as the following table will show:—

[266]

[see in original text Table of descriptions of coal]

The administration of this large Company, which represents the ninth part of the total production of France, is confided to six directors, with unlimited power. When one of these directors resigns or dies, the five remaining elect his successor. Many persons well known in the history of France have been engaged in the management of this Company—the Vicomte Desandrouin; le Prince de Croy, Marshal of France; the engineer, Laurent, who constructed the St. Quentin Canal, were amongst the first directors; and, later, the Count Dubuat, an engineer, the originator of the Turbine, and of the use of compressed air as a motive force; Claude Périer, one of the founders of the Bank of France; P. N. Berryer; Casimir Périer, the celebrated statesman in Louis Philippe's reign; Joseph Périer; Edmond Lambrecht; Monsieur Thiers, late President of the French Republic; the General Baron de Chabaud-la-Tour; and the Duke of Andiffret-Pasquier.

The directors meet three times a year, in a large and handsome mansion, at St. Vaast, in the months of April, July, and October, and also every month in Paris. M. C. de Marsilly is the present General Director, and resides at Anzin.

[267]

The administration is divided into five distinct services:—

1.—The general correspondence.

2.—The treasury.

3.—The general management.

4.—The commercial department.

5.—The stores.

Each of these departments is under the management of a Chief, responsible only to the General Director.

The works are divided into three sections:—

1.—Those which are carried on below ground.

2.—Those which are carried on above ground.

3.—Those which relate to the plant and material employed.

Each of these departments is under the sole management of a gentleman responsible only to the General Director.

The underground works are subdivided into seven sections—Vieux Condé, Thiers, Anzin, St. Vaast, Herin, Denain, and Abscon—each with an Assistant-manager.

The surface works are divided into three sections, of which one is the railway.

The men, in addition to their wages (see page 154), have the following advantages conceded them:—

1.—Free coal estimated at	£17,537 per annum.
2.—2,494 houses, excess of absolute yearly cost over rent paid by men	9,697 „
3.—10 doctors, medicine stores, and assistance in money, food, and drugs	8,128 „
4.—Education—60 schools and 6,910 scholars	3,127 „
5.—Extra assistance to necessitous families	1,008 „
6.—Advances made for building, loss of interest, etc.	1,289 „
7.—Pensions to old men, widows, and orphans	11,287 „
8.—Presents of suits of pit clothes, and dresses for the children to be confirmed in	342 „
9.—Sums paid to teach trades to such children as are too weak for pit work	98 „
	£52,513

These advantages increase the yearly salary of each workman about £3 9s. per year.

[268]

The following houses are at the disposal of the Company:—

1.—Used as offices	3	Value £244,162.
2.—For the officials	156	
3.—For the workmen	2,405	
4.— „ „	89 Rented houses.	
5.-	88 Sold to workmen to he paid off at long intervals.	

6.—	„	„	426 Built by men, with advances.
			3,167

The men also enjoy advantages in the shape of mutual insurance societies, co-operative stores, advances for one year volunteers, savings' banks (interest at 5 per cent. guaranteed), land let out at low rent for gardening; together with free churches, schools, and libraries.

THE CHABAUD LATOUR PITS.

There are three pits, one for drawing coal, one for pumping water, and one for ventilation. They are 495 feet in depth, and 13 feet 2 inches in diameter, each in the form of a polygon, and lined with stone and brick. The tubbing is of wood. They are drawing 500 tons of coal per day, and it is intended to enlarge the daily output to 1,000 tons. 500 tons of water per day are also extracted. The top of the water-bearing strata begins at a depth of 16 feet 6 inches. Sixteen beds of coal, varying from 1 foot 11¾ inches to 2 feet 7½ inches in thickness, are being worked. The coal is very hard, and contains 11 per cent. of volatile matter, and from 88 to 89 per cent. of fixed carbon, ashes, etc. The coals are put over screens for the purpose of separating the stones and pyrites. The winding engines are actuated by steam from old locomotive multitubular boilers, from which the gearing of the locomotives has been taken off and drums put on. The coal from the pit is used for heating the boilers, but as it requires a very strong draught, a fan blast has to be employed.

THE THIERS PIT.

The members then proceeded by train towards the dip of the basin to the Thiers pit. There are here two shafts, one 1,320 feet deep for pumping water, and the other 990 feet deep for drawing coals. The diameter of each pit is 13 feet 3 inches. While sinking, 13,500 gallons of water per minute were pumped with seven pumps, varying from 31 to 39 inches in diameter. In the pumping shaft there are four sets; the bottom one is a lifting set and the others are forcing sets. The counterbalance is a cushion of compressed air.

[269]

The output is about 700 tons a day. The winding engine was built twenty years ago, by M. de Quillacq. It runs at the rate of sixty strokes a minute, the piston speed being nearly 400 feet per minute. The engines make twenty-eight revolutions in thirty-five seconds. The maximum speed of the cage in the shaft is 23 feet per second. The engine has a steam brake, the cylinder of which is 13 3/4 inches in diameter. As in all M. de Quillacq's winding engines, the engineman is placed at the side and not at the front, so that, in case of accident from the wheel or the rope failing, he is out of the way. The pit top is arranged with two stages, each to work on a level. The cages are arranged so that the tubs are run in on each side to a dead end, instead of running right through. The cages are two-decked, and carry on each deck two tubs holding 9 cwts. of coal each.

There are air compressing machines on the Sommeiller system, supplying power to the rock drills below ground, by means of which roads are cut through sandstone at the rate of 10 feet a day. The mine is ventilated by a Guibal fan 30 feet in diameter.

The water for the use of the boilers is taken from the canal adjoining, and is cleared of its impurities by keeping it in a reservoir, in which are a number of pieces of oak timber, each about a foot in length and two or three inches in diameter. Round these logs the hard sediment in the water accumulates, and when the logs are thoroughly coated, they are removed and others substituted. The old logs are placed in the sun to dry, the coating is then broken off and the logs are used for fuel.

A party of about twenty gentlemen, accompanied by M. Lemaire, director of the Thiers pit, descended the shaft, Mr. T. Lindsay Galloway acting as interpreter. They first visited the steam engine for mechanical haulage, which it is unnecessary further to describe, as it resembles those which are in use in many collieries in England. At the bottom of the shaft there are two cross-measure drifts set away in contrary directions, wnich cut the various seams. The known seams are twenty-four in number, of which however only eight are in course of working. The party proceeded along the engine plane, which is carried inbye to a distance of about 2,000 yards. A little beyond this point a seam, called the No. 4 Seam, is encountered, where the party proceeded to view the actual working of the coal. The inclination of the seams at this point is about 60 degrees, and the method of working is that which is known as the Tailles Chassantes, which is a species of long-wall working, in which the faces, each of twenty yards in length, are carried forward in the direction of the strike of the seam. The various faces are served by self-acting inclined plane fitted with a balance. (See p. 175.)

[270]

Four hewers work at each face, and each man can obtain about two tons fourteen cwts. of coal per day of eight hours; they are paid, however, not by weight but by measurement. The pit is worked in two shifts.

The following is a section of No. 4 Seam:—

	Ft.	In.
Inferior coal and stone		9¾
Good coal		11¾
Stone band		2
Good coal		2
Stone band		7¾
Good coal		7¾

In working the coal the kirving is made in the upper portion of the seam, and powder is used to shoot it up. The total number of men employed in the Thiers pit is 1,200, of whom about 400 are hewers, the rest being employed in the operations of hauling, stowing, and making rolleyways. After the party had viewed two faces in succession they returned to the shaft, and afterwards joined the rest of the company at luncheon.

From the pit the members proceeded to the colliery village. Each of the workmen's houses contains four rooms, two up stairs and two down; they are heated with small stoves placed in the centre of the rooms. These stoves give a large amount of heat and great facility for cooking, with a very small consumption of fuel; there is also a portion of garden ground to each house. The workmen pay a rent of from five to six francs a month for their cottages, according to situation.

ENGINE WORKS OF M. DE QUILLACQ.

The members then visited the extensive engine works of M. de Quillacq, at Anzin. This gentleman, who had already conducted a party, speaking English, through the Anzin concession, received the members most cordially, and as he had a personal knowledge of many of the party, and had received his technical education in England, it added much to the pleasure of the meeting.

In this establishment there is a large foundry, 200 feet long by 50 feet broad, provided with large iron-girder self-acting cranes, 20 feet from the ground, worked by means of ropes, and each capable of lifting 20 tons. There are conveniences for casting pieces of 30 tons in weight, and cylinders have been made of 10 feet diameter and 13 feet stroke. The number of workmen employed is 60, and the output is 2,000 tons per annum.

The foundry is provided with two air furnaces, three cupolas (of which one can melt 12 tons), together with a lift for the coke and metal, and a

[271]

fan-blast. The whole of the minor accessories were of the most complete character, and displayed the great care that had been bestowed on each detail.

The party next visited the boiler-shop, where a number of boilers with three "bouilleurs" were to be seen. The designs or these boilers were explained, and M. de Quillacq stated that, in his opinion, they were most economical, both as to repairs and consumption of fuel, evaporating from 7½ to 8 lbs. of water per lb. of fuel. [Diagram]

The forge consists of two large steam hammers, and a Goliath crane working on a pivot, with its outer end supported by uprights running on a rail.

The fitting shops are well situated with regard to light; and most of the machines are from the celebrated shops of Sharp, Whitworth, Marsh, and Buckton; some are of Belgian and French make.

In the erecting shop the following works were in course of construction:—A pumping engine, several swing and rolling bridges, large turntables for locomotives, and a large upright blowing machine for Saarbruck, with a steam cylinder 47 in. diameter, and 9 feet stroke, and a blowing cylinder 118 inches diameter. The two fly-wheels were 25 feet 9 inches diameter, and weighed 57 tons.

The engine which drove the machinery was on the Sulzer system, of 70 horse power, and worked with the greatest possible regularity of motion, and with a very small consumption of fuel.

M. de Quillacq has made several hundred winding engines on the Sulzer system, modified by M. Martin, his chief engineer. One of these engines, exhibited at the Paris Exhibition, was explained in detail to the members, and a full description of it will be given, accompanied with a plate, at the termination of this report.

The members were invited to meet a number of the agents of the Company at a magnificent banquet prepared for them in the beautiful chateau at St. Vaast, which forms the chief office of the directors of the Anzin Company during their meetings in the north. M. de Marsilly, presiding, welcomed the members most cordially in a few words, which were most enthusiastically received and responded to.

The members afterwards went by train to visit

THE HAVELUY PITS AND COKE OVENS,

where they were received by M. Dumont, Chief Director of the underground wrorks of the Company. They were here shown a perforating machine or rock drill worked by compressed air, an adaptation of the

Sommeiller machine, used for drilling holes in cross measure drifts. It cuts a length of five yards a day, and makes 350 strokes a minute. The diameter of the holes depends upon the size of the machine.

The shaft from which the water is drawn is 340 yards in depth. The cages for drawing the coals are double decked. The winding engines are vertical, about 6 feet stroke, and about 30 inches in diameter. As at all the pits of the Company, there is a speaking tube down the pit. The winding rope is of steel. At the other pits hitherto visited the winding ropes were of hemp. The coke ovens at Haveluy are of the same construction as at Gayant, viz., the Coppée.

THE RENARD PIT.

The next visit was to the Renard pit (see Plates XXXI., XXXII., XXXIII., XXXIV.) This is the largest of the pits belonging to the Anzin Company, and has been sunk for about eight years. It is 1,633 feet deep, and is to be sunk to a depth of 3,300 feet. The shaft is 14 feet in diameter. Ten seams are being worked, and a very fine house coal is obtained. The pit-head and the engine house are under one roof. At 1,240 feet, and also at 1,570 feet, are changing places. The cages have each three decks, each deck carrying two tubs. 850 tons of coal are drawn per day of twelve hours.

The vertical winding engine, 440 horse-power, was made by M. de Quillacq, and is very handsome and imposing. The two cylinders are 40 in. diameter, and 5 feet stroke, and the engine is provided with the Guinotte variable expansion gear, by which the admission of the steam is regulated automatically. Commencing at full power, the steam is gradually cut off quicker and quicker in each succeeding stroke, until the end of the run, when the full cage arrives at the surface. The pressure of steam is 67 lbs. per square inch, and the time of running and changing is 50 seconds. A flat steel rope coiled upon a drum of 19 feet 9 inches is employed, and the engine is fitted with a steam brake. The pulleys are each 20 feet diameter. The head gear is of cellular iron, similar to that of the gear at the pit of Messrs. Taylor, Nixon, and Co., Merthyr Vale, North Wales. The heapstead is in the English style, but very perfect and well arranged, and boilers, with "bouilleurs," are used, and also magnetic indicators, and there is a superheater for drying the steam before it goes into the cylinder.

MESSRS. CAIL AND CO.'S WORKSHOPS AT DENAIN.

The next visit was to the workshops of Messrs. Cail and Company at Denain. This firm has large engine works at Paris, and branch establishments at Grenelle, Denain, Valenciennes, Douai, Amsterdam, and

Brussels, and employs in all about 4,000 men. The firm has the exclusive privilege of making locomotives on the system invented by Mr. Thomas Russel Crampton. The Paris section, with that at Grenelle, employing about 2,000 men, has large erecting shops for locomotives and other engines; it constructs sugar machinery, and conducts all kinds of mechanical operations. At Grenelle the Company has large boiler shops and bridge works, together with large iron and brass foundries, and coppersmith shops. Here were made the iron girders for the Moscow and Nidjni-Novgorod and the Moscow and Saratow Railway, the bridge of Arcole at Paris, that of Moulins over the Allier, and the girders of the Lausanne Fribourgh Railway; and in one year the output of girders, etc., amounted to 10,000 tons.

The works at Denain are mostly occupied in constructing boilers for the locomotives made at Paris. The establishment at Brussels is completely arranged for making all classes of machinery except locomotives, and at Amsterdam the works are more specially arranged for making sugar machinery. The Company has also an establishment at Cuba. The head quarters are at Paris, where the most important of the designs and drawings are made, and the business of the firm conducted.

A short time ago the workshops at Paris were burnt down, and it is contemplated conducting the whole of the business at Grenelle.*

The party then assembled at the railway station, and having thanked M. De Marsilly for the great attention he had paid them, and for the excellent arrangements he had made for their reception, returned to Douai.

* For further particulars of these works, see Vol. II., les Grandes Usine en France Turgan. Michel Levy freres, 3, Rue Auber, Paris.

THIRD DAY'S EXCURSION, FRIDAY, JUNE 7th, 1878.

PROGRAMME OF VISITS.

The Mines of the Courrières Company.

The Harnes Wharf and Pit.

Billy-Montigny Pit.

Courrières No. 5 Pit.

Lens No. 3, 4, and 5 Pits.

Liévin No. 5 Pit.

The Lens Wharves.

Bully-Grenay Pit.

THE COURRIERES COMPANY.

This morning, at seven o'clock, the members left Douai by special train to visit the mines of the Courrières Company. They were met at the station at Douai by M. Mathieu, the Managing Director of the Company, who conducted them during the day.

The Company has five winding pits at work, and one more in course of sinking. There are 1,800 workmen in the mines, and 450 above ground. About 700 or 800 tons of coal a-day are sent away by canal, and about 500 tons a-day by railway. The annual output of the whole of the collieries is 400,000 tons. The coal is bituminous, contains 38 per cent. of volatile matter, and is mostly used for household purposes.

THE HARNES SHIPPING BASIN AND WHARF.

These are situated about the centre of the concession of Courrières, on the river Souchez, which has been made navigable to its point of junction with the canal Haute-Deule. The shipping basin is rectangular in form, and on each of its long sides it has a network of railways terminating in sidings that communicate with the pits belonging to the Company.

The coal arrives in boxes each containing about 39 cubic feet, eight of these boxes being placed side by side on trucks with iron frames. The

[275]

sides of the boxes have shutters or doors, secured by strong hasps, and the sides of the wharf are provided with inclined spouts, properly counterbalanced and arranged, so that they can be raised or lowered to suit the height at which the barges are filled. When the trucks are brought alongside these spouts, the door is loosened, and a steam crane is brought to the inner side of the truck; a hook from the crane is then placed under each box in succession, and they are tilted over towards the basin, when the coals slide down the spout into the barge. After every tilt a fresh box has to be brought alongside the spout; this is done by the locomotive attached to the train, or by a horse if only a few wagons are required to be emptied. The crane is placed on a truck and can be moved about to any of the spouts round the basin. By this system a box can be tipped in a minute, that is one truck in eight minutes, or eight trucks per hour; and the day's work generally averages about 100 trucks. Three men are required for the process; one at the spout and doors, one at the crane, and one to fix the hook under the boxes. The boxes are hinged on each side of the trucks, so that they can be tipped on either side of the basin without having to turn them end for end. Each barge carries from 200 to 300 tons, and about 800 tons a-day can be shipped.

BILLY-MONTIGNY.

The party next examined this locality, and were much pleased with the arrangements for teaching the children, and generally with the provision made for the comfort and recreation of the workmen.

COURRIERES No. 5 PIT.

The next visit was to the Courrières No. 5 pit, which is a new winning. Here it is intended to work a seam of coal ten feet in thickness, which is the thickest to be found in the Pas-de-Calais; it has an inclination of ten degrees, and is found at a depth of 240 feet. Arrangements have been made for drawing 600 tons in twenty-four hours. In sinking the pit three sets of pumps were employed. The largest was 39 inches in diameter, and the two others were 25 inches each; all the pumps had a 10 feet stroke, and were driven at the rate of seven strokes per minute. They were all used in one shaft, and great difficulties were experienced in getting through the water-bearing strata.

The diameter of the shaft is 14 feet 9 inches. The pit mouth and winding engine are under one roof. Hemp ropes are used, 8½ inches in breadth by 1⅜ inches in thickness; a lever, which is struck by the cage acting upon a steam brake, prevents over-winding; and in the event of the rope breaking, there are jaws in the cage which seize the wooden guides; all

[276]

these contrivances have been in operation several times, and have succeeded perfectly. The winding engines are horizontal, not expansive. The diameter of the cylinders is 27½ inches. The ventilator is of the Guibal constriiction, 30 feet in diameter by 8¼ feet wide; it was not in action, as no coal has yet been worked.

THE LENS COMPANY

Of all those connected with the working of coal in the north, is the one which has become most rapidly developed. In 1849 this immense concession, 27 square miles in extent (Lens and Douvrin united), was not even explored, and it only commenced raising coal in 1853, yet in 1875 it had reached an output of 715,097 tons.

This great result is due partly to the ability which the managers have displayed in availing themselves of all the modern appliances, and in sparing no pains or expense in the construction of their plant; and partly to the fact that the seams here are thicker and more regular than elsewhere. The No. 5 pit is the newest and best worth describing, although the others exhibit in a remarkable degree the care that has been taken in designing and building these magnificent establishments, for the engines and framework round the pits are covered with buildings which, in elegance and size, have all the appearance of palaces. On careful inspection, however, it cannot be said that too much expense has been incurred, seeing the advantages that are being reaped from the simplification and diminution of hand labour. Plate XXXV., with the following description, will give some idea of the remarkable structure at the No. 5 pit. A description of Nos. 3 and 4 pits is unnecessary.

The pit was commenced on the 17th November, 1872, with a diameter of 16 feet, the largest which had hitherto been made in either the Nord or the Pas-de-Calais.

The sinking through the *morts terrains*, 508 feet thick, was finished in 1874. It was accompanied with great difficulties, on account of the quantity of water encountered, which, when a depth of 115 feet was reached, rose to 540,000 gallons per hour, and required the united action of six pumps, 21 inches diameter, 10 feet stroke, driven by 800 horsepower, to keep under. The depth of the pit is now 835 feet. There are two hanging-on stations, at 700 feet and 825 feet respectively. The pit is tubbed with the best oak between the depths of 28 and 306 feet, and with bricks for the remainder. The space behind the tubbing is filled in with concrete, made of Vassy and Tournai cement, sand, and broken bricks. The setting-away stages are boxed in with Bourgogne oak, and where the

[277]

pressure is greatest they are covered in with old rails, in other places with pine; they are 16 feet wide and 12 feet 6 inches high. The rails are 2 feet gauge, made of steel double-bulb, weighing 13 lbs. per yard; the sleepers are also of steel and weigh 10 lbs. each.

The cage-guides are of oak, 6¼ by 7 inches. The cages are made partly of steel and partly of iron; they are double-banked, and are 9 feet 6 inches long, 5 feet 3 inches wide, 10 feet 6 inches high, weigh 2 tons 8 cwts., and carry eight tubs each. The tubs are of wood, with steel axles and wheels; they hold 8¾ cwts. of coal, and weigh 3¼ cwts. empty. The cage weighs, therefore, with the eight empty tubs, 3 tons 14 cwts., and with the eight full tubs, 7 tons 4 cwts. These cages are provided with safety-springs and catches of the usual form, holding on by the guides in case of accident to the rope.

The water is extracted by means of wrought-iron buckets holding 840 gallons, with suitable valves for letting the water in and out. The ropes are of hemp. The tubs are changed at the 700 feet stage by hydraulic apparatus.

The pit heapstead, the pulley-frames, the winding engine, screens, and loading arrangements are all under one stately building (see Plate XXXV.) which consists of a solid foundation for the engine and the base of house, built of bricks, with stone quoins, covered with a lighter construction, principally of glass and iron.

To give some idea of the size it will suffice to say that it is 204 feet long, 56 feet wide, 42 feet to the spring of the roof, and 59 feet to the top of the roof. The point of the lightning conductor which protects the building, and which is placed over the pulley-frame, is 132 feet above the ground. The heapstead is 26 feet above the ground.

The pulley-frames are of iron, supporting the pulleys, which are 13 feet 3 inches diameter, at a height of 50 feet.

The engines are horizontal, of 450 horse-power, made by M. Dorzée. The cylinders are 39 inches diameter and 1 foot 8 inches stroke. The steam is admitted and withdrawn by means of four double-beat valves, acted on by a series of cams on the Audemar system; these cams slide on the shaft that gives them motion for the purpose of reversing the engine and varying the amount of expansion, which is done either automatically or by the engineman.

The pillars for the engine are 42 feet long, 10 feet wide, and 26 feet high; close to them are two offices for the deputies, a cabinet of samples, a large bath and washing place, a lamp repairing shop, a store house, a

[278]

large lamp-room for cleaning the lamps, and two large rooms for the miners, one above the other, communicating with each other by means of a staircase.

The first stage is at the level of the engine, and the place for the withdrawal of the tubs. The screening is performed in the way described by Mr. Daglish, Vol. XXVI., page 139.

There are sixteen boilers placed in one group, accessible on all sides. Each boiler consists of one cylindrical body 4 feet diameter, and 46 feet long, with two bouilleurs 2½ feet diameter, and 47¾ feet long, and two water heaters 2½ feet diameter, and 41¼ feet long. The two bouilleurs and the lower half of the body are in the same flue, the water heaters in the return flue. The furnaces are very large, arranged to burn the unsaleable coal by slow combustion. There is also a large steam chest. The chimney is circular, 165 feet high, and 10 feet inside diameter. The ventilation is effected by means of two large Guibal fans.

There is an ingenious way of arresting the cages on their arrival at the bottom, and of changing them, which is worthy of notice (see Plate XXXV., Fig. 5). A is the cage, B a lever attached to a hydraulic ram C, connected with a constant head of water H, controlled by the valve S, and provided with a spring safety-valve T. When the cage descends with the empty tubs, the ram C is at the top of its stroke, and helps to take off the shock of the cage. When the lower tier of tubs is taken out and replaced by full ones, the difference of weight causes C to descend on opening the valve S, and the cage is placed in a position for changing the upper tubs.

LIEVIN, No. 5 PIT.

This pit is an entirely new winning, and is not yet drawing coals. The depth of the shaft is 1,410 feet, of which about 480 feet have been sunk through water-bearing strata by the Kind-Chaudron process. A period of fifteen months was required to sink a depth of 330 feet. It is intended to deepen the shaft to 2,640 feet; and arrangements have been made so that the deepening of the shaft shall not interfere with the working and extraction of the coal. This is to be effected by means which have been designed by M. Lisbet. The diameter of the shaft is 13 feet. Arrangements have been made for drawing 800 tons of coal per day. The winding engine is horizontal and expansive, with two cylinders 36 inches diameter and 6 feet stroke. They wind with flat wire ropes. The cages are double decked, and each cage carries four tubs.

There are two landings, so that the two decks will be charged and discharged at the same time. The surface erections are upon a magnificent scale; the engine house and heapstead being in one building. The height of the pulley frame is 82 feet.

The quays which form the port of embarkation of the Lens Company were next visited. There is a quay 990 feet in length, with 25 spouts. After having described the quays at Harnes there is no necessity for further explanation here.

BULLY-GRENAY.

This was the last concession visited. It was granted to the Company in 1853, and has an extent of 22.24 square miles. The coal measures are covered by water-bearing strata of a thickness of about 450 feet.

There are seven pits, of which five are being sunk. Several of them, more especially Nos. 2 and 4, have encountered very irregular strata.

At No. 4 pit, a slightly bituminous coal containing from 15 to 18 per cent. of volatile matter has been found, which is in great demand as a steam coal. Northward, the concession contains anthracitic coal, with from 8 to 12 per cent. of volatile matter, and in the centre of the concession, between pits 2, 3, and 5, there are seams of bituminous coal which contain from 28 to 34 per cent. of volatile matter. The coal from pit No. 3 is much used for glass making, and that from pit No. 5 is held in great esteem for the manufacture of gas in the south. Pit No. 1 is working seams of highly bitumimous coal, containing from 34 to 40 per cent. of volatile matter.

The production of the Company has increased from 7,193 tons in 1853 to 288,676 tons in 1875. About 2,500 workmen are employed, of which 1,900 are below ground. The first four pits have a diameter of from 13 feet to 13 feet 10 inches, and the last three have a diameter of 14 feet 8 inches. They are tubbed with oak for the first 297 feet, and then cased with brick for the rest of their depth. The cages, which are double banked and hold four tubs, run in wooden guides. The water is extracted by means of wrought iron tubs containing 650 gallons. Pits Nos. 2 and 4 contain fire-damp. The ventilation generally is effected by means of Guibal fans. Plates Nos. XXXVI. and XXXVII. show the general arrangement of the No. 5 pit.

The members were conducted over the works by M. Dumont, the managing director of the Company, and, after having been handsomely entertained, they proceeded by special train to Arras, where they joined the ordinary train from Brussels to Paris.

VISIT TO PARIS.

WINDING-ENGINE BY M. DE QUILLACQ AT THE PARIS EXHIBITION.

On Saturday morning, June 8th, at 12 o'clock, the members met M. de Quillacq at the Exhibition by appointment, and that gentleman described to them the mode of working an engine which was exhibited by him, and which is similar to that used by several mining companies in France for winding purposes. The general arrangement is that of an ordinary horizontal engine and need not be described; the mode of working the valve-gear alone being worthy of a detailed explanation. Plate No. XXXVIII. is a diagram showing the various movements which are given to the valves, which are of the usual double beat description. The movement of the valves is dependent in the first place on two eccentrics, the centres of which are shown at o and o', the eccentric rods of which work a link a in the usual manner. Working in this link is a slider carrying with it one end of the rod b, which gives motion to a lever c. The slide end of this rod can be changed from one end to the other of the link a by means of the rod d and the lever e, the axis of which is moved by the usual reversing handle. The lever c, which works on an axis f, has a rod g, which is one of the modes of giving motion to an upright lever h, which is supported at its lower extremity i by a lever k working on an axis l, actuated by a rod m, attached to a lever n, which vibrates on its axle q, and receives its motion at p from the centre of the link a. It will be seen, therefore, that this upright lever h, which is prolonged at the top to r by means of a slot (although the prolongation is not shown to avoid confusion), receives two motions; one horizontal by means of the lever c, and the other vertical by means of the lever k; and the point r o moves in an oval path, represented by the figures 0, 1, 2, 4, 6, etc., while the point r o', moves in the path indicated by 0', 1', 2', 4', 6', etc. The exhaust valves, s s', which do not require any expansion, are worked by the levers t t, and the rods v v' attached to the upright lever h at v, while the steam valves w w' are worked by the levers x and x' and the curious shaped triggers y and y'. These triggers have faces, z and z', which are pushed against the portion r of the lever h, and remain open until r, in performing the oval motion before described, disengages itself from the trigger, when the valve closes by any of the well-known usual contrivances. Following the motion of the lever h, it will be seen that the valve w' will be open when the upper end r of the lever h moves from 0 to 1, and that the valve will close directly the point 0 falls below the trigger. On the other hand, the valve w will be open when the point 0' of the upper end r of the lever h

pushes against the trigger y, and it will be seen that by raising or lowering these triggers a greater or less amount of cut-off can be given to the valves. This raising and lowering of y and y' is effected by means of the lever a' and the connecting rods b b', either by the governor G and the levers and rods c' or by a separate lever worked by hand, which is not shown in the drawing. The centres of the various levers and rods only are given, and everything is omitted which would tend to complicate the drawing. Such a valve gear enables the engine-driver to work his engine with expansion in the ordinary running; but when desirable he may disconnect the governor G from the valves w w' by disengaging the lever c' c', and then the engine works full steam in the cylinders. The engineer works the steam brake by hand, and thus can stop the engine easily and rapidly. In this he can be assisted by reversing the engine, and the steam chests are fitted up with relief valves to allow of the escape of the air, instead of forcing it back out of the boilers.

MUSEUM OF THE SCHOOL OF MINES.

The members met on Monday, June 10th, at one o'clock, and were introduced to Professor A. Daubrée, director of the School of Mines, who exhibited and described with great minuteness the very valuable collection of fossils and models contained in this celebrated museum.

Thus terminated one of the pleasantest and most instructive meetings of the Institute, the great success of which was mainly due to the very great kindness with which the members were received by the proprietors and engineers in the North of France and Professor Daubrée at Paris; and the Secretary was instructed to convey the thanks of the Institute to the following gentlemen:—M. Vuillemin, General Director of the Mines at Aniche; M. de Marsilly, General Director of the Mines at Anzin; M. de Quillacq, Chief Director of the Quillacq Engine Works at Anzin; Professor Gosselet, of the Faculty of Science, Lille; Professor A. Daubrée, Member of the Institute and Director of the Ecole des Mines; M. Hartmann, Managing Director of the Iron and Steel Works at Denain; M. Cizancourt, President of the Société de l'Industrie Minérale, St. Etienne; M. Dombre, Engineer of the Aniche Mines, and Engineer of the Mines at Lens; M. T. Dumont, Director-in-Chief of the Underground Works of the Anzin Mines; and M. Martin, Engineer at the Quillacq Engine Works, Anzin.

[Plate XVIII. Theoretical section of the coal basin of the North of France;

Plate XXIX. Mines of Aniche: the Renaissance pit. Figs 1 to 4;

Plate XXX. Plan of the Denain Steel Works;

Plate XXXI. The Anzin mine. Plan of the Renard Pits;

Plate XXXII. The Anzin mine. General arrangements of the Renard pits – figs 1 to 5;

Plate XXXIII. The Anzin mine. Longitunal section through the boiler shed, engine house, screens of the Renard No 2;

Plate XXXIV. The Anzin mine. Sectional plan of the boiler shed, engine house, screens of the Renard No 2;

Plate XXXV. The mines at Lens;

Plates XXXVI and XXXVII. Mines of Bethune – engine house of Bully-Grenay;

Plate XXXVIII. Winding engine by M. de Quillacq of Anzin on the Sulzer-Martin system]

ANNUAL GENERAL MEETING, SATURDAY, AUGUST 3, 1878, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

LINDSAY WOOD, Esq., PRESIDENT, IN THE CHAIR.

The President nominated Messrs. W. H. Hedley, S. C. Crone, R. B. Clark, and C. Z. Bunning, as the scrutineers of the voting papers for the election of officers for the ensuing year.

The Secretary read the minutes of the general meeting of June 1st, 1878, and the minutes of the general meeting held in France on the 4th, 5th, 6th, and 7th of June, and reported the proceedings of the Council.

The Secretary then read the annual report of the Council and Finance Committees.

The President, in moving the adoption of the reports, said, he did not think there was anything to which he need draw their special attention. The visit of the Institute to France was the first it had made to any foreign country, and he was sure that every member who attended that meeting could not but be exceedingly gratified. He himself had been very much astonished to see the plant they had at the collieries there; it was very much greater and more magnificent than any he had seen in this country. Some of the engine houses were splendid structures; and the engines were certainly amongst the finest he had seen anywhere; the valve-gearing and the whole of the arrangements being very perfect. Unless he had seen them he would not have believed that colliery engines, engine houses, heapsteads, and plant had been brought to such perfection. The thanks of the members were very greatly due to those gentlemen in France who had afforded them the opportunity of visiting their works, and for the admirable arrangement made for their doing so, the only drawback being that there was not sufficient time to see everything properly. Another point in the report, to which he wished to draw their attention, was one of not so pleasing a character, and that was that the expenditure during the past year had exceeded the income. That circumstance was entirely due to the publication of the "Illustrations of Fossil Plants" and the "Catalogue of the Hutton Collection." The cost of publishing these works was very great, and being entirely additional to the ordinary expenditure, it had caused the outlay of the current year to exceed the income; but against this must be set the additional value of the stock, which now consisted of a large number of copies of these works, which had not yet been sold. Eventually, however, he had no doubt these copies would realize their value, but it would require the Institute to be careful in its expenditure for a time. In other respects he thought that, financially, they were in a very good position. The report also contained a paragraph referring to the lamentable loss of life by explosions in mines. The loss from this cause had been very large during the past year, and he believed the deaths were very nearly 500 in excess of the usual average number. But this excess, and indeed nearly the whole number, appeared to have arisen from two explosions, one of which caused the loss of 240 and the other of 200 lives. He thought the Institute ought to consider the cause of those explosions, and, if possible, discover some means by which similar disastrous occurrences might be avoided. The Institute had during the course of its existence done very much in that direction; but still more was required. They had had during the past year several papers on the subject, and he hoped that in future years continued attention would be paid to it in order that, if possible, these great calamities might be obviated.

The reports were then unanimously adopted.

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

Ordinary Members—

Mr. Robert Russell, M.E., Coltness Iron Works, Newmains.

Mr. J. S. Dixon, C. and M.E., Bent Colliery, Hamilton, N.B.

Associate—

Mr. Jos. Wm. Harrison, M.E., Gildersome, near Leeds.

Students—

Mr. E. G. Kirkhouse, Medomsley, near Newcastle-on-Tyne.

Mr. Alfred A. Atkinson, Munglepore Colliery, Bengal.

The following were nominated for election at the next meeting:—

Honorary Member—

M. Vuillemin, Engineer and General Director of the Mines at Aniche, and Vice-President of the Société de l'Industrie Minérale, France.

[285]

Ordinary Members—

Mr. Robert Winstanley, M.E., Manchester.

Mr. John Lancaster, Auchinbeath and Southfield Collieries, Lancashire.

Mr. James Hunter Goudie, Maryport Ironworks, Maryport.

Associates—

Mr. W. Gascoyne Dalziel, M.E., 2, Pembroke Terrace, Cardiff.

Mr. John Edge, Colebrook Dale, Salop, Shropshire.

Student—

Mr. H. O. Maccabe, M.E., Chilton Colliery, Ferry Hill.

The President said, that M. Vuillemin, whom it was proposed to elect as an honorary member, fulfilled all the conditions required by the rules, and was Vice-President of the Society which received the members on their visit to France; and he thought it would be a very suitable compliment to pay M. Vuillemin to elect him an honorary member of this Institute. He personally undertook a great amount of labour and trouble in preparing and carrying out the arrangements of the visit to France, and he might almost say that if it had not been for him they would never have gone there. Therefore he (the President) with several other members had nominated M. Vuillemin as an honorary member, and he hoped the nomination would be unanimously accepted.

Mr. E. H. Liveing then read the following paper:—"A New Method of Detecting very small quantities of Inflammable Gas, and of Estimating the proportion present":—

[286]

[blank page]

[287]

ON A NEW METHOD OF DETECTING VERY SMALL QUANTITIES OF INFLAMMABLE GAS, AND OF ESTIMATING THE PROPORTION PRESENT.

By E. H. LIVEING, A.R.S.M.

With respect to the importance of being able to detect very small quantities of gas, especially in the examination of the return air-ways, it is hardly necessary to make any remarks.

The following method occurred to the writer some six weeks ago, since which time he has made a considerable number of experiments on the subject, which have been so successful that he ventures to think the following description will be worthy of the consideration of the members of the Institute.

A and B (Fig. 1, Plate XXXIX.) are spirals of fine platinum wire (or riband wire two thousandths of an inch in diameter answers well) joined in series by copper wire, as shown in Fig. 1. A is sealed up in a glass tube containing atmospheric air; B is naked, but both are surrounded with a strong cylinder, the upper part of which is of glass and the lower portion of brass. This is closed at the top and bottom, but there are two entrances, E and F, consisting of short brass tubes filled with a bundle of iron or copper wires (like Hemming's oxyhydrogen blowpipe). F is provided with a mouth-piece.

The charge of air to be examined is introduced by drawing a breath through the apparatus. This being done, the platinum wires are raised to a red heat by a current of electricity from a small magneto-electrical machine turned by hand, which will be afterwards described. If no gas be present both wires glow with equal brilliancy, but if the air contains inflammable gas, even in as small a proportion as 1 in 100, the exposed or working wire glows with greater brilliancy, and the more so as the proportion of the gas is increased. The increase of comparative brilliancy is brought about in two ways; first, by the slow combustion of the gas around the exposed wire; and, secondly, the rise of temperature in the working wire increases the electrical resistance of the circuit (both wires being in circuit); less current therefore passes, and so the wire in the closed tube falls in brilliancy.

[288]

It is proposed further to estimate the proportion of gas present in the following manner:—

In front of the two wires (see Fig. 2, Plate XXXIX.) is a small sliding frame carrying two thin wedges of neutral tint glass, or strips of glass smoked with a gradual increasing density, the thickest part of one being equal in density to the thinnest part of the other; these being so placed side by side that when the slide is at one end of its run, as in the position shown in the figure referred to, both wires are seen through equally dense glass, but if the exposed wire glows brightest owing to the presence of gas, the slide will have to be moved to make the wires appear equal through it, and the amount of such movement will depend on the proportion of gas present.

The slide rod X (Fig. 2) that moves the wedges will, therefore, be graduated empirically by fitting the apparatus with known mixtures of gas and air, the graduations being little nicks capable of being counted by the nail in the dark.

The writer has not yet had time to construct the apparatus in a compact, portable form, or to try it underground, but various mixtures of coal-gas and air have been examined, as well as marsh gas (chemically prepared) and air. 1 per cent. of coal, or marsh gas in air, makes an appreciable difference in brilliancy, and with a little practice considerably less may be detected; 1 part in 60 makes a very decided difference; 1 in 30 a very great difference; and so on until the feebly explosive point is reached-—that is 1 in 14. Before this point is reached a blue cap makes its appearance above the exposed wire like that over a Davy flame. In case of explosion inside the apparatus no communication with the outside is possible, as the hot gases become completely cooled in passing through the bundle of iron wires that fill the two entrance tubes.

It will be seen that the above apparatus enables considerably smaller quantities of gas to be detected than has hitherto been possible.

It may also be used as a lamp for travelling in a very explosive atmosphere, where it would be impossible to carry an ordinary safety-lamp. The platinum wires afford quite sufficient light for a man to travel with, if the machine be turned with moderate rapidity.

With respect to the magneto-electrical machine, the writer has very little to say at present, except that the one exhibited is only a rough, temporary machine put together for experimental purposes; it weighs about 6½ lbs., with no attempt to render it portable, and it is made with the old form of Siemen's armature. There is no doubt but that a machine of more approved construction, weighing about 4 lbs., could be made capable of performing the necessary work.

[289]

The writer apologises for bringing the matter in a somewhat incomplete state before the Institute, but hopes that the importance of the subject will form a sufficient excuse. He will be happy to communicate further details when the subject has been worked out more fully.

The form of apparatus shown in the drawing is not drawn to any scale.

The President asked Mr. Liveing what sort of battery he used?

Mr. Liveing said he used a magneto-electrical machine, something like that in use at the Post-office for the A.B.C. telegraph. He considered a machine far preferable to a battery, because batteries, especially those of a portable kind, were unreliable as they were so very inconstant.

The President said, the great consideration would be to get it as portable as possible, because if it had to be used practically, a man would have to carry the battery and the apparatus about with him in the workings of the colliery in the same way that he carries a lamp at the present time; and if the presence of gas could be detected when mixed in the proportion of sixty of air to one of gas, there was a very large margin between that and the explosive point of gases, and therefore this lamp would be a very useful apparatus.

Mr. Greenwell asked what size Mr. Liveing thought the apparatus might be made?

Mr. Liveing said, he did not know exactly what was to limit the size of that part of the apparatus; it need not, he thought, exceed the size of an ordinary lamp; but as to the magneto-electrical machine, he could hardly answer the question at present, because he did not know how small it might be made. The present one was about eight inches long, five inches wide, two inches deep, and weighed about six pounds.

Mr. Greenwell said, the great value of the apparatus would be in using it for trials within short intervals, so as to discover whether the condition of the air was changing.

Mr. Liveing—No doubt; it was very sensitive in the presence of gas.

Mr. D. P. Morison asked Mr. Liveing if he had found, in his experiments, any difference by his testing machine in the brilliancy of marsh gas, of ordinary gas met with in collieries, and of coal gas? That was the important point.

Mr. Liveing said, he had tried both marsh gas and coal gas, but not pit gas at present; and he thought that if anything, marsh gas acted

better; but he did not think there was, practically, anything to choose between them; they gave equally good results.

Mr. D. P. Morison asked if the composition of marsh gas, and the inflammable gas met with in collieries, was not usually the same?

Mr. Liveing said, the great body of coal gas consists of marsh gas, but it contains variable quantities of other gases—such as olefiant gas, hydrogen, and nitrogen.

Mr. D. P. Morison said, he meant pit gas or fire-damp.

Mr. Liveing—Well, it was chiefly marsh gas, but there were generally, he thought, denser hydrocarbons present in small quantities as well as marsh gas (CH_4), and very often carbonic acid also.

Mr. D. P. Morison said, his reason for asking the question was this: the cap which was observed upon the flame of a lamp or a naked light, as the case might be, in collieries, varied very much in different seams, as he dared say some members would know practically. In the Durham field, the cap observed in the Hutton seam was widely different from that which was detected in the Busty Bank seam; and he thought there might, perhaps, have been some difference observed in the extent of the brilliancy of the bright point of the wire when different gases were used.

Mr. G. Bailes said, gas, in different seams, was more or less highly carburetted. A long brown-coloured cap was always seen where a larger amount of carbonic acid gas was present; and a much lighter, bluer, and shorter cap where there was a more or less pure carburetted hydrogen.

Professor Herschel said, he thought that the small proportion of gas which this new instrument showed would make it a very valuable application, and the members would, he felt sure, be pleased with the inspection of the instrument when they saw the great difference which the luminosity of the two wires presented with the addition of a very small trace of the ordinary coal gas. The plain simplicity with which Mr. Liveing had arranged this illustration would, he thought, commend itself to them, and to their practical appreciation of the advantages of the instrument. As to the use which Mr. Liveing suggested for it, namely, employing it occasionally for the purpose of affording light in the mine, that, he thought, required consideration; because, if it was made of such a small size as to be portable, it would hardly serve for the purpose of illumination; and if a miner or viewer was to use it for that purpose, and try to push the strength of the light in its present and portable size to the intensity necessary to serve for illumination, he (the Professor) thought he would meet with an accident such as unhappily had befallen the instrument that morning. It had been over-driven, and much trouble

[291]

and difficulty were experienced in putting it into the working order in which he hoped it would be found presently. This led him to ask whether Mr. Liveing had made any arrangement for removing the two wires from their places, and replacing them by a new pair? He supposed that new wires might be kept in stock?

Mr. Liveing—Certainly; and if the instrument was suitably constructed, they could be put in without difficulty.

Professor Herschel—So that they could be used as occasion required.

Mr. Liveing said that the diagram was not intended to show the actual construction, but only to illustrate the description.

Professor Herschel—And the wires can be kept made up, and arranged very quickly?

Mr. Liveing—Yes.

Professor Herschel said, another point which he wished to mention was about the explosion which was likely to take place in working the wire, if it acted upon an inflammable mixture of coal gas. Mr. Liveing had provided for safety against any danger of that kind, by admitting the air to be tested by the instrument through a safety jet; and he would like to ask Mr. Liveing if it would not be safer to substitute a stop-cock for this jet, and to make the instrument strong enough to resist any explosion which might occur. He (the Professor) thought that if the instrument was made of sufficient strength to contain the explosion, and of a suitable form, it might then be considered perfectly safe. At the same time, this seemed to be a drawback to the use of the instrument, that a slight ignition was possibly liable to take place by the introduction of gas.

Mr. Liveing said, as regarded the use of the stop-cock, he thought it might be just as easy as the present arrangement. There might be two stop-cocks, one to each aperture, and they might be so connected together, and with a kind of commutator, that the current from the machine could not pass till the stop-cocks were closed. This would render it impossible to ignite the wires unless the apertures were completely closed. He did not think, however, that any explosion of coal gas and air, or marsh gas and air, even in the most explosive proportions, could get through the present arrangement as the bundle of wires had such a powerful cooling effect upon the gases.

Mr. William Cochrane asked if the whole apparatus was not enclosed in a Davy lamp gauze? If that was so, an explosion could not communicate with the external mixture.

Mr. Liveing said, it was enclosed in a glass and brass vessel, the only

openings being at E and F, and these were filled with a bundle of iron or copper wires forced into a tube, which was better than wire gauze.

Mr. Bunning said, Professor Herschel had stated that some little accident had taken place that morning with regard to the lamp. Might he ask what that accident was? Were the platinum wires melted or destroyed?

Professor Herschel—Yes.

Mr. Bunning—Professor Herschel also made some observation with regard to its being unsafe, supposing an explosive mixture should be present inside the lamp. But where gas was supposed to exist, could not the inhalation, as it were, of the gas by the instrument be completed, and the instrument be filled with gas and taken away, and tried at a distance so as to make it perfectly safe, and still with perfect reliability? because the machine would be full of gas taken from the pit. Was it necessary that the air should be actually tested in the pit?

The President thought the suggestion of the Secretary would not answer very well. He thought that if the lamp had to be of any practical value, the air would have to be tested where it was. It would be almost impracticable to fill the lamp at one place and to test it at another, and then go back to another part of the workings to get the lamp re-filled, and so on; but he could not see that there would be any difficulty in making the lamp sufficiently strong to withstand an explosion in its interior. If the apparatus was made sufficiently small, the force of the explosion would be correspondingly small; and he should think the apparatus could very easily be made of sufficient strength to withstand such an explosion.

Mr. Greenwell said, the most important value of the instrument would be in ascertaining the changes which might take place in the atmosphere, because it was very clear that if any gas could explode in this apparatus it would be indicated, in the first instance, by the safety-lamps used in the places where the instrument would be tried; and, therefore, it would be only used as a test to see whether the air was approaching to such a point that it would show in the lamp. If it did not fire in the safety-lamp, he thought that the accidents from explosion in the instrument which Professor Herschel had spoken about could scarcely occur, because if the air was in an explosive condition it would certainly be seen in the lamps. If it was not in an explosive condition, any accident which could happen to the apparatus would do no harm.

Professor Herschel said, he had often heard the smallest proportion of coal gas in air sufficient to make it explosive, mentioned as being about

[293]

1 to 14 or 1 to 16; but in the very frequent laboratory experiments which they had made during the past year, they had never been able to obtain an explosion of coal gas mixed with air until the proportion reached 1 to 10 at the very least. The most exceptional proportion with which the mixture was sometimes inflammable was 1 to 10; but the least value was most frequently 1 to 6 and 1 to 7. He did not know where the numbers from 1 to 14 and 1 to 16 had been arrived at, but he thought it very rare that any explosion had arisen from that state; and, of course, before reaching even that preliminary state, it would be indicated by the cap on the flame in the lamp. It was in purer states of the air, no doubt, where caps do not serve as a very good test, that this instrument would be of the greatest value.

Mr. Liveing did not think the difficulty suggested was one of very great importance. Explosions of fire-damp and air in small volumes of this kind had very little effect. Everybody knew the effect of a lamp when it exploded inside a gauze; it was very different to an explosion of oxygen and hydrogen. Of course the explosion of fire-damp on a large scale was a very different thing.

Mr. Liveing then, in the Laboratory of the College of Physical Science, exhibited the instrument, showing experiments with mixtures of gas of 1 in 46, 1 in 23, and 1 in 60.

Professor Herschel said, perhaps Mr. Liveing would tell them whether palladium wire had been tried in the apparatus to prevent explosions, of which there was risk.

Mr. Liveing said, Professor Marreco had suggested the use of palladium wire instead of platinum, for it was known that when this metal was heated to redness in a mixture of oxygen and hydrogen, it did not explode the mixture, but simply caused it to burn quietly around the wire, even when mixed in explosive proportions. He had not himself tried palladium wire; but the suggestion was well worth trying, no doubt, because then the apparatus possibly might be used without any cover.

Mr. William Cochrane asked Professor Marreco to inform them whether the use of palladium wire was practicable? because, owing to the different action of palladium and platinum it might be possible to dispense with any gauze over the instrument, and it might be perfectly safe to travel in an explosive mixture with such an apparatus.

Mr. Freire-Marreco said, some mixtures which would explode with platinum would burn quietly enough with palladium wire, but there were two or three practical difficulties; first, palladium wire was more expensive

[294]

and difficult to get; and after being used some time it got very brittle, possibly from occlusion of the gas, and it had a very low melting point, so that great care had to be exercised in using it. However he thought it worth a trial.

Mr. Cochrane asked whether the fact that it did not explode was due to the palladium being at a lower temperature than the platinum wire?

Professor Freire-Marreco—No. When heated up to the same point it appeared to burn the gas quietly.

Mr. John B. Simpson proposed a vote of thanks to Mr. Liveing for his very interesting paper, and for the very able experiments he had made. He (Mr. S.) was quite sure there was a future before the instrument which Mr. Liveing had shown to them, and he thought that further experiments by Mr. Liveing, and possibly the Professors of the College of Physical Science, would show that this instrument would be of very great benefit in mining.

Mr. William Cochrane seconded the motion; and it was carried unanimously.

The President said, the paper by Mr. J. B. Simpson, "On the Mining Industries of Prussia," now stood for discussion.

Mr. Simpson said, he had nothing further to remark with respect to the paper except that he observed that in Prussia the output of coal was increasing year by year; and in face of the depressed times it seemed rather a singular circumstance that almost in every country this was found to be the case. In this country for the last ten years the output had increased from about one hundred millions to one hundred and thirty-four millions, or an average of about three per cent. per annum; and he believed that pretty much the same advance was going on in all the continental countries. That was a rate of progression which one could scarcely understand should have taken place during the past few years, when both the iron and coal trades, and every branch of manufacture were so depressed; a marked diminution might rather have been expected. Perhaps some gentleman present might have given attention to the subject, and could explain it, but he (Mr. S.) could hardly see how the output of coal and iron could go on increasing so much in the face of the bad times. It must be that there was some silent expansion of trade which was not observable. From the statistics which he had been able to obtain he believed that during the last ten or twelve years the population

[plate XXXIX. To illustrate Mr E.H. Living's paper “on a new method of detecting small quantities of inflammable gas.”]

[295]

had increased at the rate of from one-and-a-half to two per cent., and the output of coal seemed to be increasing at the rate of about three per cent. per annum.

Mr. Greenwell thought there was one way of accounting for it, which was this—That when any given number of tons of coal are worked in a year, and the same quantity of coal is worked in the following year, it is pretty clear that there has been no falling back in the trade; but if pits are sunk, and machinery is erected to raise double the quantity, and this causes each pit to work only half the time which was worked before, then every one said, "How very bad trade is." He thought that one great reason why it was said trade was bad was, there being so many more people and appliances to do the same amount of work.

Mr. Simpson—But there is more work done.

Mr. Greenwell—That showed trade was rather improving; but if there was no other very great increase in the powers of production than that which the trade naturally required, of course then only in proportion to the still further increased powers was there less employment for each individual employed; and if the quantity produced was maintained, and if each person or pit was only half employed instead of fully employed, it was not right to say trade was bad, for it was really because the powers had been increased too much.

Mr. Cochrane asked if Mr. Greenwell meant to argue that trade was not bad?

Mr. Greenwell said, he went upon the statistics of the matter. If they found that the quantity they raised was so much more than the country could take from them, and they put that quantity into the market and thereby created a competition amongst themselves, and made trade bad by over-supplying the market, and thus bringing down prices; and if they made the results still worse by increasing the demand for labour, it was burning the candle at both ends. They were paying dearer for their labour, and competing with each other for the sale of the coal which they produced.

Mr. Simpson said, the same remark would hold good with regard to the iron trade. The quantity of iron produced was greater than ever it was.

Mr. Greenwell said, the same argument would hold good.

The President asked Mr. Greenwell if he meant in England?

Mr. Greenwell said, he meant in England. The actual use of both minerals in this country was greater than in the previous year.

Mr. Weeks said, that showed that trade was good, but that prices

[296]

were bad; hence the complaint, and it had been brought about in the way Mr. Greenwell stated.

The President—Yes, by over production.

Mr. Weeks said, the production had increased and was going on in a greater ratio than the expansion of trade and the demand for coal.

The Scrutineers having made known the result of the voting for the election of officers, and Mr. G. C. Greenwell having been declared President,

Mr. Cochrane said, as Mr. Lindsay Wood would no longer occupy the chair which he had filled for the past three years so entirely to the satisfaction of the members, he (Mr. Cochrane) was sure they would all join in offering him their best thanks for the very able manner in which he had filled the office of President. He (Mr. Cochrane) need hardly remind the members of the important advantages they had acquired during Mr. Wood's occupancy of the presidential chair, and mainly by the strenuous efforts which he put forth to obtain for them the Royal Charter which they now possessed. He was sure that everybody connected with the Institute, who had seen the untiring efforts which Mr. Wood used to obtain that important concession, would consider that the Institute dated from his presidency a most important era in its history. Not only that, but his conduct of the whole of the business, both at the ordinary and Council meetings, and his studied attention and readiness at all times to be consulted, both by the officers and Secretary, had earned him the best thanks of the members. He was certain that the personal attention which Mr. Wood had paid to the affairs of the Institute during his presidency had been attended with very satisfactory results; and with all due respect to his successor, he would say that he would have his work set before him to follow in the footsteps of Mr. Wood and to do for the Institute the amount of good which he had done. The able manner also in which he had represented the Institute at the various meetings outside Newcastle during his presidency had been extremely satisfactory. To say more would, he thought, be to detain them unnecessarily, as they were all of the same opinion as himself with regard to the manner in which his duties as President had been performed, and he would therefore conclude by asking them to acknowledge by acclamation their appreciation of his very valuable services.

The President begged to thank them for the manner in which they

had received the remarks which Mr. Cochrane had made respecting him. He could only say that while he had been President of the Institute he had endeavoured to do his duty, and he did not think he had in any way done more than his duty. Indeed, he felt that he might have performed the duties more efficiently. Mr. Cochrane had been kind enough to refer to the success of their meetings which had been held in other towns than Newcastle; he thought it was not due to anything he had done, but to the efforts of the members themselves. With respect to his successor, he was sure that in Mr. Greenwell they had elected a gentleman who would most worthily fill the office. He had known Mr. Greenwell personally for a great number of years, in fact, ever since the establishment of the Institute, and he knew that he had taken very great interest in it from its commencement. He believed that in some of the very first papers which were written for it by his (Mr. Wood's) father, in 1852, he was assisted by Mr. Greenwell; and he was sure that in electing him they had elected a gentleman who was in every way well fitted for the office of President. He begged now to resign his position to Mr. Greenwell.

The President-Elect, on taking the chair, said, that if he was to have a future such as had been indicated for him by his friend, Mr. Cochrane, he was afraid he would be placed in a very difficult position—a position which he was perfectly certain he would not be able to fulfil. All he could say was that he would endeavour to do his best; and, if at the close of his presidency he could leave them with the same feelings which they had evinced towards Mr. Wood, he would be exceedingly proud, although he scarcely expected it. He little thought some five or six-and-twenty years ago, when one of those by whom this Institute was commenced, that he would be placed in the position he now occupied; and he would only say that he would do his best, and that they must excuse any shortcomings.

The discussion of Mr. Burns' paper on the "Intrusion of the Whin Sill" was then proceeded with.

Mr. Burns said, that when he read the paper on this subject there was one difficulty which occurred to him as militating against his theory, and that was, that if the intimate connection between the whin and the limestone was due to gases being given off by the heated whin acting on the limestone, it should apply also to the coal which would, he considered, give off gases similarly. He was very much pleased in walking through

Glasgow shortly after reading his paper to see the following note on one of the sheets of sections of the Scotch Geological Survey exposed in a window:—

"Geological Survey of Scotland—Vertical Sections, Sheet 3. Kilmarnock and Hurlford Coal-field. James Geikie. This coal-field is traversed in many places by intrusive sheets of dolerite, which vary considerably in thickness. Such igneous masses are often found to occupy the position of the coal seams, those latter having apparently formed lines of weakness along which the melted rock was prone to be intruded. Near Dolish, the coals invariably give evidence of having been subjected to the influence of great heat; sometimes the coal is entirely consumed, in other places it is converted into a kind of coke, and occasionally becomes altered into what is known as blind coal (anthracite), so called because it burns with little or no flame. The blind coal worked at Caprington, near Kilmarnock, is the same seam as the Hurlford stone coal or main seam of Allandale Colliery, and has assumed its present anthracitic character from the influence of a mass of dolerite intruded in its neighbourhood."

It would appear, then, that coal affords the same facility for the spread of those intrusive masses as limestone; and, taking coal as soft and limestone as hard, he did not see that this argument of weakness would hold. The only common ground which he could see between the two was the fact that both subjected to heat would give off gas, and that gas forming a little chamber in front of the mass determined the road it was to take. He referred in his paper to a black substance, which he had seen at the bottom of a limestone and on the top of the whin. He sent some down to his friend, Mr. Lebour, who had had it analysed, and possibly was prepared to state the result. He (Mr. Burns) might, however, explain that when he went back to the quarry it had been partially filled up, and he could not obtain the best qualities, and what he did get was mixed up with substances washed in from above. He was sorry Mr. Bewick was not present, as he had brought a diagram to show him. Mr. Bewick objected—and his large experience in mining matters gave his opinion great weight—that this theory of the intrusion of the whin sill was not borne out by deep sections. Now, the diagram (Plate XL.) showed a part of two sections in Weardale—the Burtree Ford Shaft and the Slitt Shaft— but it was only a small portion of them drawn to a large scale. The beds were perfectly identifiable in both shafts; there was no dispute whatever about that until the neighbourhood of the whin was reached. There was a bed known as the Cockle Shell Limestone, about two feet thick. It was a well known bed, full of *productus giganteus*, so well known that nobody disputed it; and it was to be seen in both shafts with many feet of section above it.

Mr. Burns then co-ordinated the strata as indicated by the dotted lines in the plate, and explained that the appearance of the limestones

bore out that view as well as their thicknesses. He stated that no value was to be attached to the names of the limestones near the whin, as miners invariably called the next limestones above the whin the Tyne Bottom Limestone because it was found there.

Mr. Lebour said, as Mr. Burns had alluded to some of the black stuff, as he called it, which he sent to him a short time ago, he (Mr. L.) might state that the substance was a black earthy one, and was placed by him in the hands of Mr. Dunn, the demonstrator in chemistry to the College of Physical Science. Mr. Dunn went through some experiments with it, and proved that in one of the samples there was about 13 per cent. of volatile matter, and in another, which had been previously sifted, there was as much as 17 per cent. of volatile matter—that was to say that 17 per cent. was burnt away. What that matter was there was no direct evidence to prove, but that it was to a great extent free carbon, he should think there was very little doubt. As Mr. Hedley, when Mr. Burns' paper was read, said that he (Mr. L.) had not brought all the evidence that he (Mr. L.) had published elsewhere concerning the intrusive character of the whin sill, he had thought that to-day he might perhaps save the Institute the further trouble of listening to more on this subject on a future occasion by bringing down and hanging on the wall diagrams representing the position of the whin as shown in a paper by Mr. Topley and himself, read before the Geological Society. The large diagram shown was lent by the Geological Society for the occasion. In it the horizon of the whin sill was shown by the pink colour as it varied from Alston Moor to Dunstanborough. The drawing was to the scale of about 400 feet to 15 inches. The blue represented the limestones which are the guiding lines to the geological horizons of the Carboniferous Limestone series of Northumberland. They would see it was at its deepest point at Rugley, where the whin was very low down in this series, whereas at Ward's Hill, and further on still, at Snab Leazes, it actually covered the Great Limestone. In one of the diagrams was a section of a pit at Shilbottle, and that section was interesting from its showing two sheets, or what appeared to be sheets, of whin; but what that whin was they did not know, and whether they were sheets which came from the whin sill, or mere overflows from neighbouring dykes, he was not at all in a position to say, but he thought the case was doubtful unless any gentleman could give positive evidence on the subject. These portions of it could not be examined now, and a record of the existence of those sheets of whin was therefore important. He pointed to a rough section of the Stonecroft shaft. There, one of the great lead veins of the district, which was also a

fault, threw the intrusive whin, as well as the beds amongst which it lay; but it did not follow, as it might perhaps be thought, that because the whin had followed the other beds there, it was necessarily contemporaneous with them. It simply showed that the vein was newer than either the whin or the beds among which it lay. The exact age of the whin was not known. Mr. Topley and himself hazarded a guess, based upon certain theoretical considerations, that the age was pre-Permian, but there was no true evidence on the subject, and it was indeed quite possible that some positive evidence might turn up to show that the age of the whin was similar to that of many of the whin dykes which run in a very orderly series through the North of England and South of Scotland. In that case it might possibly be as late as miocene. If that were proved it would follow that the vein at Stonecroft was post-miocene.

The President said, he would like to ask if the sections marked Ward's Hill and Elf Hills Quarry were taken from observations and exploration, or from supposition?

Mr. Lebour replied that the Elf Hills section was an actual drawing from the face of the quarry; the one at Ward's Hill was a diagrammatic sketch, and was based partly on inference of quite a conclusive character.

The President said there was just another point, namely, the section of the Shilbottle shaft. The members were aware that it had been very common in the north country to call any stratum of peculiarly hard rock, whin; and if it was only put down on the section as basalt upon such information as that, and no more, it was very possible it might not be basalt at all.

Mr. Lebour said, he thought the first observation of the whin in Shilbottle shaft was made by the late Mr. George Tate, geologist, of Alnwick, or at least was witnessed and corroborated by him. But Mr. George Bailes was present, to whom the geology of North Northumberland was extremely well known. He had been connected with the pits in the limestone series there for many years, and had been associated, he believed, with Mr. Boyd in his very admirable map of the northern portion of that Lower Carboniferous coal-field. Perhaps Mr. Bailes would throw light upon the subject, as he probably knew the Shilbottle sections much better than he himself did.

Mr. George Bailes said, he had no doubt that the section would be obtained from Mr. Wilson, who was manager of the Shilbottle Colliery, and a very able geologist and close observer, and to whom Mr. Tate was indebted for much information. Having been personally acquainted with Mr. Wilson, and knowing some of his maps and sections, he had no doubt but

that he knew the difference between the whin shown on the section and that hard rock which, as Mr. Greenwell said, was called whin by the miners. He (Mr. Bailes) quite agreed with Mr. Lebour as to the intrusive character of the whin sill, of which there are many proofs in the region in North-east Northumberland in which it occurs, and with which he was very well acquainted. Commencing from the Kyloe Hills in which the whin sill terminates to the north-west, and from which its course can be traced by its repeated escarpments, which present a rugged and jagged appearance through Dechant, Belford, Spindlestone, to Bamborough on the coast, this range of the whin sill is on the north side of the great anticline, and its dip with the other strata is to the north-east. The whin sill on the south side of the great anticline ranges from Dunstanborough on the coast, in a southwesterly direction by Craster, Ratcheugh Cragg, and Alnwick Moor, from which it continues through the south-west of Northumberland; the range of the whin sill dipping with the other strata to the south-east. The apex of the great anticline, in which the two ranges of the whin sill are found, is on the coast line from Beadnell to North Sunderland; it is narrowest on this line and to the east, but expands rapidly as it extends to the west. This anticlinal region, between the two ranges of the whin sill, is heavily and extensively fractured, and broken up by great faults; the great central fault is to be seen on the coast at North Sunderland, and runs nearly due west to the south of Chatton Moor, where it is split into different branches, which follow nearly the course of the strike of the strata through the country to the north and to the south, causing the repeated outcrops of the same series of strata which exist within that region; the faults running south from Chatton Moor were traced by the late Mr. G. Tate, of Alnwick, through Sweendykes, east of Ross Castle, at the head of Chillingham Park, east of Eglingham, past Alnwick and on to Rothbury, a course nearly parallel to the range of the whin sill to the east, and to the base of the Cheviot range to the west. One of the branches of this great fault can be traced in a northerly direction along the west side of the great escarpment of sandstone which is seen at Cuddy's Cave, Hazelrigg, Holborn, and Black Heddon. In its course to the north it appears in the banks of the Biver Low, and joins the other down-cast fault to the south, which runs to the west by Lickar, Bowsden, and Etal. All the limestones and coals which have cropped out between Fenham on the coast and the Kyloe Hills are, by this great fault, thrown down to the west about 400 fathoms; the tilted edges of the strata in the leader are visible on the surface, and are about 300 yards wide. A second outcrop of all the limestones and coals occurs between the great fault and

Doddington to the west; the whin sill is found to be 130 feet thick on the Kyloe Hills, in the series to the east of the fault, and its position is below the Dun limestone, which is the lowest limestone in the series. At Bamborough the whin sill is associated with the Acre limestone, which is the fifth from the bottom. There is not a single trace of the whin sill in the series to the west of the great fault along the base of the Kyloe Hills; this series ranges from Etal, through Ford, Barmoor, Hetton, Doddington, and Harton, a distance of 10 or 12 miles. Along the whole extent of this country hundreds of pits are sunk through the Dun limestone to the Fawcet coal seam, in none of which has any trace of the whin sill been found; even further east, in the country between the two ranges of the whin sill from the coast, where the faults have caused the repeated outcrops of the same series, no whin sill accompanies them. The whin sill does not exist in any part of the Scremerston field between the River Tweed and the whin dyke running from Etal through Bowsden to Holy Island. He submitted the above facts in support of the theory that the whin sill was injected among the other strata, after the deposition of the whole carboniferous series, and against the theory that it was formed by an overflow during the period of the deposition. A whin sill formed by an overflow can never occupy a position below and above the same bed, or a number of beds of limestone in the different parts of the same country; nor could it occur in great thickness and prominence in one outcrop of the series and be entirely left out of all the other outcrops of the same series in close proximity to it. He submitted that the existence of these numerous large faults which are running, many of them parallel to, and co-extensive with, the whin sill and the base of the Cheviot Hills, in that part of the country, indicate that, at the first break up of the carboniferous series, all the country between the range of the whin sill and the Cheviot Hills had gone down and injected the whin sill and the numerous whin dykes which traverse the carboniferous series in Northumberland and Durham. Consistent with this theory he would give reasons for the non-existence of the whin sill in the Scremerston field. At the period of the injection the lava would find vent in the Etal and Duddo whin dykes, from these dykes to the sea coast, from Scremerston Sea House to the mouth of the river, and even north of the Tweed. Both at the slip faults in this region and along this coast line, there were features to indicate that the whole had been acted upon by a force operating from beneath. The stratification along that part of the coast rises or outcrops at a high angle to the northwest ; this is peculiar to the coast line; a very short distance inland it bends over and runs level to the west along the strike. In following the

[303]

course of this ridge, or bend, to the north, across the River Tweed, there may be found in its lines the great protrusion of whin extending from the Berwick bounds to Lamberton, which comes out at the base of the great thick sandstone which occurs at the bottom of the limestone and coal series, as if the force exerted had not been sufficient to break, and fissure, and inject the whin in any part of the field occupied by the limestones and coals, but had found vent at that weaker part along a line where the greatest force had been exerted. He ventured, from these facts, to suggest that the great protrusion of whin in the Berwick bounds, north of the River Tweed, was of the same age, and was injected by the same force which injected the whin sill.

The meeting then terminated.

[304]

[Plate XL. Portions of sections of Burtree & Slitt shafts in Weardale, to illustrate the change of horizon of the Whin Sill in depth.]

[305]

PATENTS

The publication of the Chronological and Descriptive Index of Patents having terminated in December, 1875, The Secretary is reluctantly compelled to discontinue the List of Patents formerly issued with the Transactions.

[306]

[blank page]

[307]

APPENDIX

BAROMETER AND THERMOMETER READINGS FOR 1877.

By the SECRETARY.

These readings have been obtained from the observatories of Kew and Glasgow, and will give a very fair idea of the variations of temperature and atmospheric pressure in the intervening country, in which most of the mining operations in this country are carried on.

The Kew barometer is 34 feet, and the Glasgow barometer 180 feet above the sea level. The latter readings have been reduced to 32 feet above the sea level, by the addition of 150 of an inch to each reading, and both readings are reduced to 32 degrees Fahrenheit.

The fatal accidents have been obtained from the Inspectors' reports, and are printed across the lines, showing the various readings. The name of the colliery at which the explosion took place is given first, then the number of deaths, followed by the district in which it happened.

At the request of the Council the exact readings at both Kew and Glasgow have been published in figures.

[308]

[Barometer readings for Kew and Glasgow – Jan and Feb 1877]

[309]

[Barometer readings for Kew and Glasgow – March and April 1877]

[310]

[Barometer readings for Kew and Glasgow – May and June 1877]

[311]

[Barometer readings for Kew and Glasgow – June and July 1877]

[312]

[Barometer readings for Kew and Glasgow – Sept and Oct 1877]

[313]

[Barometer readings for Kew and Glasgow – Nov and Dec 1877]

[314]

[Diagrams showing the height of the barometer, the maxima and minima temperatures and the direction of the wind at the observatories of Kew and Glasgow, together with explosions of fire damp in England and Scotland for 1877]

[315]

INDEX TO VOL. XXVII.

Accidents in Prussia, &c, 50, 58 (See J. B. Simpson's paper *On Mining industries in Prussia*.)

Account of the condition of the mining industries of Prussia in the year 1875, by J. B. Simpson. (See *Mining industries*.)

Accounts, xii.

Advertisement, xi.

Analyses: Gloucestershire coal, 94. — Cornish iron ore and pig iron, 134.— Canadian coals, 215—241.

Anzin Mines, France, History of, 265.

Associate Members, xxxvii.

Bainbridge, Emerson; Discussion of his paper, "On different methods of lubricating coal-tubs or corves," 8. *Plate*. 3. Thomas', Hadfield's and other methods of greasing.

Barometer readings, Appendix. Diagrams. *Plates* 1, 2, 3, 4, Appendix.

Bernicourt pit, France, 255.

Billy-Montigny mines, France, 275.

Boiler, marine, new form of, by John Shaw, 9.

Boilers, mechanical stoking for, by Alex. Ross. (*See Mechanical*)

Bristol coal-field, Notes on the geology of, by Walter Saise, D.Sc. (See *Geology of*, &c)

Bully-Grenay mines, France, 279.

Bunning, C. Z., paper "A description of an instrument for levelling underground." (See *Description*.)

Burns, David, "On the intrusion of the whin sill." (See *Intrusion*.)

Butcher's furnace, 208.

Bye-laws, xlix.

Cail and Co.'s workshops at Denain, France, 272.

Canadian coals —their composition and uses, by Edwin Gilpin: Analyses of Cape Breton coals; arrangement of seams; sections of the following seams and analyses of the coal: — Hub seam, 215.—Harbour seam, Block House seam, 216.—Victoria seam, 218. — Sydney seam, 219. — McAulay seam, 221.—Phelan seam, 222. —Lingan main seam, 224.—South Head seam, Ross seam, 225.—Rollins' seam, 226.—Seam at Broad Cove, 228.—Pictou coal-field, 228.—Pictou main seam, 229. —Clay, ironstone, &c, 230.—Deep seam, 230.—Acadia seam, 231.—McBean seam, 232. Practical trials of the Pictou coals: The Springhill coal-field, 233. — New Brunswick coal, 235. — Coals of the North-west territory and British Columbia, 236.—Colorado, Wyoming, and Utah coals, 237.—Queen Charlotte Islands, 240.

Chabaud Latour pits, France, 268.

Charter, copy of, xliii.

Coal, Production of, in Germany, 1853, 1876, 26. (See J. B. Simpson's paper "*On mining industries in Prussia*")— Analyses of Gloucestershire coal, 94.

Coal-field, North of France, geological sketch of, by Henry Laporte. (See *Geological sketch*, &c.)

[316]

Coal-field: Notes on the geology of the Bristol coal-field, with special reference to the Gloucestershire basin, by Walter Saise, D.Sc. (See *Geology of*, &c.)

Coals, Canadian, their composition and uses, by Edwin Gilpin. (See *Canadian Coals*.)

Cochrane, Wm., his paper "On the advantages of centrifugal action machines for the ventilation of mines" discussed. (See *Ventilators*.)

Cockburn, Wm., his paper "On Cooke's ventilating machine" discussed. (See Ventilators.)

Coke, On increased economy in the manufacture of, by mechanical means, by Wm. Harle, 127.—Discussed, 128. Plates. 11. General elevation and plan of apparatus.—12. Front elevation, showing the mode of driving the belts and the elevator.—13. Side elevation, showing the mode of driving the elevator.—14. Plan showing the mode of driving the elevator.

Coke-ovens, Haveluy, France, 271.

Contents of volume, v.

Continent, On the present condition of mining in some of the principal coal-producing districts of, by T. Lindsay Galloway. (See *Mining*, &c.)

Cooke's ventilating machine, 100.

Coquillion's grisoumetre, exhibited, 97.

Cornwall, On the Perran iron lode in, by C. Parkin. (See *Perran*, &c.)

Council report, vii.

Courrieres mines, France, 274, 275.

Denain, Iron and steel works at, 257.—Cail and Co.'s workshops at, 272.

Description of an instrument for levelling underground, by T. Lindsay Galloway and C. Z. Bunning, 3.—Discussed, 6,128. —Description of a small instrument of similar construction for levelling over hilly districts, 129. *Plates*. 1. Sketch view to show method of levelling round a pillar.—2. The instrument.

Douai, Meeting at. (See *France*.)

Ecole des Mines, Paris, 281.

Economy in the manufacture of coke by mechanical means, by Wm. Harle. (See Coke.)

Engine-works at Anzin, de Quillacq's, 270.

Escarpelle pit, France, 255.

Exhibition at Paris, de Quillacq's winding engine at, 280.

Experiments : with gas, 66.—With ventilating machines at Upleatham, 106.— With Liveing's lamp to detect small quantities of gas, 293.

Finance Committee's report, ix.

Forms of nomination, 56.

France, A geological sketch of the northern coal-field of, by Henry Laporte. (See Geological sketch, &c.)

France, Meeting in, 245.—-Assembly at Douai. —Address by M. Vuillemin, 245. —Discussion of Mr. Laporte's paper,— A geological sketch of the northern coal-field of France, 249.—Visit to the Aniche Mines, 253.—Gayant coke-ovens and pit, 254.—The Bernicourt and Escarpelle pits, 255.—Patent fuel works at Somain, 256.—The Renaissance pit.— The iron and steel works at Denain, 257.—History of the Anzin Mines, 265. —The Chabaud Latour pits. — The Thiers pit, 268.—Engine works of M. de Quillacq, 270. — The Haveluy pits and coke-ovens, 271.—The Renard pit. -—Messrs. Cail and Co.'s workshops at Denain, 272.—The Courrieres Company. —The Harnes shipping basin and wharf, 274.—Billy-Montigny, Courrieres No. 5 pit, 275.—The Lens Company, 276.— Lievin No. 5 pit, 278.—Bully-Grenay, 279.—Winding-engine, by M. de Quillacq, at the Paris Exhibition, 280.—

Museum of the School of Mines, 281.—Conclusion, 281. *Plates*.29. Buildings at the Renaissance pit, Aniche. — 30. Plan of the Denain Steel Works.—31. General plan of the Renard pits, Anzin.—32. General arrangement of the Renard pit No. 2, Anzin.—33. Longitudinal section through the boiler-shed, engine-house, and screens of the Renard No. 2 pit. —34. Sectional plan of the boiler-shed, engine house, and screens of the Renard No. 2 pit.—35. Plan and elevation of buildings at the No. 5 pit, Lens.—36. Elevation and sections of the engine-house at Bully-Grenay.—37. Plan of ditto.—38.

Winding-engine by M. de Quillacq, of Anzin, on the Sulzer-Martin system; skeleton sketch of valve gear. Fuel works at Somain, France, 256.

Galloway, T. Lindsay, A description of an instrument for levelling underground. (See *Description.*) On the present condition of mining in some of the principal coal-producing districts of the continent. (See *Mining*, &c.)

Gas, A. L. Steavenson's paper," On an improved method of detecting small quantities of inflammable gas," discussed, 65.

Gas, A new method of detecting small quantities of, by E. H. Liveing. (See *New Method*.)

Gas, Experiments with, 66.

Gayant coke-ovens and pit, France, 254.

General statement of accounts, xvi.

Geological sketch of the northern coalfield of France, by Henry Laporte, 143. —Extent of the coal-field, 143.—Covering strata, etc., 144.—The "Boulonnais" coal-field, 148.—Production, 151.—Output in 1875-76-77, 152.—Companies in the northern coal-field of France, 152.—Descriptions of coal raised, 153. —Workmen and wages, 154. — The Anzin mines, 155.—Azincourt, Escarpelle, etc., mines — The "Lens" Company, 158.—The "Carvin," "Meurchin," and "Bully-Grenay" companies, 159.— The "Vicoigue-Noeux" concession, 160. —The "Bruay," "Marles," and "Ferfay" companies, 161.— Statistical information on the coal-fields — Names and dates of origin of the different companies, 163. — Market value of the capital employed in the collieries of the department of the Nord and of the Pas de Calais in 1873 and 1874, 164-5. —Consumption of coal, 166.—Coal sent from the different stations of the North of France—Railway and cost of transport in 1873,167.—Wages of workmen, 168.—Value of the quantities extracted, 169. *Plates*. 18. Map of the northern coal-field of France.—19. Sketch map showing position of pits at Ferques and Hardinghem. — 20. The "Boulonnais" coal-field.—21. Section through the Valenciennes coal-field. Discussed, 249.—Plate.—28. Sketch illustrating Prof. Gosselet's remarks.

Geology of the Bristol coal-field, Notes on, with special reference to the Gloucester basin, by Walter Saise, D.Sc., 87.— Formation of the coal-field, 88.—Strata, 89.—Quality of the coal—Methods of working, 92-96.—Analysis of coal, 94. —Quantity of coal in the basin, 95.— Faults, etc., 96. *Plates*. 6. Sketch map of the Bristol coal-field. —7. Diagrammatic section of the coal-field. — 8. Vertical section of strata in Gloucestershire, with pit sections arranged for comparison.—9. Method of working coal on the lower series at Kingswood.

Gilpin, Edwin, On Canadian coals: their composition and uses. (See *Canadian*.)

Glass, coloured, used for detecting gas, 65. Gloucestershire coal-basin. (See *Geology of*, &c.)

Gosselet, Professor, Remarks on the geology of the northern coal-field of France, 250.

Greenwell, G. C, Elected president, 296.

Greyside lead mines. (See *Visit to*.)

Grisoumetre, Coquillion's, exhibited, 97.

Hall, Henry, Telephonic ventilation tell-tale. (See *Telephonic.*)

Harle, Wm., On increased economy in the manufacture of coke by mechanical means. (See *Coke*.)

Harnes shipping basin and wharf, 274.

Haveluy pits and coke-ovens, 271.

Honorary members, xviii. Hunter's stone-dressing machine, 15.

Increased economy in the manufacture of coke by mechanical means, by William Harle. (See *Coke*.)

Instrument for levelling underground, Description of, by T. Lindsay Galloway and C. Z. Bunning. (See *Description*.)

Intrusion of the Whin sill, by David Burns, 73.—Discussed, 78, 297. Plate. 5. Sections of strata illustrating the paper.

Iron (Perran) lode in Cornwall, On the, by C. Parkin. (See *Perran,* &c.)

Iron and steel works at Denain, France, 257.

Jukes' furnace, 206.

Laporte, Henry, A geological sketch of the northern coal-field of France. (See *Geological sketch*, &c.)

Lead Mines, Stonecroft, Greyside, and Settlingstones. (See *Visit to*).

Lens company, France, 276.

Levelling underground, Description of an instrument for, by T. Lindsay Galloway and C. Z. Bunning. (See *Description*.)

Lievin pits, France, 278.

Life members, xviii.

Liveing, E. H., On a new method of detecting very small quantities of inflammable gas. (See *New method.*)

Lubricating coal tubs or corves; E. Bainbridge's paper discussed, 8.

Marine boiler, new form of, by John Shaw, discussed, 9.

Mechanical stoking for colliery boilers, by Alexander Ross, 205.—Jukes' furnace, 206.—Vicar's furnace, 207.—Butcher's furnace, 208.—Discussed, 209. Plates. 26 and 27. Butcher's apparatus.

Mechanical ventilators, Discussion on. (See *Ventilators*.)

Members, Honorary, xviii.—Life, xviii. —Original, xx. — Ordinary, xxxvii.— Associate, xxxvii.— Students, xxxviii.

Mining industries of Prussia, An account of the condition of, in 1875, by J. B. Simpson, 25. — Tables showing total German production of coal in the years 1853-1876, Imports and exports, 1860-1872, Output of Westphalian coal, 1737-1875, Output of the Saarbrucken coal-field, 1817-1861, Lower Silesian coal-field, 1740-1860, Upper Silesian coal-field, 1790-1873, Plauen and Zuickau, 1850-1867, 26-29, General position of the mining industry in 1875, 29. —The collieries, 31. —Summary of the mining productions, their value, number of works and men.—The Government coal, lignite, and iron mines, 36.— Researches, 37.—Government grants, 40.—Mine taxes, mining colleges, and schools, 41.—Mining laws and mining police, 42.—Transport, 43.—Condition of the men employed, 45.

[319]

—Economical and moral situation of the men, etc., 49. —Accidents, 50, 58. — Experiences in mechanical and other contrivances gained in 1875, 52.—Output per man per annum, 58.—Tables showing number and causes of accidents, output of coal, value, etc., 60-63.—Discussed, 64 and 294.

Mining in some of the principal coal-producing districts of the Continent, On the present condition of, by T. Lindsay Galloway, 171.—Mines of the North of France : Mines of Aniche, 171.—Shaft arrangements: Section of the "Conche de Nord," 172.—Wages and prices, 173. —Mines of Anzin: Method of working inclines, 174.—Hours, wages, and prices. —Fuel works, 175. —Mines of Belgium: Produits mines, 176.—Sections of the "Veine a la pierre," the "Georges" seam, and the "Petit feuillet" seam, 177.—Female labour underground, 177. Shafts, ventilators, coke-ovens, 178.— Mines of l'Agrappe and Grisoeul: Vertical workings, 179.—Air-compressors, 180.—Rock drills.—Mines of Mariemont and Bascoup.—Mechanical screens, 181. — Surface haulage. — Underground haulage, 182.—Man engines.—Pumping engine, 183.—Electric light.—Hazard pit.—Workmen's hotel, 184.—Mines of Saarbruck: Production. — Gerhard mines, 185.—Dudweiler mines: Section of Blucher seam.—Method of working, 186.—Counterbalance.—Iron frames for propping, 187.—Heinitz colliery, 188.— Hydraulic pump.—Mining theodolites, 189.—Mines of Upper Silesia: Königin Luise mines.—Method of working, 190. —New winning.-—Konigs mines, 191.— Mines of Bohemia: Production.-- Mines at Kladno, 192.—Method of working.— Prices, 193.—Mines of Westphalia: Production.—Railway charges, 194.— Westphalia company.—Method of working.—Rock drill, 195.—Coal-washing.— Rope counterbalance, 196. — New Manning, by Messrs. Krupp and Company, 197.— Consolidation mines: Heinrich Gustav colliery, 198.—Section of No. 12 seam, 198.—Underground pump. —Coke-ovens, 199.—English and foreign mines compared, 200. *Plates*. 22. Illustrating the tailles-montantes and tailles-chassantes methods of working.—23. Inclined plane, vertical working, counterbalancing.—24. Method of working the 23-feet seam of coal at the Königin Luise mines.— 25. Method of working at the Kladno mines.

New method of detecting very small quantities of inflammable gas, and of estimating the proportion present, by Mr. E. H. Liveing, 287.—Discussed, 289.— Experiments with lamp, 293. Plate. 39. Illustrating the apparatus.

Nomination of members, forms of, 56.

Northern coal-field of France, A geological sketch of, by Henry Laporte. (See *Geological sketch*.)

Notes on the geology of the Bristol coal-field, by Walter Saise, D.Sc. (See *Geology of*, &c.)

Officers, xix.

Ordinary members, xxxvii.

Original members, xx.

Paris Exhibition, De Quillacq's winding engine at, 280.

Parkin, Charles, On the Perran iron lode in Cornwall. (See *Perran*, &c.)

Patents, 305.

Patrons, xvii.

Perran iron lode in Cornwall, and the mines in the district, by Charles Parkin, 131.—General description.—Extent, 131. —Composition of the ore, 132.—Analyses of brown hematite, white spathose,

and pig iron, 134.—Cost of working, wages, &c, 135.—Description of mines working upon the lode, 135. Plates. 15. System of the Cornwall minerals railway, showing its connection with the mines of the Perran iron lode.—16. Longitudinal section of some workings on the Perran iron lode.—17. Sketch of working plan, Deer-park mines.

Prudham quarries. (See Visit to.)

Prussia, An account of the mining industries of, in 1875, by J. B. Simpson. (See *Mining Industries*.)

Quarries, Prudham. (See *Visit to.)*

Quillacq's engine-works at Anzin, France, 270.

Quiliacq's winding-engine at the Paris Exhibition, 280.

Renaissance pit, France, 257.

Renard pit, France, 272.

Report of Council, vii.

Report of Finance Committee, ix.

Ross, Alex., On mechanical stoking for colliery boilers. (See *Mechanical*.)

Royal Charter, copy of, xliii.

"Royal Dane," coal consumed, 10.

Rules, xlix.

Saise, Walter, On the geology of the Bristol coal-field, with special reference to the Gloucestershire basin. (See *Geology of*, &c.)

School of Mines, Paris, 281.

Sections: Strata illustrating D. Burns' paper "On the intrusion of the whin sill," Plate 5.—Diagrammatic section of the Bristol coal-field, Plate 7.— Vertical section of strata in Gloucestershire, with pit sections arranged for comparison, Plate 8.—Continental coal seams, namely, "Conche du Nord," at Aniche, 172; "Veine a la pierre," "Georges," and "Petit feuillet." in Belgium, 177; No. 12 seam, Consolidation mines, 198.—Through the Valenciennes coal-field, Plate 21.—Canadian coal seams, 215, 241.

Settlingstones lead mines. (See *Visit to*.)

Shaw, John, Discussion of his paper on a new form of marine boiler. 9.

Simpson, J. B., An account of the mining industries of Prussia, by. (See *Mining Industries*)

Somain, patent fuel works at, 256.

Steavenson, A. L., his paper, "On a method of detecting small quantities of inflammable gas," discussed, 65.

Steel works at Denain, France, 257.

Stoking (mechanical) for colliery boilers, by Alex. Ross. (See *Mechanical*, &c.)

Stonecroft lead mines. (See *Visit to*.)

Stone-dressing machine, Hunter's, 15.

Students, xxxviii.

Subscribing collieries, xlii.

Subscriptions, account of, xii.

Tail-ropes: appointment of a committee to consider the advisability of obtaining a further report, 99.

Telephonic ventilation tell-tale, by Henry Hall, 121.

Thiers pit, France, 268.

Treasurer's accounts, xiv.

Underground levelling, Description of an instrument for, by T. Lindsay Galloway and C. Z. Bunning. (See *Description*.)

Ventilation tell-tale, telephonic, by Henry Hall. (See *Telephonic, &c*.)

Ventilators, mechanical, Discussion on, 100. —Remarks by John Cooke, 100.— Results of experiments at Upleatham, 106.—Summary of working duties of Guibal ventilators, 107.—Consideration of the appointment of a committee to report upon ventilators referred to the council, 119.

Vicars' furnace, 207.

Visit to the Stonecroft and Greyside lead mines, the Prudham quarries, and the Settlingstones lead mines, 15.—Benson's colliery, limeworks, and quarries: Hunter's stone-dressing machine; boring, sawing, and planing machines, 15.— Selenitic works—limekilns—the Prudham stone, 16.—Geological features of the neighbourhood, 17.—The Stonecroft mines, 18.—Sketch showing the position of the veins, method of working, 19.— Screening, washing, crushing, etc., 20.—Sketch of "dolly-tub," 21.—Pumping, 21. — Settlingstones, Description of Mines, &c, 22. Plate. 4. Sketch of "circular buddle."

Vuillemin, M., Address by, at the meeting in France, 245.

Whin sill, Intrusion of, by David Burns. (See *Intrusion*.)

Winding-engine, Quillacq's, at the Paris Exhibition, 290.