NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS

TRANSACTIONS

VOL. XXIII

1873-74.

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

1874.

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1873

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REPORT

The Council, in presenting their Annual Report to the Members, have again to announce the continued prosperity of the Institute, 86 new members having been elected during the past year. The total number now on the register, after deducting losses by deaths and resignations, is 779, being a net increase of 56 over the preceding year, and considerably above the average number annually elected.

The Papers read since last August, though not numerous, contain much useful information, and will form a valuable addition to the Proceedings of the Institute. Mr. T. F. Hedley's Paper, "On the Valuation of Mines for the Purposes of Rating," will, no doubt, be of much interest to colliery owners, the subject matter having been treated of only once before in the Transactions, namely, in 1865, when Mr. G. C. Greenwell read a Paper on the subject.

It will be remembered that in October, 1872, it was resolved that Prizes of Books, not exceeding £50 in value, should be awarded annually to writers of such Papers, afterwards printed in the Transactions, as the Council should recommend; and, in pursuance of this resolution, the first distribution has taken place, the sum of £25 having been awarded for the following Papers which appeared in Vol. XXII. of the Transactions, namely:—

"On the Experience afforded in the Manufacture of Coke during the last Twelve Years," by Mr. A. L. Steavenson.

"On Coppée's Patent Coke Ovens, and the extent to which their Waste Gases can be Utilized," by Mr. Emerson Bainbridge.

"On the Geology of the Redesdale Ironstone District," by Mr. G. A. Lebour.

"On the Pictou Coal-Field," by Mr. E. Gilpin.


And the compilation of the "Barometer and Thermometer Readings at Kew and Glasgow, List of Patents," etc., by the Secretary.

It was stated in the Report of last year that arrangements had been made to publish, in a separate volume, the Sections of Strata contained in

the Boring and Strata Books of the late Mr. John Watson, and that, in order to make the volume additionally valuable as a reference, it had been decided that the members of the Institute should be
invited to contribute such descriptions of borings and sinkings as they might be willing to have published. In reply to this invitation, particulars of a large number of sinkings and borings have been received, and many more are promised. The progress of the work has necessarily been somewhat slow, but it is hoped the volume will soon be ready for publication.

During the past year, arrangements have been made with the following Societies for an exchange of Transactions:—

The Civil Engineers of Ireland.

The Cleveland Institute of Engineers.

Les Ingenieurs Civils de France.

In December, 1873, a Deputation from the Institute of Colliery Engineers waited upon the Council, with a view to effecting an arrangement whereby their members might join this Institute on payment of a reduced subscription. As it appeared such a proceeding would involve a change in the Rules of this Institute, a Committee was appointed to give the subject consideration. This Committee having subsequently recommended that no such change should be made, the application was declined.

On the recommendation of the Council, it was decided last year that the surplus funds of the Institute should be invested in shares of the Institute and Coal Trade Chambers Co. Limited, and that the sum of £2,000, invested with the Tyne Commissioners, should be withdrawn, and applied for that purpose, as opportunity occurred.

Shares to the amount of £2,040 have already been bought up, upon which a dividend, at the rate of £6 per cent., was received last March, for the year then ending, which is a much higher rate of interest than was received when the money was invested with the Tyne Commissioners, and a yet more important advantage is gained by the step, in securing to the Institute the building which it now partly occupies as offices, and of which it may thus, in the course of a few years, become wholly possessed.

ADVERTISEMENT

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

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FINANCE REPORT

The Finance Committee have to report that the income for the past year shows an increase, as compared with the preceding year, of £214 5s. 7d. The receipts, from all sources, in 1872-3 being £1,730 12s. 1d., and in 1873-4, £1,944 17s. 8d.

The expenditure has been £510 10s. 9d. below the income of the year. In accordance with the recommendation of the Council, agreed to by the General Meeting in June, 1873, the Stephenson legacy of £2,000, invested with the Tyne Commissioners, has been withdrawn for the purchase of shares in the Institute and Coal Trade Chambers Co. Limited, and the Committee recommend that a similar investment be made of the present surplus funds.

Signed on behalf of the Finance Committee,

WILLIAM COCHRANE.

[see in original text Table of the treasurer in account with subscriptions, 1873-74.]

[see in original text Table of the treasurer in account with subscriptions, 1873-74.]

[see in original text Table of treasurer in account with the north of England Institute of Mining and Mechanical Engineers.]

[see in original text Table of treasurer in account with the north of England Institute of Mining and Mechanical Engineers.]

[see in original text General Statement, July 1874]
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 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

WILLIAM ALEXANDER, Esq., Inspector of Mines, Glasgow 1863

*JAMES P. BAKER, Esq., Inspector of Mines, Wolverhampton 1853 1866

LIONEL BROUGH, Esq., Inspector of Mines, Clifton, Bristol 1855

JOSEPH DICKINSON, Esq., Inspector of Mines, Manchester 1853

THOMAS EVANS, Esq., Inspector of Mines, Pen-y-Bryn, Duffield Road, Derby 1855

PETER HIGSON Esq., Inspector of Mines, 94, Cross Street, Manchester 1854 1856

*RALPH MOOR, Esq., Inspector of Mines, Glasgow 1866

*G. W. SOUTHERN, Esq., Inspector of Mines, 17, Wentworth Place, Newcastle-upon-Tyne 1854 1866

*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, 13, Old Elvet, Durham 1857 1871
THOMAS WYNNE, Esq., Inspector of Mines, Stone 1853
SIR GOLDSWORTHY GURNEY, Bude Castle, Cornwall 1853
CHARLES MORTON, Esq., Ex-Inspector of Mines 1853
R. P. PHILIPSON, Esq., Newcastle-upon-Tyne 1874
WARINGTON W. SMYTH, Esq., 28, Jermyn Street, London 1869
The Very Rev. Dr. LAKE, Dean of Durham 1872
PROF. A. FREIRE-MARRECO, M.A., College of Physical Science, Newcastle 1872
„ A. S. HERSCHEL, B.A., F.R.A.S., College of Physical Science, Newcastle 1872
„ W. S. ALDIS, M.A., College of Physical Science, Newcastle 1872
Dr. DAVID PAGE, LL.D., College of Physical Science, Newcastle 1872
M. DE BOUREUILLE, Commandeur de la Legion d'Honneur, Conseiller d'etat, Inspecteur General des Mines, Paris 1853
Herr R. von CARNALL, Berghauptmann, Ritter, etc., Breslau Silesia, Prussia 1853
Dr. H. von DECHEN, Berghauptmann, Ritter, etc., Bonn am Rhine, Prussia 1853
M. THEOPHILE GUIBAL, School of Mines, Mons, Belgium 1870

* Honorary Members during term of office only.

LIFE MEMBERS

E. B. COXE, Esq., Drifton, Jeddo, P.O., Luzerne Co., Penns., U.S. 1873 1874
H. J. MORTON, Esq., Garforth House, West Garforth, near Leeds 1856 1861
W. A. POTTER, Esq., Cramlington House, Northumberland (Member of Council) 1853 1874

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OFFICERS, 1874-75,

PRESIDENT

VICE-PRESIDENTS

WM. ARMSTRONG, Sen., Pelaw House, Chester-le-Street.


WM. COCHRANE, St. John's Chambers, Grainger Street West, Newcastle.

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

JOHN MARLEY, Mining Offices, Darlington.

A. L. STEAVENSON, Durham.

COUNCIL

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

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

THOS. DOUGLAS, Pease's West Collieries, via Darlington.

WM. GREEN, Jun., Thornelly House, Blaydon-on-Tyne.

THOS. HAWTHORN, 74, Rye Hill, Newcastle-on-Tyne.

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

R. HODGSON, Whitburn, near Sunderland.

Col. JOICEY, Quay, Newcastle-on-Tyne.

H. LAWS, Grainger Street West, Newcastle-on-Tyne.

D. P. MORISON, Collingwood Street, Newcastle-on-Tyne.

JAMES NELSON, King's House Engine Works, Sunderland.

Capt. NOBLE, Jesmond, Newcastle-on-Tyne.

W. A. POTTER, Cramlington House, Northumberland.


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

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

JAMES WILLIS, 13, Old Elvet, Durham.

W. H. WOOD, West Hetton, Ferry Hill.
Ex-officio

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

Sir GEO. ELLIOT, Bart., M.P., Houghton Hall, Fence Houses.

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

JOHN DAGLISH, F.G.S., Tynemouth.

R. S. NEWALL, Ferndene, Gateshead.

Past presidents

Past presidents

SECRETARY AND TREASURER

THEO. WOOD BUNNING, Newcastle-on-Tyne.

LIST OF MEMBERS

AUGUST, 1874.

ELECTED.

1 Ackroyd, Thomas, Berkenshaw, Leeds Mar. 7, 1867
2 Adams, G. F., Guildhall Chambers, Cardiff Dec. 6, 1873
3 Adams, W., Cardiff 1854
4 Ainslie, Aymer, Iron Ore Master, Ulverston Aug. 7, 1869
5 Aitken, Henry, Falkirk, N.B Mar. 2, 1865
6 Allison, T., Belmont Mines, Guisbro' Feb. 1, 1868
7 Anderson, C. W., St. Hilda Colliery, South Shields Aug. 21, 1852
8 Anderson, William, Rainton Colliery, Fence Houses Aug. 21, 1852
9 Andrews, Hugh, Eastfield Hall, Bilton, Northumberland Oct. 5, 1872
10 Appleby, C. E., Renishaw Colliery, near Chesterfield Aug. 1, 1861
11 Archbold, James, Engineer, Ryton-on-Tyne Feb. 1, 1873
12 Archer, T., Dunston Engine Works, Gateshead    July 2, 1872
13 Arkless, John, Tantoby, Burnopfield    Nov. 7, 1868
15 Armstrong, William, Senior, Pelaw House, Chester-le-Street,(Vice-President) Aug. 21, 1852
16 Armstrong, W., jun., Wingate, Co. Durham    April 7, 1867
17 Armstrong, W. L., 5, Hawthorn Terrace, Newcastle    Mar. 3, 1864
18 Ashwell, H., Anchor Colliery, Longton, No. Staffordshire    Mar. 6, 1862
19 Asquith, T. W., Seaton Delaval Colliery, Northumberland    Feb. 2, 1867
20 Attwood, C, Holywood House, Wolsingham, Darlington    May 7, 1857
21 Aubrey, R. C, Astley House, Woodlesford, near Leeds    Feb. 5, 1870
22 Austin, C. D., 40, Mosley Street, Newcastle    July 2, 1872
23 Aynsley, Wm., West Stanley Colliery, Chester-le-Street    Mar. 3, 1873
24 Bachke, A. S., Ytterven Mines, near Drontheim, Norway    Mar. 5, 1870
25 Bagnall, T., jun., Milton Ernest Hall, Bedford    Mar. 6, 1862
26 Bailes, John, Wingate Colliery, Ferryhill    Sept. 5, 1868
27 Bailes, T., jun. 41, Lovaine Place, Newcastle-on-Tyne    Oct. 7, 1858

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ELECTED.

28 Bailey, G., St. John's Colliery, Wakefield    June 5, 1869
29 Bailey, Samuel, The Pleck, Walsall, Staffordshire    June 2, 1859
30 Bailey, W. W., Kilburn, near Derby    May 13, 1858
31 Bainbridge, E., Nunnery Colliery Offices, Sheffield    Dec. 3, 1863
32 Barclay, A., 54, St. Vincent Street, Glasgow    Dec. 6, 1866
33 Barkus, Wm., Tynemouth    Aug. 21, 1852
34 Barnes, R. J., Atherton Collieries, near Manchester    Sept. 13, 1873
35 Barnes, T., Seaton Delaval Office, Quay, Newcastle    Oct. 7, 1871
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<th>Date</th>
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<td>36</td>
<td>Bartholomew, C.</td>
<td>Doncaster, Yorkshire</td>
<td>Aug. 5, 1853</td>
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<td>37</td>
<td>Bassett, A.</td>
<td>Tredgar Mineral Estate Office, Cardiff</td>
<td>1854</td>
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<td>38</td>
<td>Bates, Matthew</td>
<td>Cyfarthfa Iron Works, Merthyr Tydvil</td>
<td>Feb. 1, 1868</td>
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<tr>
<td>39</td>
<td>Bates, Matthew</td>
<td>Bews Hill, Blaydon-on-Tyne</td>
<td>Mar. 3, 1873</td>
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<td>40</td>
<td>Bates, Thomas</td>
<td>Heddon, Wylam, Northumberland</td>
<td>Mar. 3, 1873</td>
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<td>41</td>
<td>Bates, W. J.</td>
<td>Bews Hill, Blaydon-on-Tyne</td>
<td>Mar. 3, 1873</td>
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<td>42</td>
<td>Batey, John</td>
<td>Newbury Collieries, Coleford, Bath</td>
<td>Dec. 5, 1868</td>
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<td>43</td>
<td>Beacher, E.</td>
<td>Chapeltown, near Sheffield</td>
<td>1854</td>
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<td>44</td>
<td>Beanlands, A.</td>
<td>North Bailey, Durham</td>
<td>Mar. 7, 1867</td>
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<tr>
<td>45</td>
<td>Bell, I.</td>
<td>Lowthian, Washington, Washington Station, N.E. Railway (Vice-President)</td>
<td>July 6, 1854</td>
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<td>46</td>
<td>Bell, John</td>
<td>Normanby Mines, Middlesbro'-on-Tees</td>
<td>Oct. 1, 1857</td>
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<td>47</td>
<td>Bell, J. T.</td>
<td>Wolsingham, via Darlington</td>
<td>May 2, 1874</td>
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<td>48</td>
<td>Bell, Thomas</td>
<td>Jesmond, Newcastle-upon-Tyne</td>
<td>Sept. 3, 1870</td>
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<tr>
<td>49</td>
<td>Bell, T., jun.</td>
<td>Britannia Terrace, Saltburn-by-the-Sea</td>
<td>Mar. 7, 1867</td>
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<td>50</td>
<td>Benson, T. W.</td>
<td>Newgate Street, Newcastle</td>
<td>Aug. 2, 1866</td>
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<tr>
<td>51</td>
<td>Berkley, C.</td>
<td>Marley Hill Colliery, Gateshead</td>
<td>Aug. 21, 1852</td>
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<tr>
<td>52</td>
<td>Bewick, T. J.</td>
<td>M. Inst. C.E., F.G.S., Haydon Bridge, Northumberland</td>
<td>April 5, 1860</td>
</tr>
<tr>
<td>53</td>
<td>Bidder, B. P.</td>
<td>Duffryn Collieries, Neath, Glamorganshire</td>
<td>May 2, 1867</td>
</tr>
<tr>
<td>54</td>
<td>Bidder, S. P.</td>
<td>24, Great George Street, Westminster, London, S.W.</td>
<td>Dec. 4, 1869</td>
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<tr>
<td>55</td>
<td>Bigland, J.</td>
<td>Bedford Lodge, Bishop Auckland</td>
<td>June 4, 1857</td>
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<td>56</td>
<td>Binns, C.</td>
<td>Claycross, Derbyshire</td>
<td>July 6, 1854</td>
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<td>57</td>
<td>Biram, B.</td>
<td>Peasely Cross Collieries, St. Helen's, Lancs.</td>
<td>1856</td>
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<td>58</td>
<td>Birkbeck, G. H.</td>
<td>34, Southampton Buildings, Chancery Lane, London</td>
<td>Dec. 7, 1867</td>
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<tr>
<td>59</td>
<td>Black, James, jun.</td>
<td>Portobello Foundry, Sunderland</td>
<td>Sept. 2, 1871</td>
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<tr>
<td>60</td>
<td>Black, W.</td>
<td>Hedworth Villa, South Shields</td>
<td>April 2, 1870</td>
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<td>61</td>
<td>Blagburn, C.</td>
<td>Quay, Newcastle</td>
<td>Sept. 2, 1871</td>
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<td>62</td>
<td>Blandford, Thomas</td>
<td>Corbridge, Northumberland</td>
<td>Feb. 14, 1874</td>
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</table>
63  Bolckow, H. W. F., M.P., Middlesbro'-on-Tees  April 5, 1855

64  Bolton, H. H, Newchurch Collieries, near Manchester  Dec. 5, 1868
65  Boot, J. T., M.E., The Orchards, Hucknall, near Mansfield  April 1, 1871
66  Booth, R. L., South Tyne Colliery, Haltwhistle  1864
67  Borries, Theo., Quay, Newcastle  April 11, 1874
68  Bouch, W., Shildon Works, Darlington  June 4, 1870
69  Bourne, Peter, 39, Rodney Street, Liverpool  1854
70  Bourne, S., West Cumberland Hematite Iron Works, Workington  Aug. 21, 1852
71  Boyd, E. F., Moor House, near Durham (Past President, Member of Council)  Aug. 21, 1852
72  Boyd, Wm., 74, Jesmond Road, Newcastle (Member of Council)  Feb. 2, 1867
73  Bradford, Geo., Newbottle Colliery, Fence Houses  Oct. 11, 1873
74  Breckon, J. R., Park Place, Sunderland  Sept. 3, 1864
75  Brettell, T., Mine Agent, Dudley, Worcestershire  Nov. 3, 1866
76  Briart, A., Ingénieur en chef des Charbonnages de Mariemont et de Bascoup, Mons  Sept. 2, 1871
77  Brogden, James, Tondu Iron and Coal Works, Bridgend Glamorganshire  1861
78  Brougham, the Hon. Wilfred, Brougham, Penrith  May 6, 1871
79  Brown, E., 27, Cromwell Street, Newcastle  Mar. 7, 1874
80  Brown, John, Littleworth, Hednesford, near Stafford  Oct. 5, 1854
81  Brown, J. N., 56, Union Passage, New St., Birmingham  1861
82  Brown, Ralph, Ryhope Colliery, Sunderland  Oct. 1, 1863
83  Brown, Thos. Forster, Guildhall Chambers, Cardiff  1861
84  Browne, B. C., Assoc. M.I.C.E., North Ashfield House, Newcastle-on-Tyne  Oct. 1, 1870
85  Bruton, W., M.E., Whitwood Collieries, near Normanton  Feb. 6, 1869
86  Bryham, William, Rosebridge, &c, Collieries, Wigan  Aug. 1, 1861
87  Bryham, W., jun., Douglas Bank Collieries, Wigan  Aug. 3, 1865
88  Bunn, R. T., Grey Street, Newcastle  Dec. 6, 1873
89  Bunning, Theo. Wood, Neville Cottage, Newcastle-on-Tyne (Secretary and Treasurer) 1864
90  Burn, James, The Avenue, Sunderland  Aug. 2, 1866
91  Burrows, James, Douglas Bank, Wigan, Lancashire  May 2, 1867
92  Cabry, J., Blyth and Tyne Railway Offices, Newcastle  Sept. 4, 1869
93  Caldwell, George, Moss Hall Colliery, near Wigan  Mar. 6, 1869
94  Campbell, James, Staveley Works, Chesterfield  Aug. 3, 1865
95  Carr, Charles, Waterhead, Windermere  Aug. 21, 1852

96  Carr, Matthew, Scotswood, Newcastle-on-Tyne  May 3, 1873
97  Carr, Wm. Cochrane, South Benwell, Newcastle  Dec. 3, 1857
98  Carrington, T., jun., Kiveton Park Coll., near Sheffield  Aug. 1, 1861
99  Catron, J., Shincliffe Colliery Offices, near Durham  Nov. 3, 1866
100  Chadborn, B.T., Pinxton Collieries, Alfreton, Derbyshire  1864
101  Chambers, A. M., Thorncliffe Iron Works, nr. Sheffield  Mar. 6, 1869
102  Chambers, H., Tinsley Collieries, Sheffield  Dec. 2, 1871
103  Chapman, M., Plashetts Colliery, Falstone, Northd.  Aug. 1, 1868
104  Charlton, E., Evenwood Colliery, Bishop Auckland  Sept. 5, 1868
105  Charlton, F., C.E., Moot Hall, Newcastle-on-Tyne  Sept. 2, 1871
106  Checkley, Thomas, M.E., Lichfield Street, Walsall  Aug. 7, 1869
107  Cheesman, I., Throckley Colliery, Newcastle  Feb. 1, 1873
108  Childe, Rowland, Wakefield, Yorkshire  May 15, 1862
109  Clarbour, Fountain, 11, Mark Lane, Withy Grove, Manchester  Nov. 1, 1873
110  Clark, C.F., Garswood Coal & Iron Co., near Wigan  Aug. 2, 1866
111 Clark, G., Ravenhead Colliery, St. Helen's, Lancashire  Dec. 7, 1867
112 Clark, G., jun., Monkwearmouth Engine Works, Sunderland  Dec. 6, 1873
113 Clark, N., South Tanfield, Chester-le-Street  June 6, 1868
114 Clark, R. P., 22, Windsor Terrace, Newcastle  Nov. 7, 1868
115 Clark, W., M.E., The Grange, Teversall, nr. Mansfield  April 7, 1866
116 Clark, William, Victoria Engine Works, Gateshead  Dec. 7, 1867
117 Clarke, T., Ince Hall Collieries, Wigan  Mar. 2, 1872
118 Coates, C. N., Whitefield House, Acklington  May 3, 1866
119 Cochrane, B., Aldin Grange, Durham  Dec. 6, 1866
120 Cochrane, C., The Grange, Stourbridge  June 3, 1857
121 Cochrane, H., The Longlands, Middlesbro'-on-Tees  Mar. 4, 1871
122 Cochrane, W., Oakfield House, Coxledge, Northumberland (Vice-President)  1859
123 Cockburn, G., 8, Summerhill Grove, Newcastle  Dec. 6, 1866
125 Coke, R. G., Tapton Grove, Chesterfield, Derbyshire  May 5, 1859
126 Cole, H. A. B., Willington Quay, Newcastle-on-Tyne  Mar. 3, 1873
127 Cole, Richard, Walker Colliery, nr. Newcastle-on-Tyne  April 5, 1873
128 Cole, Robert E., Willington Quay, Newcastle-on-Tyne  Nov. 2, 1872
130 Collis, W. B., High House, Stourbridge, Worcestershire  June 6, 1861
131 Cook, J., jun., Washington Iron Works, Gateshead  May 8, 1869
132 Cook, R. F., Esh Colliery, Durham  1860

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133 Cooke, John, North Brancepeth Colliery, nr. Durham  Nov. 1, 1860
134 Cooksey, Joseph, West Bromwich, Staffordshire  Aug. 3, 1865
135 Cooper, P., Thornley Colliery Office, Ferryhill Dec. 3, 1857
136 Cooper, R. E., C.E., York Place, Leeds Mar. 4, 1871
137 Cooper, T., Park Gate, Rotherham, Yorkshire April 2, 1863
138 Cope, James, Port Vale, Longport, Staffordshire Oct. 5, 1872
139 Corbett, V. W., Londonderry Offices, Seaham Harbour Sept. 3, 1870
140 Coulson, F., Shamrock House, Durham Aug. 1, 1868
141 Coulson, W., Shamrock House, Durham Oct. 1, 1852
142 Cowen, Joseph, M.P., Blaydon Burn, Newcastle Oct. 5, 1854
143 Cowey, John, Wearmouth Colliery, Sunderland Nov. 2, 1872
144 Cowlishaw, J., Thorncliffe, &c, Collieries, nr. Sheffield Mar. 7, 1867
145 Coxon, Henry, Quay, Newcastle-on-Tyne Sept. 2, 1871
146 Coxon, S. B., Usworth Colliery, Washington Station, Co. Durham June 5, 1856
147 Craig, W. Y., Milton House, Alsager, Stoke-upon-Trent Nov. 3, 1866
148 Crawford, T., Littleton Colliery, near Durham Aug. 21, 1852
149 Crawford, T., Bishop Middleham Colliery, nr. Ferryhill Sept. 3, 1864
150 Crawford, T., jun., Littleton Colliery, near Durham Aug. 7, 1869
151 Crawshay, E., Gateshead-on-Tyne Dec. 4, 1869
152 Crawshay, G., Gateshead-on-Tyne Dec. 4, 1869
153 Creighton, C. E., 10, Grey Street, Newcastle-on-Tyne May 6, 1871
154 Crofton, J. G., Kenyon Collieries, Ruabon, Denbighshire Feb. 7, 1861
155 Crone, J. R., Stanhope, Darlington Feb. 1, 1868
156 Crone, S. C., Killingworth Colliery, Newcastle-upon-Tyne (Member of Council) 1853
157 Cross, John, 78, Cross Street, Manchester June 5, 1869
158 Croudace, C. J., Tondu Iron & Coal Works, Bridgend, Glamorganshire Nov. 2, 1872
159 Croudace, John, The Priory, Monkseaton June 7, 1873
160 Croudace, Thomas, Lambton Lodge, New South Wales 1862
161 Croudace, T. Dacre, Newstead, Nottingham Mar. 7, 1867
162 Daglish, John, F.G.S., Tynemouth (Member of Council) Aug. 21, 1852
163 Daglish, W. S., Solicitor, Newcastle July 2, 1872
164 Dakers, J., Old Durham Colliery, Durham April 11, 1874
165 Dakers, W., Tyne Main Colliery, Gateshead April 7, 1866
166 Dale, David, West Lodge, Darlington Feb. 5, 1870
167 D'Andrimont, T., Liege, Belgium Sept. 3, 1870
168 Daniel, W., 11, Blenheim Square, Leeds June 4, 1870

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169 Darlington, John, 2, Coleman Street Buildings, Moorgate Street, Great Swan Alley, London April 1, 1865
170 Davey, Henry, C.E., Leeds Oct. 11, 1873
171 Davidson, James, Newbattle Colliery, Dalkeith 1854
172-Davison, A., Hastings Cottage, Dudley, Northumberland Feb. 4, 1858
173 Day, W. H., Eversley Garth, So. Milford Mar. 6, 1869
174 Dees, J., Whitehaven Nov. 1, 1855
175 Dees, R. R., Solicitor, Newcastle-on-Tyne Oct. 7, 1871
176 Dickinson, G. T., Wheelbirks, Northumberland July 2, 1872
177 Dickinson, J. L., Belle Vue House, Shotley Bridge Aug. 6, 1870
178 Dickinson, R., Coalowner, Shotley Bridge Mar. 4, 1871
179 Dickinson, W. R., Priestfield Lodge, Lintz Green, Co. Durham Aug. 7, 1862
180 Dinning, Joseph, Langley Smelt Mills, Northd. April 5, 1873
181 Dixon, D. W., Skelton Park Pit, Marske-by-the-Sea Nov. 2, 1872
182 Dixon, George, Lowther Street, Whitehaven Dec. 3, 1857
183 Dobson, W., Baron House, Gilsland Station, N.E. Railway Sept. 4, 1869
184 Dodd, B., Bearpark Colliery, near Durham May 3, 1866
185 Dodds, J., M.P., Stockton-on-Tees Mar. 7, 1874
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<td>Donaldson, P., Alipore, Calcutta</td>
<td>Nov. 1, 1873</td>
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<td>Douglas, C. P., Consett Iron Works, Gateshead</td>
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<td>Douglas, T., Pease's West Collieries, Darlington (Member of Council)</td>
<td>Aug. 21, 1852</td>
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<td>Douthwaite, T., Merthyr Vale Colliery, Merthyr Tydvil</td>
<td>June 5, 1869</td>
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<td>Dove, G., Portland Square, Carlisle</td>
<td>July 2, 1872</td>
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<td>Dowdeswell, H., Flour Mill Colliery, Bream, near Sydney, Gloucestershire</td>
<td>April 5, 1873</td>
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<td>Dunlop, Colin, jun., Quarter Iron Works, Hamilton</td>
<td>Sept. 3, 1870</td>
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<td>Dunn, D. G.</td>
<td>April 6, 1867</td>
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<td>Dyson, George, Middlesborough</td>
<td>June 2, 1866</td>
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<td>Dyson, O., Saltburn-by-the-Sea</td>
<td>Mar. 2, 1872</td>
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<td>Easton, J., Nest House, Gateshead</td>
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<td>Eaton, W. C., Saltburn-by-the-Sea</td>
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<td>Elliot, Sir G., Bart., M.P., Houghton Hall, Fence Houses (Member of Council)</td>
<td>Aug. 21, 1852</td>
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<td>Elliott, W., Tudhoe House, Durham</td>
<td>1854</td>
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<td>Elliott, W. D., Pemberton Street, Hull</td>
<td>Oct. 11, 1873</td>
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<td>202</td>
<td>Embleton, T. W., The Cedars, Methley, Leeds</td>
<td>Sept. 6, 1855</td>
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[xxiv]

**ELECTED.**

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<td>Embleton, T. W., jun., The Cedars, Methley, Leeds</td>
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<td>Eminson, J. B., Londonderry Offices, Seaham Harbour</td>
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<td>Emslie, J. T.</td>
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<td>Everard, I. B., M.E., 6, Millstone Lane, Leicester</td>
<td>Mar. 6, 1869</td>
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<td>Farmer, A., Westbrook, Darlington</td>
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<td>Farrar, James, Old Foundry, Barnsley</td>
<td>July 2, 1872</td>
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209 Favell, Thos. M., 14, Saville Street, North Shields April 5, 1873
210 Fearn, John Wilmot, Chesterfield Mar. 6, 1869
211 Fenwick, Barnabas, Team Colliery, Gateshead Aug. 2, 1866
212 Fenwick, George, Banker, Newcastle-on-Tyne Sept. 2, 1871
213 Fenwick, Thomas, East Pontop Colliery, by Lintz Green April 5, 1873
214 Fidler, E., Platt Lane Colliery, Wigan, Lancashire Sept. 1, 1866
215 Firth, 8., M.A., 16, York Place, Leeds 1865
216 Firth, William, Burley Wood, Leeds Nov. 7, 1863
217 Fisher, R. C., Ystalyfera, near Swansea July 2, 1872
218 Fletcher, G., Trimdon Colliery, Trimdon Grange April 4, 1868
220 Fletcher, I., M.P., Clifton Colliery, Workington Nov. 7, 1863
221 Fletcher, J., C.E., 69, Lowther Street, Whitehaven 1857
222 Fletcher, W., Croft, Windermere Feb. 4, 1871
223 Foord, J. B., Secretary General Mining Association, 52, Old Broad Street, London Nov. 5, 1852
224 Forrest, J., Assoc. Inst. C.E., Pentrehobin Hall, Mold, Flintshire Mar. 5, 1870
225 Forster, G. B., M. A., Backworth House, near Newcastle (Vice-President) Nov. 5, 1852
226 Forster, George E., Washington, Gateshead Aug. 1, 1868
227 Forster, J. R., Water Co.'s Office, Newcastle July 2, 1872
228 Forster, Richard, White House, Gateshead Oct. 5, 1872
229 Forster, R., Trimdon Grange Colliery, Ferryhill Sept. 5, 1868
230 Forster, T. E., 7, Ellison Place, Newcastle-on-Tyne (Past President, Member of Council) Aug. 21, 1852
231 Foster, Geo., Osmondthorpe Colliery, near Leeds Mar. 7, 1874
232 Fothergill, J., King Street, Quay, Newcastle Aug. 7, 1862
233 Fowler, G., Basford Hall, near Nottingham July 4, 1861
234 Fowler, W. C, Babbington Collieries, Nottingham Aug. 6, 1870
235 France, W., Lofthouse Mines, Saltburn-by-the-Sea April 6, 1867
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<td>Frazer, B.</td>
<td>Quay, Newcastle-upon-Tyne</td>
<td>Oct. 4, 1866</td>
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<td>Frazer, W., S.</td>
<td>East Parade, Newcastle-upon-Tyne</td>
<td>Oct. 4, 1866</td>
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<td>Frazier, Prof. B. W.</td>
<td>Lehigh University, Bethlehem, Penns., U.S.</td>
<td>Nov. 2, 1872</td>
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<td>Fryar, M., C.E.</td>
<td>Post Office, Rangoon, British Burmah</td>
<td>Sept. 7, 1867</td>
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<td>Furness, H. D.</td>
<td>Whickham, Gateshead-on-Tyne</td>
<td>Dec. 2, 1871</td>
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<td>Gainsford, T. R.</td>
<td>Whiteley Wood Hall, near Sheffield</td>
<td>Nov. 5, 1864</td>
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<td>Galloway, R. L.</td>
<td>Barmoor, Ryton</td>
<td>Dec. 6, 1873</td>
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<td>Garforth, W. E.</td>
<td>Lord's Field Coll., Ashton-under-Lyne</td>
<td>Aug. 2, 1866</td>
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<td>Gerrard, John</td>
<td>Westgate, Wakefield</td>
<td>Mar. 5, 1870</td>
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<td>246</td>
<td>Gill, Harry, Consulting Engineer</td>
<td>Newcastle</td>
<td>May 2, 1874</td>
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<td>247</td>
<td>Gille, J., Ingenieur au Corps Royal des Mines, Mons</td>
<td>Sept. 2, 1871</td>
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<td>248</td>
<td>Gillett, F. C.</td>
<td>16, Tenant Street, Derby</td>
<td>July 4, 1861</td>
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<td>Gilpin, Edwin, 26</td>
<td>Spring Gardens, Halifax, Nova Scotia</td>
<td>April 5, 1873</td>
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<td>Gilroy, G., Ince Hall Colliery, Wigan, Lancashire</td>
<td>Aug. 7, 1856</td>
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<td>251</td>
<td>Gilroy, S. B., Assistant Government Inspector of Mines, Stone, Staffordshire</td>
<td>Sept. 5, 1868</td>
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<td>252</td>
<td>Gjers, John</td>
<td>South Field Villas, Middlesbro'</td>
<td>June 7, 1873</td>
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<td>253</td>
<td>Goddard, D. H.</td>
<td>Newcastle-on-Tyne</td>
<td>July 2, 1872</td>
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<td>254</td>
<td>Goddard, W., Golden Hill Coll., Longton, No. Stafford.</td>
<td>March 6, 1862</td>
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<td>Gooch, G. H., Lintz Colliery, Burnopfield, Gateshead</td>
<td>Oct. 3, 1856</td>
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<td>256</td>
<td>Goodman, A., Walker Iron Works, Newcastle</td>
<td>Sept. 5, 1868</td>
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<td>257</td>
<td>Gott, Wm. L., Shincliffe Collieries, Durham</td>
<td>Sept. 3, 1864</td>
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<td>258</td>
<td>Grace, E. N., Dhadka, Assensole, Bengal, India</td>
<td>Feb. 1, 1868</td>
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259  Grant, J. H., care of C. Grant, 69, Lower Circular Street, Calcutta  Sept. 4, 1869
260  Gray, Thomas, Underhill, Taibach, South Wales  June 5, 1869
261  Greaves, J. O., M.E., St. John's, Wakefield  Aug. 7, 1862
262  Green, J. T., 5, Victoria Pl., Newport, Monmouthshire  Dec. 3, 1870
263  Green, W., jun., Garesfield Colliery, Blaydon-on-Tyne (Member of Council)  Feb. 4, 1853
264  Greener, Thos., Benton Lodge, Darlington  Aug. 3, 1865
265  Greenwell, G. C., F.G.S., Poynton and Worth Collieries, Stockport  Aug. 21, 1852
266  Greenwell, G. C., jun., Poynton, near Stockport  March 6, 1869
267  Greig, D., Leeds  Aug. 2, 1866
268  Grey, C. G., Dilston, Northumberland  May 4, 1872
269  Griffith, N. R., 13, Grosvenor Road, Wrexham  1866
270  Grimshaw, E. J., Cowley Hill, St. Helen's, Lancashire  Sept. 5, 1868
271  Grimshaw, W. J., Stand Lane Coll., Radcliffe, Manchester.  Nov. 1, 1873

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ELECTED.

272  Ground, H. N., Brotton Ironstone Mines, near Saltburn-by-the-Sea  July 2, 1872
273  Guinotte, Lucien, Directeur des Charbonnages de Mariemont et de Bascoup, Mons  Sept. 2, 1871

274  Haggie, P., Gateshead  1854
275  Hair, T. C., Shire Moor Colliery, Earsdon, Northumberland  Feb. 1, 1873
276  Hales, C., Englesea Brook, Barthomley, by Crewe, Ches.  1865
277  Hall, Edward, 24, Bigg Market, Newcastle  Oct. 3, 1868
278  Hall, F. W., 23, St. Thomas' Street, Newcastle  Aug. 7, 1869
279  Hall, Henry, Westbury Villa, Swansea

280  Hall, M., Pease's West Collieries, via Darlington  Sept. 5, 1868
281  Hall, M. S., M.E., Woodlesford, near Leeds  Feb. 14, 1874
282 Hall, W., Albion Mines, Pictou, Nova Scotia  Sept. 13, 1873
283 Hall, William F., Haswell Colliery, Fence Houses  May 13, 1858
284 Hann, Edmund, Brotton, near Saltburn-by-the-Sea  Sept. 5, 1868
285 Hargreaves, William, Rothwell Haigh, Leeds  Sept. 5, 1868
286 Harkness, A., Birtley Iron Works, Fence Houses  Dec. 5, 1868
287 Harper, J. P., All Saints’ Chambers, Derby  Feb. 2, 1867
288 Harper, Matthew, Whitehaven  Oct. 1, 1863
289 Harrison, R., Eastwood Collieries, Nottingham  1861
290 Harrison, T., Rhos LLantwit Colliery, Caerphilly, near Cardiff  Aug. 2, 1873
291 Harrison, T. E., C.E., Central Station, Newcastle  May 6, 1853
292 Harrison, W. B., Brownhills Collieries, near Walsall  April 6, 1867
293 Haswell, G. H., 11, South Preston Terr., North Shields  March 2, 1872
294 Hay, J., jun., Widdrington Colliery, Ashington  Sept. 4, 1869
295 Hawthorn, T., 74, Rye Hill, Newcastle (Member of Council)  Dec. 6, 1866
296 Hawthorn, W., C.E., 92, Pilgrim Street, Newcastle  March 4, 1853
297 Head, J., Newport Rolling Mills, Middlesbrough  Oct. 2, 1869
298 Heckels, Matthew, Boldon Colliery, Durham  April 11, 1874
299 Heckels, R., Wearmouth Colliery, Sunderland  Nov. 5, 1852
300 Hedley, Edward, Osmaston Street, Derby  Dec. 2, 1858
301 Hedley, J. J., Medomsley, Newcastle-on-Tyne  April 6, 1872
302 Hedley, J. L., 3, Elm Vale, Fairfield, Liverpool  Feb. 5, 1870
303 Hedley, T. F., Valuer, Sunderland  March 4, 1871
304 Hedley, W. H., Consent Collieries, Medomsley, Newcastle-on-Tyne (Member of Council) 1864
305 Henderson, H., Pelton Colliery, Chester-le-Street  Feb. 14, 1874

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306 Henderson, John, Leazes House, Durham  
307 Heppell, T., Leafield House, Birtley, Fence Houses  
308 Heppell, W., Brancepeth Coll., Willington, Co. Durham  
309 Herdman, J., Park Crescent, Bridgend, Glamorganshire  
310 Heslop, C., Upleatham Mines, Marske  
311 Heslop, Grainger, Whitwell Colliery, Sunderland  
312 Heslop, J., Hucknall Torkard Coll., near Nottingham  
313 Hetherington, D., Coxlodge Colliery, Newcastle  
314 Hetherington, Robert, Coanwood, Haltwhistle  
315 Hewitt, G. C., Coal Pit Heath Colliery, near Bristol  
316 Hewlett, A., Haigh Colliery, Wigan, Lancashire  
317 Hick, G. W., 14, Blenheim Terrace, Leeds  
318 Higson, Jacob, 94, Cross Street, Manchester  
319 Higson, P., jun., Hope View, Eccles, near Manchester  
320 Hill, P., Littleburn Colliery, near Durham  
321 Hilton, J., Standish and Sherington Cols., near Wigan  
322 Hilton, T. W., Wigan Coal & Iron Co., Limited, Wigan  
323 Hodgkin, T., Banker, Newcastle-on-Tyne  
324 Hodgson, R., Whitburn, Sunderland (Member of Council)  
325 Holmes, C., Kilton Mines, Brotton, Saltburn-by-the-Sea  
326 Homer, Charles James, Chatterley Hall, Tunstall  
327 Hood, A., 6, Bute Crescent, Cardiff  
328 Hopper, John J., Britannia Iron Works, Fence Houses  
329 Horsfall, J. J., Bradley Green Colliery, near Congleton  
330 Horsley, W., Whitehill Point, Percy Main  
331 Hoskold, H. D.  
332 Howard, W. F., 13, Cavendish Street, Chesterfield
333 Hoyt, J., Acadia Coal Mines, Pictou, Nova Scotia  May 8, 1869
334 Hudson, James, Albion Mines, Pictou, Nova Scotia  1862
335 Humble, John, West Pelton, Chester-le-Street  March 4, 1871
336 Humble, Jos., jun., Pemberton Collieries, near Wigan  June 2, 1866
337 Humble, W. J., Forth Banks West Factory, Newcastle  Sept. 1, 1866
338 Hunt, A. H., Quayside, Newcastle-upon-Tyne  Dec. 6, 1862
339 Hunter, W., Cannock, Staffordshire  Oct. 3, 1861
340 Hunter, Wm., Charlaw Colliery Office, Quay, Newcastle  Aug. 21, 1852
341 Hunter, W. S., Moor Lodge, Newcastle-upon-Tyne  Feb. 1, 1868
342 Hunting, Charles, Fence Houses  Dec. 6, 1866
343 Huntsman, Benjamin, West Retford Hall, Retford  June 1, 1867
344 Hurd, F., Grove House, Walton, near Wakefield  Dec. 4, 1869
345 Hurst, T. G., F.G.S., Riding Mill, Northumberland  Aug. 21, 1852

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ELECTED.

346 Hatchings, W. M., 5, Bouverie St., Fleet St., London  Sept. 5, 1868
347 Hutchinson, G., Howden Colliery, Darlington  July 2, 1872
348 Hyslop, J. S., Belmont Mines, Guisbro'  April 1, 1871

349 Jackson, C. G., Wigan Coal and Iron Co, Limited, Wigan  June 4, 1870
350 Jackson, W., Cannock Chase Collieries, Walsall  Feb. 14, 1874
351 Jackson, W. G., 3, Garnett Street, Saltburn  June 7, 1873
352 Jameson, John, Printing Court Chambers, Newcastle  Nov. 6, 1869
353 Jarratt, J., Broomside Colliery Office, Durham  Nov. 2, 1867
354 Jeffcock, T. W., 18, Bank Street, Sheffield  Sept. 4, 1869
355 Jenkins, W., M.E., Ocean S.C. Collieries, Ystrad, near Pontypridd, South Wales  Dec. 6, 1862
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<td>Jenkins, Wm.</td>
<td>Consett Iron Works, Consett, Lintz Green</td>
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<td>Johnasson, J.</td>
<td>Leadenhall Street, London, E.O.</td>
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<td>Johnson, Henry</td>
<td>Dudley, Worcestershire</td>
<td>Aug. 7, 1869</td>
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<td>Johnson, John</td>
<td>M. Inst. C.E., F.G.S., Osborne Terrace, Jesmond Road, Newcastle</td>
<td>Aug. 21, 1852</td>
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<td>360</td>
<td>Johnson, John</td>
<td>Ruabon Coal Company, Ruabon</td>
<td>March 7, 1874</td>
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<td>Johnson, John S.</td>
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<td>Johnson, W. J.</td>
<td>W.B. Lead Works, Allendale</td>
<td>April 6, 1872</td>
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<td>363</td>
<td>Johnston, T.</td>
<td>North Fenham Colliery, Newcastle</td>
<td>April 6, 1872</td>
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<td>364</td>
<td>Joicey, E.</td>
<td>Coal Owner, Newcastle-on-Tyne</td>
<td>April 6, 1872</td>
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<tr>
<td>365</td>
<td>Joicey, John</td>
<td>Newton Hall, Stocksfield-on-Tyne (Member of Council)</td>
<td>Sept. 3, 1852</td>
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<td>366</td>
<td>Joicey, J. G.</td>
<td>Forth Banks West Factory, Newcastle</td>
<td>April 10, 1869</td>
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<td>367</td>
<td>Joicey, W. J.</td>
<td>Tanfield Lea Colliery, Burnopfield</td>
<td>March 6, 1869</td>
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<tr>
<td>368</td>
<td>Jones, E.</td>
<td>Granville Lodge, Wellington, Salop</td>
<td>Oct. 5, 1854</td>
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<tr>
<td>369</td>
<td>Jones, John F.G.S.</td>
<td>Secretary, North of England Iron Trade, Middlesbro'-on-Tees</td>
<td>Sept. 7, 1867</td>
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<tr>
<td>370</td>
<td>Joseph, D. Davis</td>
<td>Ty Draw, Pontypridd, South Wales</td>
<td>April 6, 1872</td>
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<td>371</td>
<td>Joseph, T.</td>
<td>Ty Draw, near Pontypridd, South Wales</td>
<td>April 6, 1872</td>
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<td>372</td>
<td>Kelsey, William</td>
<td>2, Grange Crescent, Sunderland</td>
<td>March 7, 1874</td>
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<td>373</td>
<td>Kendall, W.</td>
<td>Blyth and Tyne Railway, Percy Main</td>
<td>Sept. 1, 1866</td>
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<td>374</td>
<td>Kennedy, Myles</td>
<td>M.E., Hill Foot, Ulverstone</td>
<td>June 6, 1868</td>
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<td>375</td>
<td>Kimpton, J. G.</td>
<td>40, St. Mary Gate, Derby</td>
<td>Oct. 5, 1872</td>
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<td>376</td>
<td>Kirkby, J. W.</td>
<td>Pirnie Colliery, Leven, Fife</td>
<td>Feb. 1, 1873</td>
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<td>377</td>
<td>Kirkwood, William</td>
<td>Larkhall Colliery, Hamilton</td>
<td>Aug. 7, 1869</td>
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<td>378</td>
<td>Kirscopp, John</td>
<td>Team Colliery, Gateshead</td>
<td>April 5, 1873</td>
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<td>379</td>
<td>Knowles, A.</td>
<td>High Bank, Pendlebury, Manchester</td>
<td>Dec. 5, 1856</td>
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</tbody>
</table>
380  Knowles, A., jun., The Poplars, Hope Eccles, near Manchester  
Dec. 3, 1863

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

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

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

384  Knowles, Thomas, Ince Hall, Wigan  
Aug. 1, 1861

385  Lackland, J. J., Port Mulgrave, Saltburn-by-the-Sea  
March 7, 1874

386  Lamb, R., Cleator Moor Colliery, near Whitehaven  
Sept. 2, 1865

387  Lamb, R. O., Axwell Park, Gateshead  
Aug. 2, 1866

388  Lamb, Richard W., Coal Owner, Newcastle-on-Tyne  
Nov. 2, 1872

389  Lambert, M. W., 44, Quay, Newcastle  
July 2, 1872

390  Lancaster, John, M.P., Bilton Grange, Rugby  
July 4, 1861

391  Lancaster, J., jun., Bilton Grange, Rugby  
March 2, 1865

392  Lancaster, Joshua, Mostyn Collieries, near Holywell  
Aug. 3, 1865

393  Lancaster, S., Prescot Colliery, Prescot  
Aug. 3, 1865

394  Landale, A., Lochgelly Iron Works, Fifeshire, N.B.  
Dec. 2, 1858

395  Lange, C., Queen Street, Newcastle-on-Tyne  
March 5, 1870

396  Laverick, J., West Rainton, Fence Houses  
July 2, 1872

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

398  Laws, H., Grainger Street West, Newcastle-on-Tyne (Member of Council)  
Feb. 6, 1869

399  Laws, John, Blyth, Northumberland  
1854

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

401  Lawson, J. P., Vale Colliery, New Glasgow, N. Scotia  
Dec. 3, 1870

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

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

404  Lebour, G. A., Weedpark House, Dipton, Lintz Green  
Feb. 1, 1873
405  Lee, George, Liverton Mines, Lofthouse  
June 4, 1870

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

407  Lever, Ellis, West Gorton Works, Manchester  
1861

408  Lewis, G., Imperial Chambers, Derby  
Aug. 6, 1863

409  Lewis, Henry, Annesley Colliery, near Mansfield  
Aug. 2, 1866

410  Lewis, Lewis Thomas, Cadoxton Lodge, Neath  
Feb. 1, 1868

411  Lewis, William Thomas, Mardy, Aberdare  
1864

412  Liddell, G. H., Burnhope Colliery, Lanchester, Co. Durham  
Sept. 4, 1869

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

414  Liddell, M., Prudhoe Hall, Prudhoe  
Oct. 1, 1852

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

416  Linsley, R., Hamsteels Colliery, near Durham  
July 2, 1872

417  Linsley, S. W., Silksworth New Winning, nr. Sunderland  
Sept. 4, 1869

418  Lishman, John, Western Hill, Durham  
June 2, 1866

419  Lishman, T., jun., Hetton Colliery, Fence Houses  
Nov. 5, 1870

420  Lishman, William, Etherley Colliery, Darlington  
1857

421  Lishman, William, Bunker Hill, Fence Houses  
Mar. 7, 1861

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

423  Livesey, T., Prestwich Park, near Manchester  
Aug. 1, 1861

424  Llewellyn, D., Glanwern Offices, Pontypool, Monmouthshire  
Aug. 4, 1864

425  Llewelyn, L., Aberaman, Aberdare, South Wales  
May 4, 1872

426  Logan, William, Langley Park Colliery, Durham  
Sept. 7, 1867

427  Longbotham, J., Consett Colls., Leadgate, Co. Durham  
May 2, 1868

Aug. 21, 1852
429 Love, Joseph, Brancepeth Colliery, Durham  Sept. 5, 1856
430 Low, W., Vron Colliery, Wrexham, Denbighshire  Sept. 6, 1855
431 Lupton, A., F.G.S., Bagillt, North Wales  Nov. 6, 1869

432 Mackenzie, J., Tamworth House, 16, Whiteladies Road, Clifton, Bristol  Mar. 5, 1870
433 Maddison, W. P., Thornhill Collieries, near Dewsbury  Oct. 6, 1859
434 Maling, C. T., Ford Pottery, Newcastle-on-Tyne  Oct. 5, 1872
435 Mammatt, J. E., C.E., Beechwood, Bramley, nr. Leeds  1864
436 Marley, John, Mining Offices, Darlington (Vice-President)  Aug. 21, 1852
487 Marley, J. W., Mining Offices, Darlington  Aug. 1, 1868
440 Marston, W. B., Leeswood Vale Oil Works, Mold  Oct. 3, 1868
441 Marten, E. B., C.E., Pedmore, near Stourbridge  July 2, 1872
442 Martin, Joseph S., Bury New Road, Prestwich, near Manchester  Mar. 3, 1873
443 Martin, R. F., Colliery Office, Whitehaven  April 11, 1874
444 Matthews, R.F., South Hetton Colliery, Fence Houses  Mar. 5, 1857
445 Maughan, J. A., 6, Sandhill, Newcastle  Nov. 7, 1863
446 May, George, Harton Colliery Offices, Tyne Dock, South Shields  Mar. 6, 1862
447 McCreath, J., 138, West George Street, Glasgow  Mar. 5, 1870

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ELECTED.

449 McGhie, T., Cannock, Staffordshire  Oct. 1, 1857
450 McMurtrie, J., Radstock Colliery, Bath  Nov. 7, 1863
451 McMurtrie, W. G., Llwynypia Colliery, near Pontypridd, South Wales  Sept. 4, 1869
<table>
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<tr>
<th>No.</th>
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<th>Date</th>
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<tr>
<td>452</td>
<td>Meik, Thomas, C.E.</td>
<td>Sunderland</td>
<td>June 4, 1870</td>
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<td>453</td>
<td>Menzies, W.,</td>
<td>King Street, Newcastle</td>
<td>Sept. 13, 1873</td>
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<td>454</td>
<td>Miller, Robert,</td>
<td>Strafford Collieries, near Barnsley</td>
<td>Mar. 2, 1865</td>
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<td>455</td>
<td>Mills, John</td>
<td>Forth Street, Newcastle</td>
<td>July 2, 1872</td>
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<td>456</td>
<td>Mitchell, Charles,</td>
<td>Shipbuilder, Newcastle</td>
<td>April 11, 1874</td>
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<td>457</td>
<td>Mitchell, Joseph,</td>
<td>jun., Worsbro' Dale, near Barnsley</td>
<td>Feb. 14, 1874</td>
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<td>458</td>
<td>Mitchinson, R.,</td>
<td>jun., Pontop Colliery, Lintz Green Station, Co. Durham</td>
<td>Feb. 4, 1865</td>
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<td>459</td>
<td>Moffat, T.</td>
<td>New Mains, by Motherwell, N.B.</td>
<td>Sept. 4, 1869</td>
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<td>460</td>
<td>Monkhouse, Jos.</td>
<td>Yeat House, Frizington, Whitehaven</td>
<td>June 4, 1863</td>
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<td>461</td>
<td>Moody, John</td>
<td>Alipore Road, Calcutta</td>
<td>Feb. 3, 1872</td>
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<td>462</td>
<td>Moor, T.</td>
<td>North Seaton Colliery, Morpeth</td>
<td>Oct. 3, 1868</td>
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<td>463</td>
<td>Moore, T. H.</td>
<td>Smeaton Park, Inveresk, Edinburgh</td>
<td>Feb. 2, 1867</td>
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<td>464</td>
<td>Morison, D. P.</td>
<td>21, Collingwood Street, Newcastle (Member of Council)</td>
<td>1861</td>
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<td>465</td>
<td>Morris, W.</td>
<td>Waldridge Colliery, Chester-le-Street, Fence Houses</td>
<td>1858</td>
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<td>466</td>
<td>Morrison, Jas.</td>
<td>34, Grey Street, Newcastle-upon-Tyne</td>
<td>Aug. 5, 1853</td>
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<td>467</td>
<td>Morton, H. T.</td>
<td>Lampton, Fence Houses</td>
<td>Aug. 21, 1852</td>
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<td>468</td>
<td>Muckle, John</td>
<td>Monk Bretton, Barnsley</td>
<td>Mar. 7, 1861</td>
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<td>469</td>
<td>Mulcaster, W.,</td>
<td>jun., M.E., Croft House, Aspatria, near Carlisle</td>
<td>Dec. 3, 1870</td>
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<td>470</td>
<td>Mulvany, W. T.</td>
<td>1335, CarlsThor, Dusseldorf-on-the-Rhine</td>
<td>Dec. 3, 1857</td>
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<td>471</td>
<td>Mundle, W.</td>
<td>Redesdale Mines, Bellingham</td>
<td>Aug. 2, 1873</td>
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<td>Murray, T. H.</td>
<td>Chester-le-Street, Fence Houses</td>
<td>April 18, 1861</td>
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<td>473</td>
<td>Nanson, J.,</td>
<td>4, Queen Street, Newcastle-on-Tyne</td>
<td>Dec. 4, 1869</td>
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<td>474</td>
<td>Nasse, Herr Bergassessor, Louisenthal, Saarbrucken, Prussia</td>
<td>Sept. 4, 1869</td>
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<td>475</td>
<td>Naylor, J. T.</td>
<td>10, West Clayton Street, Newcastle</td>
<td>Dec. 6, 1866</td>
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<td>476</td>
<td>Nelson, J.,</td>
<td>C.E. King's House Engine Works, Sunderland (Member of Council)</td>
<td>Oct. 4, 1866</td>
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<td>477</td>
<td>Nevin, John</td>
<td>Mirfield, Yorkshire</td>
<td>May 2, 1868</td>
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478 Newall, R. S., Ferndene, Gateshead (Member of Council) May 2, 1863

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479 Newby, J. E., Usworth Colliery, by Washington Station, County Durham Oct. 2, 1869
480 Nicholson, E., jun., Beamish Colliery, Chester-le-Street Aug. 7, 1869
481 Nicholson, J W., Greenside Colliery, Milton, Carlisle Oct. 11, 1873
482 Nicholson, Marshall, Middleton Hall, Leeds Nov. 7, 1863
483 Nicholson, R., Blaydon-on-Tyne July 2, 1872
484 Nicholson, T., Park Lane Engine Works, Gateshead Dec. 4, 1869
485 Nicholson, W., Seghill Colliery, Newcastle Oct. 1, 1863
486 Noble, Captain, Jesmond, Newcastle-upon-Tyne (Member of Council) Feb. 3, 1866
487 North, F.W., F.G.S., Rowley Hall Colliery, Dudley, Staffordshire Oct. 6, 1864

488 Ogden, John M., Solicitor, Sunderland Mar. 5, 1857
489 Owen, R. July 2, 1872

490 Pacey, T., Bishop Auckland April 10, 1869
491 Palmer, A. S., Wardley Colliery, Durham July 2, 1872
492 Palmer, C. M., M.P., Quay, Newcastle-upon-Tyne Nov. 5, 1852
493 Palmer, John B., Jarrow-on-Tyne April 1, 1871
494 Panton, F.S., Silksworth Colliery, Sunderland Oct. 5, 1867
495 Papik, Johanne, Teplitz, Bohemia Feb. 5, 1870
496 Parkin, John, Duchy Peru, Newlyn East, Grampound Road, Cornwall April 11, 1874
497 Parrington, M. W., Wearmouth Colliery, Sunderland Dec. 1, 1864
498 Parton, T., F.G.S., Ash Cottage, Birmingham Road, West Bromwich Oct. 2, 1869
499 Pattison, W., Westminster Colliery, Wrexham Oct. 11, 1873
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<th>Number</th>
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<th>Date</th>
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<td>500</td>
<td>Pattison, W., jun.</td>
<td>Ffrwd Coll. and Ironworks, Wrexham</td>
<td>Oct. 11, 1873</td>
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<td>501</td>
<td>Pattinson, John</td>
<td>Analytical Chemist, Newcastle</td>
<td>May 2, 1868</td>
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<td>502</td>
<td>Patton, John</td>
<td>Westoe, South Shields</td>
<td>April 6, 1872</td>
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<td>Peace, M. W.</td>
<td>Wigan, Lancashire</td>
<td>July 2, 1872</td>
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<td>Peacock, David</td>
<td>Horsley, Tipton</td>
<td>Aug. 7, 1869</td>
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<td>Pearson, J.E.</td>
<td>Golborne Park, near Newton-le-Willows</td>
<td>Feb. 3, 1872</td>
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<td>Pease, J. W., M.P.</td>
<td>Woodlands, Darlington</td>
<td>Mar. 5, 1857</td>
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<td>508</td>
<td>Peel, John</td>
<td>Wharncliffe and Silkstone Collieries, Wortley, near Sheffield</td>
<td>Nov. 1, 1860</td>
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<td>509</td>
<td>Peile, William</td>
<td>6, College Street, Whitehaven</td>
<td>Oct. 1, 1863</td>
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<td>Penman, J. Hugh</td>
<td>Clarence Buildings, 2, Booth Street, Manchester</td>
<td>Mar. 7, 1874</td>
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<td>Perrot, S. W.</td>
<td>Hibernia and Shamrock Collieries, Gelsenkirchen, Dusseldorf</td>
<td>June 2, 1866</td>
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<td>512</td>
<td>Philipson, H.</td>
<td>8, Queen Street, Newcastle-on-Tyne</td>
<td>Oct. 7, 1871</td>
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<td>513</td>
<td>Pickersgill, T.</td>
<td>Waterloo Main Colliery, near Leeds</td>
<td>June 5, 1869</td>
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<td>514</td>
<td>Piggford, J.</td>
<td>Risca House, Risca, near Newport, Mon.</td>
<td>Aug. 2, 1866</td>
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<td>515</td>
<td>Pilkington, Wm., jun.</td>
<td>St. Helen's, Lancashire</td>
<td>Sept. 6, 1855</td>
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<td>516</td>
<td>Potter, Addison</td>
<td>Heaton Hall, Newcastle-on-Tyne</td>
<td>Mar. 6, 1869</td>
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<td>517</td>
<td>Priestman, Jon.</td>
<td>Coal Owner, Newcastle-on-Tyne</td>
<td>Sept. 2, 1871</td>
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<td>518</td>
<td>Ramsay, J. A.</td>
<td>Washington Colliery, near Durham (Member of Council)</td>
<td>Mar. 6, 1869</td>
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<td>519</td>
<td>Ramsay, J. T.</td>
<td>Walbottle Hall, near Blaydon-on-Tyne (Member of Council)</td>
<td>Aug. 3, 1853</td>
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<td>520</td>
<td>Ramsay, T. D.</td>
<td>So. Durham Colliery, via Darlington</td>
<td>Mar. 1, 1866</td>
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<td>521</td>
<td>Redmayne, J. M.</td>
<td>Chemical Manufacturer, Gateshead</td>
<td>July 2, 1872</td>
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<tr>
<td>522</td>
<td>Redmayne, R. R.</td>
<td>Chemical Manufacturer, Gateshead</td>
<td>Sept. 2, 1871</td>
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523 Reed, Robert, Felling Colliery, Gateshead  Dec. 3, 1863
524 Rees, Daniel, Gwaelodygarth Colliery, Merthyr-Tydvil  1862
525 Reefe, Wm., Teplitz, Bohemia  Oct. 5, 1872
526 Reid, Andrew, Newcastle-on-Tyne  April 2, 1870
527 Richardson, E., 2, Queen Street, Newcastle-on-Tyne  Feb. 5, 1870
528 Richardson, H., Backworth Colliery, Newcastle  Mar. 2, 1865
529 Richardson, J. W., Iron Shipbuilder, Newcastle-on-Tyne  Sept. 3, 1870
530 Ridley, G., Trinity Chambers, Newcastle-on-Tyne  Feb. 4, 1865
531 Ridley, J. H., R. and W. Hawthorn's, Newcastle  April 6, 1872
532 Ritson, U. A., 6, Queen Street, Newcastle-on-Tyne  Oct. 7, 1871
533 Roberts, Thomas  Nov. 2, 1872
534 Robertson, W., M.E., 123, St. Vincent Street, Glasgow  Mar. 5, 1870
535 Robinson, G. C., Butterknowle Colliery, Staindrop, Darlington  Nov. 5, 1870
537 Robinson, R., jun., Grosvenor House, Bishop Auckland  Feb. 1, 1868
538 Robinson, R. H., Staveley Works, near Chesterfield  Sept. 5, 1868
539 Robson, E., Cassop and Tyne Main Colliery Offices, Middlesbrough-on-Tees  April 2, 1870
540 Robson, J. S., Butterknowle Colliery, via Staindrop, Darlington  1853
541 Robson, J. T., Cambuslang, Glasgow  Sept. 4, 1869
542 Robson, M., Copp Colliery, near Mold, Flintshire  May 4, 1872
543 Robson, Thomas, Lumley Colliery, Fence Houses  Oct. 4, 1860

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ELECTED.

544 Robson, W. C., Walbottle Colliery, near Newcastle  Sept. 4, 1869
545 Rogerson, J., Weardale Iron and Coal Co., Newcastle  Mar. 6, 1869
546 Roscamp, J., Acomb Colliery, Hexham  Feb. 2, 1867
<table>
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<th>Date</th>
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<tr>
<td>547</td>
<td>Roseby, John</td>
<td>Haverholme House, Brigg, Lincolnshire</td>
<td>Nov. 2, 1872</td>
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<td>548</td>
<td>Ross, A.</td>
<td>Shipcote Colliery, Gateshead</td>
<td>Oct. 1, 1857</td>
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<tr>
<td>549</td>
<td>Ross, E. A.</td>
<td>Tondu Coal Works, Bridgend, Glam.</td>
<td>Apr. 11, 1874</td>
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<td>550</td>
<td>Ross, J. A. G.</td>
<td>Elswick Engine Works, Newcastle</td>
<td>Jul. 2, 1872</td>
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<tr>
<td>551</td>
<td>Rosser, W.</td>
<td>Mineral Surveyor, Llanelly, Carmarthensh.</td>
<td>1856</td>
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<td>552</td>
<td>Rothwell, R. P.</td>
<td>71, Broadway, New York</td>
<td>Mar. 5, 1870</td>
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<td>553</td>
<td>Routledge, T.</td>
<td>Lorway Coal Co., Limited, Sydney, Cape Breton</td>
<td>Dec. 3, 1870</td>
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<tr>
<td>554</td>
<td>Routledge, Wm.</td>
<td>Sydney, Cape Breton</td>
<td>Aug. 6, 1857</td>
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<td>555</td>
<td>Rusby, W. J.</td>
<td>99, Cannon Street, London, E.</td>
<td>Aug. 1, 1868</td>
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<td>556</td>
<td>Rutherford, J.</td>
<td>Halifax, Nova Scotia</td>
<td>1866</td>
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<td></td>
<td>Saint, Geo.</td>
<td>Llangennech Colliery, Llanelly, South Wales</td>
<td>Apr. 11, 1874</td>
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<td>558</td>
<td>Sanderson, R.</td>
<td>Burdon, 33, Westgate Road, Newcastle</td>
<td>1852</td>
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<td>559</td>
<td>Scarth, W. T.</td>
<td>Raby Castle, Darlington</td>
<td>Apr. 4, 1868</td>
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<td>560</td>
<td>Scott, Andrew</td>
<td>Broomhill Colliery, Acklington</td>
<td>Dec. 7, 1867</td>
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<td>Scoular, G.</td>
<td>Parkside, Frizington, Cumberland</td>
<td>Jul. 2, 1872</td>
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<td>Seddon, W.</td>
<td>Lower Moor Collieries, Oldham, Lancashire</td>
<td>Oct. 5, 1865</td>
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<td>563</td>
<td>Shallis, F. W.</td>
<td>1, South Villas, Camden Square, London</td>
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<td>564</td>
<td>Shaw, W., jun.</td>
<td>Wolsingham, via Darlington</td>
<td>Jun. 3, 1871</td>
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<td>Sheppard, F. C.</td>
<td>71, Maple St., Newcastle-on-Tyne</td>
<td>Nov. 2, 1872</td>
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<td>Shiel, John</td>
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<td>May 6, 1871</td>
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<td>Shiel, H., Lamb's Cottage, Gilesgate Moor, Durham</td>
<td>Mar. 6, 1862</td>
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<td>Shone, Isaac</td>
<td>Pentrefelin House, Wrexham</td>
<td>1858</td>
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<td>Shortrede, T.</td>
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<td>Shute, C. A.</td>
<td>Westoe, South Shields</td>
<td>Apr. 11, 1874</td>
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<td>571</td>
<td>Simpson, J.</td>
<td>Heworth Colliery, nr. Gateshead-on-Tyne</td>
<td>Dec. 6, 1866</td>
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<tr>
<td>No.</td>
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<td>1855</td>
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<td>Simpson, R., Moor House, Ryton-on-Tyne</td>
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<td>Slinn, T., Radcliffe House, Acklington</td>
<td>July 2, 1872</td>
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<td>Smith, C. J., 16, Whitehall Place, Westminster, London, S.W.</td>
<td>July 2, 1872</td>
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<td>Mar. 7, 1874</td>
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<td>Snowdon, T., jun., West Bitchburn Colliery, nr. Tow-law, via Darlington</td>
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<td>Aug. 1, 1868</td>
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<td>May 6, 1853</td>
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<td>Southern, R., Burleigh House, The Parade, Tredegarville, Cardiff</td>
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<td>Southworth, Thos., Hindley Green Collieries, nr. Wigan</td>
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<td>Spark, H. K., Darlington</td>
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<td>Spence, G., Clifton and Millgramfitz Colls., Workington</td>
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<td>Spencer, John, Westgate Street, Newcastle-on-Tyne</td>
<td>Sept. 4, 1869</td>
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<td>593</td>
<td>Spencer, M., Newburn, near Newcastle-on-Tyne</td>
<td>Sept. 4, 1869</td>
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<td>Spencer, T., Ryton, Newcastle-on-Tyne</td>
<td>Dec. 6, 1866</td>
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595  Spencer, W., 6, Villiers Street, Sunderland  Aug. 21, 1852
596  Spooner, P., Haswell Colliery, Fence Houses  Dec. 4, 1869
597  Spours, J. L., Victoria Colliery, Howden, Darlington  April 11, 1874
598  Steavenson, A. L., Durham (Vice-President)  Dec. 6, 1855
599  Steavenson, D. F., B.A., LL.B., Barrister-at-Law, Cross House, Westgate Street, Newcastle-on-Tyne  April 1, 1871
600  Steele, Chas., Bolton Colliery, Mealsgate, Cumberland  June 7, 1873
601  Steele, Charles, R., Ellenborough Colliery, Maryport  Mar. 3, 1864
602  Stenson, W. T., Whitwick Coll., Coalville, nr. Leicester  Aug. 5, 1853
604  Stephenson, W. H., Summerhill Grove, Newcastle  Mar. 7, 1867
605  Stevenson, Archibald, South Shields  Sept. 2, 1871
606  Stobart, H. S., Witton-le-Wear, Darlington  Feb. 2, 1854
607  Stobart, W., Cocken Hall, Fence Houses  July 2, 1872
608  Stokoe, Joseph, Houghton-le-Spring, Fence Houses  April 11, 1874
609  Straker, John, West House, Tynemouth  May 2, 1867
610  Stratton, T. H. M., Seaham Colliery, Sunderland  Dec. 3, 1870
611  Swallow, John, East Boldon, Co. Durham  Aug. 6, 1863
612  Swallow, John, East Castle Collieries, Annfield Plain, Lintz Green  May 2, 1874

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ELECTED.

613  Swallow, R. T., Springwell, Gateshead  1862
614  Swan, Charles, Low Walker, Newcastle  April 11, 1874
615  Swan, H. F., Shipbuilder, Newcastle-on-Tyne  Sept. 2, 1871
616  Swan, J. G., Upsall Hall, near Middlesbro'  Sept. 2, 1871

617  Taylor, Hugh, 8, Queen Street, Quay, Newcastle  Sept. 5, 1856
618 Taylor, John, Earsdon, Newcastle-upon-Tyne Aug. 21, 1852
619 Taylor, John, B., The Mount, Clent, Stourbridge May 3, 1873
620 Taylor, T., Chipchase Castle, Northumberland July 2, 1872
621 Taylor, W. N., Ryhope Colliery Office, near Sunderland Oct. 1, 1863
622 Taylor-Smith, Thomas, Urpeth Hall, Chester-le-Street Aug. 2, 1866
623 Telford, W., Cramlington, Northumberland May 6, 1853
624 Terry, E., M. E., Dudley Sept. 13, 1873
625 Thomas, A., Bilson House, near Newnham, Glouces. Mar. 2, 1872
626 Thompson, Astley, Kidwelly, Carmarthenshire 1864
627 Thompson, James, Bishop Auckland June 2, 1866
628 Thompson, John, Marley Hill Colliery, Gateshead Oct. 4, 1860
629 Thompson, John, Boughton Hall, Chester Sept. 2, 1865
630 Thompson, J., Norley Colliery, Wigan, Lancashire April 6, 1867
631 Thompson, R., jun., North Brancepeth Coll., nr. Durham Sept. 7, 1867
632 Thompson, T. C, Milton Hall, Carlisle May 4, 1854
633 Thorpe, R. S., 17, Picton Place, Newcastle Sept. 5, 1868
634 Tinn, J., C.E., Ashton Iron Rolling Mills, Bower Ashton, Bristol Sept. 7, 1867
635 Toller, J. E., Royal Engineers July 2, 1872
636 Tone, J. F., C.E., Pilgrim Street, Newcastle-on-Tyne Feb. 7, 1856
637 Truran, M., Dowlais, Glamorgan Dec. 1, 1859
638 Turner, W. B., C. and M.E., Sella Park, Calder Bridge, via Cornforth Dec. 7, 1867
639 Tylden-Wright, C., Shireoaks Coll., Worksop, Notts. 1862
640 Tyzack, D., Warkworth, Acklington, Northumberland Feb. 14, 1874
641 Ure, J. F., Engineer, Tyne Commissioners, Newcastle May 8, 1869

642 Vaughan, Thomas, Middlesbro'-on-Tees 1857
643 Vaughan, W. S., Abbot & Co., Gateshead Nov. 1, 1873
645 Wake, H.H., River Wear Commissioners, Sunderland  Feb. 3, 1872
646 Waldo-Sibthorpe, M. R., Saltburn-by-the-Sea  June 6, 1874
647 Walker, G. W., Bulwell, Notts.  Sept. 7, 1867

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648 Walker, J. S., 15, Wallgate, Wigan, Lancashire  Dec. 4, 1869
649 Walker, T. F., 58, Oxford Street, Birmingham  April 11, 1874
650 Walker, W., Saltburn-by-the-Sea  March 5, 1870
651 Wallace, Henry, Trench Hall, Gateshead  Nov. 2, 1870
652 Wallace, J., 3, St. Nicholas Buildings, Newcastle-on-Tyne  Sept. 13, 1873
653 Ward, H., Priestfields Iron Works, Oaklands, Wolverhampton  Mar. 6, 1862
654 Wardell, S. C., Doe Hill House, Alfreton  Apr. 1, 1865
655 Warrington, J., Worsborough Hall, near Barnsley  Oct. 6, 1859
656 Watkin, Wm. J. L., Pemberton Colliery, Wigan  Aug. 7, 1862
657 Watson, H., High Bridge, Newcastle-upon-Tyne  Mar. 7, 1868
658 Watson, M., Ibstock Coll., near Ashby-de-la-Zouch  Mar. 7, 1868
659 Webster, R. C., Ruabon Coll., Ruabon, Denbighshire  Sept. 6, 1855
660 Weeks, J. G., Bedlington Colliery, Bedlington  Feb. 4, 1865
661 Westmacott, P. G. B., Elswick Iron Works, Newcastle  June 2, 1866
662 Whaley, John, Coanwood Colliery, Haltwhistle  Feb. 1, 1873
663 Whaley, Thomas, Orrell Mount, Wigan  Aug. 2, 1866
664 White, H., So. Skelton Mines, Saltburn-by-the-Sea  1866
665 White, J. F., M.E., Wakefield  July 2, 1872
666 Whitelaw, A., 168, West George Street, Glasgow  Mar. 5, 1870
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<td>Whitelaw, John</td>
<td>Fordel Colliery, Inverkeithing, N.B.</td>
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<td>Whitelaw, T.</td>
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<td>April 6, 1872</td>
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<td>669</td>
<td>Whitwell, T.</td>
<td>Thornaby Iron Works, Stockton-on-Tees</td>
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<td>670</td>
<td>Widdas, C.</td>
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<td>671</td>
<td>Wild, J. G.</td>
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<td>Wilkinson, W.</td>
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<td>Mar. 3, 1873</td>
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<td>Williams, E.</td>
<td>(Bolckow, Vaughan, &amp; Co.), Middlesbro'</td>
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<td>Williams, J. J.</td>
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<td>Nov. 2, 1872</td>
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<td>676</td>
<td>Williams, John L.</td>
<td>Mold, Flintshire</td>
<td>Nov. 2, 1872</td>
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<td>Williamson, John</td>
<td>Chemical Manufacturer, So. Shields</td>
<td>Sept. 2, 1871</td>
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<td>Cannock, &amp;c, Collieries, Hednesford</td>
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<td>Sept. 5, 1868</td>
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<td>Willis, James</td>
<td>13, Old Elvet, Durham (Member of Council)</td>
<td>Mar. 5, 1857</td>
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<td>Wilmer, F. B.</td>
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<td>June 6, 1856</td>
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<td>Wingfield Iron Works and Coll., Alfreton</td>
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<td>Wood, C. L.</td>
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<td>1853</td>
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<td>Wood, J.</td>
<td>Flockton Collieries, Wakefield</td>
<td>April 2, 1863</td>
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691 Wood, Lindsay, Southill, Chester-le-Street Oct. 1, 1857
692 Wood, Thomas, Rainton House, Fence Houses Sept. 3, 1870
693 Wood, W.H., West Hetton, Ferryhill (Member of Council) 1856
694 Wood, W. O., East Hetton Colliery, Coxhoe, Co. Durham Nov. 7, 1863
695 Woodgate, A., Chemical Manure Manfr., Newcastle Feb. 3, 1872
696 Woodhouse, J. T., Midland Road, Derby Dec. 13, 1852
697 Woolcock, Henry, St. Bees, Cumberland Mar. 3, 1873
698 Wright, G. H., Heanor Hall, Heanor, near Derby July 2, 1872
699 Wright, R., Killingworth Colliery, Newcastle Oct. 11, 1873
700 Wrightson, T., Stockton-on-Tees Sept. 13, 1873

701 Young, J., July 2, 1872
702 Young, Philip, Colliery Manager, Alnwick Oct. 11, 1873

STUDENTS
1 Atkinson, F. R., Haswell Colliery, Fence Houses Feb. 14, 1874
2 Atkinson, J. B., Chilton Moor, Fence Houses Mar. 5, 1870
3 Atkinson, W. N., 10, Gloucester Terrace, Newcastle June 6, 1868
4 Avery, F. S., Killingworth Colliery, Newcastle May 2, 1874
5 Bain, Donald, Seaton Delaval Colliery, Dudley, Northd. Mar. 3, 1873
6 Barnes, A. W., East Hetton Coll., Coxhoe, Co. Durham Oct. 5, 1872
7 Bell, C. E., 31, Old Elvet, Durham Dec. 3, 1870
8 Berkley, R. W., Marley Hill Colliery, Gateshead Feb. 14, 1874
9 Bewick, T. B., Haydon Bridge, Northumberland Mar. 7, 1874
10 Boyd, R. F., Moor House, near Durham Nov. 6, 1869
11 Bragge, G. S., Nunnery Colliery Offices, Sheffield July 2, 1872
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<td>Apr. 11, 1874</td>
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<td>Dec. 6, 1873</td>
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<td>Whitwood</td>
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<td>Chambers, W. Henry</td>
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<td>Dec. 2, 1871</td>
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<td>Clark, R. B.</td>
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<td>Apr. 5, 1873</td>
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<td>Cobbold, C. H.</td>
<td>Harton Colliery Office, Tyne Dock, South Shields</td>
<td>May 3, 1873</td>
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<td>Summerhill Grove, Newcastle</td>
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<td>Cockin, G. M.</td>
<td>Bishopwearmouth Rectory, Sunderland</td>
<td>Nov. 2, 1872</td>
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<td>Aug. 2, 1873</td>
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<td>Crone, E. W.</td>
<td>Killingworth Hall, near Newcastle</td>
<td>Mar. 5, 1870</td>
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<td>Eden, C. H.</td>
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<td>Sept. 13, 1873</td>
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<td>Fletcher, J.</td>
<td>Kelton House, Dumfries</td>
<td>July 2, 1872</td>
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<td>Forster, J. T.</td>
<td>Washington, Gateshead</td>
<td>Aug. 1, 1868</td>
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<td>Garthwaite, T. Y. B.</td>
<td>Greenside, Blaydon-on-Tyne</td>
<td>Feb. 1, 1873</td>
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<td>Gerrard, James</td>
<td>Ince Hall Coal and Cannel Co., Wigan</td>
<td>Mar. 3, 1873</td>
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</table>
34 Gilmour, D., Gilmilnscroft Colliery, near Auckinleck  
Feb. 3, 1872

35 Greener, T. Y., Peases' West Collieries, Darlington  
July 2, 1872

36 Hague, E., Towneley Colliery, Blaydon-on-Tyne  
Mar. 2, 1872

37 Hallimond, W. T., Etherley Colliery, Escomb, Bishop Auckland  
May 2, 1874

38 Hamilton, E., Tursdale Colliery, Coxhoe  
Nov. 1, 1873

39 Harris, W. S., Marley Hill Colliery, Gateshead  
Feb. 14, 1874

40 Heckels, W. J., Wearmouth Colliery, Sunderland  
May 2, 1868

41 Hedley, E., 2, St. John's Villas, Haverstock Hill, London, N.W.  
Dec. 2871

42 Hedley, George, 3, Princess Street, Bishop Auckland  
Aug. 2, 1873

43 Hodgson, J. W., Dipton Coll., via Lintz Green Station  
Feb. 5, 1870

44 Hughes, H. E., Bowers Allerton Collieries, Limited, Astley, Woodlesford  
Nov. 6, 1869

45 Hunter, J., jun., Seaham Coll. Offices, nr. Sunderland  
Mar. 6, 1869

46 Hutton, J. A., Killingworth Colliery, near Newcastle  
Sept. 4, 1869

47 Jepson, H., Harton Colliery Office, Tyne Docks, South Shields  
July 2, 1872

48 Johnson, W., Strangeways Hall, &c, Collieries, Wigan  
Feb. 14, 1874

49 Jordan, J. J., South Derwent Colliery, via Lintz Green  
Mar. 3, 1873

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50 Key, Thomas, 57, Percy Park, Tynemouth  
Nov. 2, 1872

51 Kyrke, R. H. V., Nant-y-Ffrith, Wrexham, No. Wales  
Feb. 5, 1870

52 Leach, C. C., Bedlington Collieries, Bedlington  
Mar. 7, 1874

53 Lishman, C. J., Helensville West, Newcastle  
June 7, 1873

54 Lisle, J., Washington Colliery, Co. Durham  
July 2, 1872

55 Marsh, T. G., Dudley  
Sept. 13, 1873

56 Mills, M.H., Weardale Iron & Coal Co., Towlaw, Darlington  
Feb. 4, 1871
57 Moor, W., jun., Lanelay Coll., Llantrissant, Glam.  July 2, 1872
58 Moore, R. W., Colliery Office, Whitehaven  Nov. 5, 1870
59 Moses, W., Lumley Colliery, Fence Houses  Mar. 2, 1872

60 Pamely, C., Radstock Coal Works, near Bath  Sept. 5, 1868
61 Place, Thomas, Newbottle Land, Houghton-le-Spring, Fence Houses  April 2, 1870
62 Pooley, John, Towneley Colliery, Blaydon-on-Tyne  Feb. 1, 1873
63 Potter, A. M., Heaton Hall, Newcastle  Feb. 3, 1872
64 Price, J. R., Wigan Coal and Iron Co., Wigan  Aug. 7, 1869

65 Rathbone, Edgar P., D. of Norfolk’s Colliery Offices, Sheffield  Mar. 7, 1874
66 Reed, R. B., Newbottle Colliery, Fence Houses  Mar. 5, 1870
67 Ritson, W. A., Towneley Colliery, Blaydon-on-Tyne  April 2, 1870
68 Robson, J. M., 11, Belhaven Terrace, Glasgow  Dec. 5, 1868

69 Sawyer, A. R., Towneley Colliery, Blaydon-on-Tyne  Dec. 6, 1873
70 Scott, C. F., Monk Bretton, near Barnsley  April 11, 1874
71 Sopwith, T., jun., South Derwent Coll., near Annfield Plain, County Durham  Nov. 2, 1867
72 Sparkes, C., Wearmouth Colliery, Sunderland  Sept. 5, 1868
73 Stobart, F., Crocken Hall, Fence Houses  Aug. 2, 1873

74 Thompson, William, Washington Colliery, Co. Durham  May 2, 1874
75 Vernon, J. O., Villa de St. George, Newcastle  Sept. 7, 1867
76 Walker, G. B., Osgathorpe, Sheffield  Dec. 2, 1871
LIST OF SUBSCRIBING COLLIERIES

Owners of Ashington Colliery, Newcastle-on-Tyne.

" East Holywell Colliery, Earsdon, Northumberland.
" Haswell Colliery, Fence Houses.
" Hetton Collieries, Fence Houses.
" Lambton Collieries, Fence Houses (Earl Durham).
" North Hetton Colliery, Fence Houses.
" Rainton Collieries (Marquess of Londonderry).
" Ryhope Colliery, near Sunderland.
" Seghill Colliery, Northumberland.
" South Hetton and Murton Collieries, Fence Houses.
" Stella Colliery, Hedgefield, Blaydon-on-Tyne.
" Throckley Colliery, Newcastle.
" Wearmouth Colliery, Sunderland.
" Whitworth Colliery, Ferryhill.

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RULES

1.—The objects of the North of England Institute of Mining and Mechanical Engineers are to enable its members to meet together to discuss the means for the Ventilation of Coal and other Mines, the Winning and Working of Collieries and Mines, the Prevention of Accidents, and the advancement of the Sciences of Mining and Engineering generally.

2.—The North of England Institute of Mining and Mechanical Engineers shall consist of three classes of members, namely:—Ordinary Members, Life Members, and Honorary Members, with a class of Students attached.

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

4.—Honorary Members shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society, Government Mining Inspectors during the term of their office, and the Professors of the College of Physical Science, Newcastle-upon-Tyne, during their connection with the said College.
5.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineers, and such persons may continue Students until they attain the age of 23 years.

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

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

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

9.—Each Subscriber of £2 2s. annually (not being a member) 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.—Persons desirous of being admitted into the Institute as Ordinary Members, Life Members, or Students, shall be proposed by three Members, and as Honorary Members by at least five Members. The nomination shall be in writing and signed by the proposers (see Form A), and shall be submitted to the first General or Special Meeting after the date thereof. The name of the person proposed shall be exhibited in the Society's room until the next General or Special Meeting, when the election shall be proceeded with by ballot, unless it be then decided to elect by show of hands. A majority of votes shall determine every election. Notice of election shall be sent to each Member or Student within one week after his election, on Form B, enclosing at the same time Form C, which shall be returned by the Member or Student, signed, and accompanied with the amount of his annual subscription, within two months from the date of such election, which otherwise shall become void.

11.—The Officers of the Institute shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and Secretary (if Members of the Institute), shall constitute a Council for the direction and management of the affairs of the Institute. The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting (except in case of vacancies), and shall be eligible for re-election, with the exception of any President or Vice-President who may have held office for the three immediately preceding years, and such six Councillors who may have attended the fewest Council Meetings during the past year; but such Members shall be eligible for re-election after being one year out of office.

12.—All Members shall be at liberty to nominate, in writing, and send to the Secretary, not less than fourteen days prior to the Annual or Special Meeting, a list of Ordinary and Life Members who are considered suitable to fill the various offices, such list being signed by the nominators. A list of the
persons so nominated and of the retiring Officers, indicating those who are ineligible for re-election (see Form G), shall constitute a balloting list, and shall be posted at least seven days previous to the Annual or Special Meeting, to all Members of the Institute, who may erase any name or names from this 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 as above enumerated. The balloting papers must be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman

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of the Meeting, so as to be received before the hour fixed for the election of Officers. The Chairman shall then appoint four Scrutineers, who shall receive the balloting papers, and shall sign and hand to the Chairman of the Meeting a list of the elected Officers, after destroying the papers. Those papers which do not accord with these directions shall be rejected by the Scrutineers. The votes for any Members who may not be elected Vice-Presidents shall count for them as Members of the Council.

In case of the decease or resignation of any Officer or Officers, notice thereof shall be given at the next General or Special Meeting, and a new Officer or Officers elected at the succeeding General or Special Meeting, in accordance with the mode above indicated.

13.—At meetings of the Council, five shall be a quorum, and the minutes of the Council's proceedings shall be at all times open to the inspection of the Members of the Institute. The President shall be ex-officio Chairman of every committee.

14.—All Past-Presidents shall be ex-officio Members of the Council so long as they continue Members of the Institute, and Vice-Presidents who become ineligible from having held office for three consecutive years shall be ex-officio Members of the Council for the following year.

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

16.—Every question, not otherwise provided for, which shall come before any Meeting of the Institute, shall be decided by the votes of the majority of the Ordinary or Life Members then present.

17.—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.

18.—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.
19.—The Copyright of all Papers communicated to, and accepted for printing by the Council, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

20.—All proofs of discussion, 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.

21.—The Institute is not, as a body, responsible for the facts and opinions advanced in the Papers which may be read, nor in the discussions which may take place at the Meetings of the Institute.

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

23.—Members elected at any Meeting between the Annual Meetings shall be entitled to all Papers issued in that year, as soon as they have signed and returned Form C, and paid their subscriptions.

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

25.—Any person whose subscription is two years in arrear, that is to say, whose arrears and current subscriptions shall not have been paid on or before the first of August, shall be reported to the Council, who shall direct application to be made for it according to form D, and in the event of it continuing one month in arrear after such application, the Council shall have the power, after suitable remonstrance by letter in the form so provided (Form E), of erasing the name of the defaulter from the register of the Institute.

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

27.—Invitations shall be forwarded by the Secretary to any gentleman whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings. Any Member of the Institute shall also have power to introduce two strangers (see form F) to any of the General Meetings of the Institute, but they shall not take part in the proceedings except by permission of the meeting.

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

[FORM A.]

Name in full—Mr.

Designation or Occupation

Address

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 a thereof.

Proposed by (Signatures) of three members

Dated 18

[FORM B.]

Sir,—I beg 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 £

If the first subscription is not received within two months from the present date, the election will become void, under Rule 10.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM C]

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 regulations of the said Institute as they are now formed, or as they may hereafter be altered; 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) be free from this obligation.
Witness my hand this day of 18

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[FORM D.]

18

Sir,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to draw your attention to Rule 25, 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 Rule above referred to.

I am, Sir,

Yours faithfully,

Secretary.

[FORM E.]

18

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 Rule 25, the Council have declared, by special vote, on the day of 18... that you have forfeited your claim to belong to the Institute, and your name will be in consequence expunged from the Register, unless payment is made previous to

But notwithstanding such forfeiture, I am directed to call upon you for payment of your arrears, amounting to £

I am, Sir,

Yours faithfully,

Secretary.

[FORM E.]

Admit of

to the Meeting on Saturday, the
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.

Not transferable.

[see in original text Form G. Balloting list]

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING, SEPTEMBER 13, 1873, IN THE WOOD MEMORIAL HALL.

E. F. BOYD, Esq., Vice-President, in the Chair.

The Secretary read the minutes of the last meeting, and they were signed by the Chairman.

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

Members—

Mr. Edward Terry, M.E., Dudley.

Mr. Richd. J. Barnes, Atherton Collieries, near Manchester.

Mr. Wrightson, Stockton-on-Tees.

Mr. William Hall, Albion Mines, Pictou, Nova Scotia.

Mr. John Wallace, 3, St. Nicholas Buildings, Newcastle-on-Tyne.

Mr. William Menzies, King Street, Newcastle-on-Tyne.

Students—

Mr. W. Stobart Elliot, The Green, Sunderland.

Mr. C. H. Eden, Sedgefield, Ferryhill.

Mr. T. G. MARSH, Dudley.
The following were nominated for election at the next meeting:—

Members—

Mr. W. D. Elliott, Pemberton Street, Hull.

Mr. George Bradford, Newbottle Colliery, Fence Houses.

Mr. William Pattison, Westminster Colliery, near Wrexham

Mr. William Pattison, Jun., Ffrwd Colliery and Ironworks, Wrexham.

Mr. Philip Young, Fenham Colliery, Newcastle-on-Tyne.

Mr. Joseph Nicholson, Greenside Colliery, Milton Station, Carlisle.

Mr. Henry Davey, C.E., Leeds.

Mr. Robert Wight, Engineer, Killingworth Colliery, Newcastle.

Student:—

Mr. J. S. Burrows, Pease's West Collieries, Darlington.

The President remarked that the gentleman who was to read the first paper, Mr. Henry Davey, Civil Engineer, of Leeds, as he did not happen to be a member of the Institute at that moment, was not quite in order; but when they knew that he was nominated for election at the next meeting, in all probability they would feel complimented in having a gentleman of such high standing as a member, and would have no objection to receive the paper.

Mr. Henry Davey then read a paper on the "Differential Expansive Pumping Engine."

[3]

DIFFERENTIAL EXPANSIVE PUMPING ENGINE.

By HENRY DAVEY.

The differential expansive pumping engine exists in two types, the single cylinder and the compound engine, and the designs and arrangements are varied to suit different applications. Plates I. and II. show an arrangement of compound engine now being constructed for a north country colliery; Plate
III. shows the arrangement of valve gear; Plate IV. is an engraving from a photograph of the expansive pumping engine at Newton Cap Colliery; Plate V. is an engraving from a photograph of the pumping engine at the Clay Cross Works; Plate VI. shows the adaptation of the principle to a steam pump arranged for boiler feeding; and Plate VII. shows a reciprocating hydraulic engine applied to work a double-acting force pump for lifting and forcing water in dip levels, &c, and applied to working the air-pump of the condenser of the pair of engines illustrated on Plate IV.

It will be seen that the compound engine consists of a pair of horizontal cylinders A B, Plates I. and II., placed end to end, the bottom of the high pressure cylinder A forming one of the covers of the low pressure cylinder B. There are two piston rods to the low pressure piston, which pass through tubes cast on the jacket of the high pressure cylinder, so that they come in the same plane with the rod of the high pressure piston. These three rods are coupled to one crosshead, to which is attached the connecting rod for working the pumps C. The cylinders are firmly secured to a strong girder bed, and the condenser is carried on a separate bed at the rear of the engine, and is not shown in the plate—the air pump bucket being worked by means of a tail rod D from the low pressure piston. Such is the simple form of the compound engine.

The valve gear can be readily understood by reference to Plate III., which shows it applied to a single cylinder engine. The main slide valve C receives its motion from a lever A, to the centre B of which it is connected. This lever receives two motions, one at the end D derived directly from the main moving parts of the engine by another lever of the first order, which, receiving the full motion of the piston at the long end, imparts from its short limb, to the end D of the lever A

the amount of motion suitable to the working of the valve — this lever is seen clearly at X, Plates IV., V., and VI.—and another motion derived from a subsidiary piston F. This subsidiary piston receives its motion from the steam in the main slide chest, by means of a small valve G, and gives motion to a cataract piston H, working in a cylinder filled with water, which escapes from side to side through a small opening that can be regulated at pleasure by means of the valve I. This cataract regulates the speed of the piston F, and, consequently, the motion of the end E of the lever A, to which it is attached. The valve G, admitting steam on the subsidiary piston F, is actuated by means of a lever K, to which it is attached at L, and this lever, usually fixed at M, receives motion from the lever A by the connecting link N. When it is required to start the engine, motion can be given to the valve G by removing the pivot M of the lever K, and moving the lever by hand at the end 0.

The action of this gear upon the motion of the engine will be best understood by an illustration.

Suppose the main piston to be at rest at one end of the cylinder, then to start the engine, steam would be admitted into the subsidiary cylinder F, and motion would be communicated to the valve C, and the engine would commence its stroke; as it moves, however, it is giving motion to the lever A in a contrary direction to the motion communicated by the subsidiary piston F, and cuts off the steam. The main valve, therefore, has a differential motion compounded of the motion derived from the direct action of the main cylinder, and an opposite motion from the subsidiary piston. Now the motion of this subsidiary piston is rendered constant by means of the cataract H. Seeing, then, that the cataract end E of the lever has a constant motion independent of the engine itself, and that the other end D must needs have a varying motion depending on the varying motion of the main piston,
the resultant motion of the main valve being taken from the centre of the lever, and compounded of a varying and a constant motion, must vary as the first varying motion varies. Further, because variations of load on the engine produce variations in the motion of the main piston, therefore the increases or decreases of load produce corresponding corrections in the distribution of steam. It must be understood that the force acting on the subsidiary piston is far greater than that required to move the slide valve, the surplus being absorbed in driving the fluid in the cataract through a small opening, and as the resistance to a fluid increases with the square of the speed at which it flows, it requires a very great variation of force on the subsidiary piston to cause a very small variation in the

speed, so that the speed is practically constant for a given adjustment of the cataract plug, although the boiler pressure may vary. It will be seen from the description just given that the chief peculiarity in the invention is the simple manner in which the engine is rendered safe in working against variable loads, automatically and instantly varying the distribution of steam with every minute increase or decrease of resistance. A pause is produced at the completion of each single stroke of the piston, during which time the pump valves fall to their seats, preventing slip and the shock which occurs when pump valves close under pressure from a moving plunger. This freedom from shocks in the pumps is an important point. There is security also against accidents (such as bursting pipes, &c), and the durability of the valves and seats is greatly increased. The action of the valve gear of the engine is so sensitive and so perfect that the load may be greatly varied on the engine when it is in full work. Engines on this plan may be employed to pump direct into town mains without the intervention of stand pipes, balance valves, or anything of the sort. There is great economy in the construction of these engines, as will be readily seen from an inspection of the plates and the following tables of dimensions and powers, &c.—

[see in original text Table of powers, etc., of the single cylinder differential expansive pumping engine.]

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The columns headed "units of work" are for ready comparison with the work required to be done in any given example. Thus, let it be required to pump 250 gallons of water 200 feet high per minute, then the number of units of work to be done = 250 x 10 x 200 = 500,000, and on reference to the tables the size of the engine required for the work is readily selected.

The calculations in the above table have been made for an effective pressure of 25 lbs. per square inch on the piston, corresponding to a boiler pressure of from 35 to 45 lbs., a pressure which is very usual for such engines in collieries. The friction of the engine and that of the water in the column are included.

[see in original text Table of Compound differential expansive engines - This table is calculated for an effective pressure or load on the larger piston of 20 lbs. per square inch.]
The single cylinder engines, shown on the Plates IV., V., and VIII., are placed underground and are employed in pumping the water direct to the surface. The pair at Clay Cross Colliery are to pump against 1,000 feet head of water, whilst those at Newton Cap have 240 feet. This method of pumping in collieries is becoming very usual, and where there is no chance of the engine being flooded it is probably the best and certainly the most economical plan, as regards first cost.

No condensers are shown on Plates IV. and V., although the large pair of engines are provided with one. It is not, however, a part of the engine, but is entirely distinct, the air-pump being worked by means

of a small hydraulic engine from the pressure in the main column. In a more recent design the air-pump has been put on the bed with the engine, and is worked by means of a tail rod from the main piston, the pumps being placed both in front of the cylinder, with a plunger common to both barrels. See Plate VIII.

As regards the economy of fuel in the use of the condenser in this type of engine used underground, nothing can be said but that which is self-evident to all present; but in connection with the compound engine much has been said of late; and, judging from the demand which there exists for compound engines, there is every reason to believe that they possess certain advantages, but as far as economy of fuel is concerned it is well known that this is governed by the pressure and ratio of expansion employed and the introduction of the second cylinder is therefore purely a practical question. By the introduction of a second cylinder the maximum strain thrown on the piston and its attachments is greatly reduced, and a greater uniformity of motion secured. In the present example the variation of force between the commencement and end of the stroke is about 3 to 1 with an eight-fold expansion, whereas in a single cylinder engine it would be as 8 to 1. In Cornwall during the race, for economy of fuel, some years ago, the engineers carried expansion in a single cylinder to its utmost practical limit. Taylor’s engine, at the United Mines, worked with a cut-off of one-tenth the stroke, and did a duty of 112 millions. Experience has proved, however, that such high grades of expansion cannot be safely employed in a single cylinder; and we find that the custom is, now to work Cornish engines with a three-fold, or at most a five-fold, expansion; this partly accounts for the falling off in the duty reports. A high degree of expansion cannot be employed with safety in the single cylinder engine, because the variation of force during the steam stroke is too great—therefore the reason for the use of the second cylinder. The economy in the construction of this engine and the buildings for it is very great as will be readily seen by an inspection of the model before us. Power for power, this engine does not weigh two-thirds that of a Cornish engine, although the ratio of expansion employed is far greater, whilst the gear is of the most simple description, and the safety secured in working by the peculiar action of the gear must effect considerable economy in maintenance.

One of these engines has been at work for nearly two years at the Sudbury Water Works. It is always worked with the stop valve wide open, and the load may be changed from the high level reservoir to the
low level without in any way affecting the proper working of the engine, proving the efficiency of the
gear, which is further demonstrated by the fact that the engine is so unequally loaded that the
steam is cut off automatically at about one-third stroke on one side and half stroke on the other side
of the piston.

The President was sure they would all join with him in thanking Mr. Davey for the very excellent
paper which he had been kind enough to present to them. He hoped that some of them would take
the opportunity of informing themselves upon any variations which this engine had from others
used for a like purpose. There seemed to be one or two very interesting points worth the attention
of those who had the management of high-pressure engines applied to pumping. They very well
knew what serious damage takes place in the case of a bucket coming off, or a broken spear allowing
the engine to come rapidly into the house, and there was also the point of the action of the double
cylinder. If they had any question to ask or anything to inform themselves upon from Mr. Davey, he
would advise them to take that opportunity.

Mr. Lawrence would like to ask Mr. Davey if he could show them a diagram of one of those engines,
because, as he conceived, the only new thing about it was the motion given to the slide-valve or the
means of working the slide-valve, and certainly to his mind it was a very simple one, and he had no
doubt a very efficient one. But they all knew that they could judge better as to the result and the
proper working of a slide-valve if they saw a diagram of it. He would very much like to know if Mr.
Davey had the diagram with him, and if he had, if he would show it to them. They could then form a
very much better idea of the proper working of the differential motion which he had brought before
them. He would also like to ask Mr. Davey, seeing that the motion of the slide-valve corresponded
with the motion of the engine, which of course, as they knew, was different from the motion given
by the eccentric, how it was that he arrived at a variable expansion. He could easily see that the
differential motion gave him a corresponding inlet of steam corresponding with the motion
but suppose he wanted to work with a very high pressure of steam, and cut off, they would say, at about
one-tenth of the stroke, as was done in the Corliss engine, he wished to know how he had this at
command with

this particular motion; because the commencement and end of the stroke of the valve must
necessarily correspond with the stroke of the piston, seeing that it was worked directly from the
piston; but it might be that he got a different motion by the speed of the piston changing while the
motion of the piston working the cataract remained uniform. He did not know whether that was so
or not, but perhaps Mr. Davey would explain that to him. There was no doubt that the first cost of
the engine was considerably below that of some of the other kinds of engines which they had in this
district; but he thought the use of slide-valves in those very large engines was an objection, and Mr.
Davey did not seem to take any measures to overcome the great pressure on the back of the slide.
Again, his slides were placed at the top of the cylinder, and, therefore, did not allow the water to
escape, as they did in many of their engines in this neighbourhood. He understood that the same motion could be given to the double Cornish valves, and Mr. Davey might overcome the difficulty of the great pressure on the slide-valves in very large engines by using, he supposed, four such valves instead of the ordinary slide-valves. He should like to know if Mr. Davey had applied or could apply his motion to the ordinary four valves, such as were commonly used by the horizontal and winding engines in this district.

Mr. Davey said, in reply to the gentleman who had just spoken, he must admit that he had not taken any diagram at all, for this simple reason that the best engine which he could take a diagram from would be the one alluded to in his paper, which was at work at the Sudbury Water Works, Suffolk. That engine, as he said, was a high pressure engine, it cuts off at about half stroke on one side of the piston, and a third of the stroke on the other. Certainly a diagram of that would be of some service; but as a question of economy of fuel, with such a low rate of expansion, it would not be of much value, and on that account he had not taken the trouble to indicate the engine. He hoped when the compound engine was completed, which it was intended to erect in this district, to make some elaborate experiments as to the economy of fuel; but while cutting off about half stroke, it would be useless at present to do so. The next point raised was that with reference to the cut-off. Mr. Lawrence seemed to look at the action of the gear in this way; that the slide valve, instead of varying the cut-off, varies the amount of opening, and, consequently, acts as a throttle valve would in an ordinary engine. But this was not the result. There were two or three points which he, perhaps, did not sufficiently explain in the paper to make the action thoroughly understood. It required almost to see the gear at work to understand the exact action; but he thought he could explain it better by taking an example. He would suppose an engine employed to pump 1,500 gallons of water per minute from a depth of 70 fathoms. Now, the dead weight to be set in motion at the commencement of the stroke would, of course, be very great, and, consequently, the steam piston would not move simultaneously with the opening of the steam valve; and if the action of a Cornish engine on the steam stroke was observed it would be seen that there was a time from the opening of the steam valve to the time that the engine starts off. There was a certain amount of pause which was consequent on the inertia of the load to be set in motion. Now, in this engine, at the time that the steam was being admitted to the cylinder, by means of the slide valve, the slide valve was travelling at its maximum speed, and the steam piston had the least tendency to move. The consequence was that the motion on the slide valve was very great compared with that of the steam piston. Now, immediately the steam piston began to move—supposing it was cutting off at a point similar to that referred to by the speaker, an eighth or a tenth—immediately the inertia of the load was overcome, and that this little pause, which he had spoken of, had taken place, it was almost time for the engine to cut off the steam. The speed then of the steam piston would be increasing, so that at the point of cut-off, the slide valve would be moving in the opposite direction, with an increased speed consequent on the increased speed of the steam piston; therefore, whilst the engine is taking the steam, the slide valve is opening to the steam quickly, and the engine is moving off slowly. At the time that the cut-off takes place the motion of the slide valve is very quick in the opposite direction, consequent upon the motion of the engine, so
that in reality there was a sharp cut-off, and there was no throttling whatever of the steam. During
the time that the valve was opening to the steam, it would seem that there was no motion to the
end of the lever connected with the piston, and that the connection to the slide valve had a motion
given entirely from the cataract. Now if the motion were compounded of the two motions at that
time, the motion of the slide valve would be slow; but as the motion was then entirely dependent on
the second motion, the slide valve then was moving at its quickest speed. Immediately the engine
commenced to move off, and the steam piston was under weigh, the cut-off then, they would see,
would take place at the time the steam piston was moving at its greatest speed, so that there was a
sharp opening to the steam and

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a sharp cut-off. Then, with reference to the question raised as to whether the gear could be used
with Cornish valves, there were several illustrations given in a pamphlet he had published; and one
illustration showed its application to the three valves, the steam, equilibrium and eduction valves of
the Cornish engine, although there was no illustration showing how it might be applied to four
valves, such as the four valves of a winding engine; but its application in that case was precisely the
same as its application to the slide valves. Mr. Lawrence compared the motion of the valves in this
engine to the motion of the steam piston, and said he regarded it as being dissimilar to that of the
motion of an eccentric. It was in reality not the motion of an eccentric, but that of a cam; and the
motion of the slide valve was not that of the motion of the steam piston, but it was compounded of
the motion of the steam piston and the motion of the cataract. They knew, of course, that they
could actuate double beat valves of winding engines by means of an eccentric as well as by means of
tappits; so that this motion, applied to actuate the four valves, does the same for the four valves as
it does in its substitution for an eccentric in the other case. Then, as regards the lodgment of water
in the cylinder, through placing the valve chests on the top: it would be observed that those
cylinders were both steam jacketed, and, consequently, he did not anticipate that they would have
much difficulty on that score. Both the high and low pressure cylinders were steam jacketed. Had
they not been so, it perhaps might be advisable to place the working valves in inverted positions
under the cylinder, in order to get rid of the water. He thought these were all the points which had
been mentioned.

Mr. Lawrence said he was very much obliged for Mr. Davey's explanation. He was surprised to find
that gentleman make the remark that it was scarcely necessary to give a diagram of an engine
cutting off at half stroke. He could not see how Mr. Davey could bring out a new engine before them
and not bring a diagram to show exactly what the engine was doing, and compare its economy with
other engines which they had before them. He should have thought the diagram was the most
important part of the paper; a great portion of the power might be absorbed in working the slide
valves and other friction parts of the engine, the amount of which could be exactly ascertained if a
diagram had been taken, and the action of each valve would be brought before them at a glance
without any question. He was obliged to Mr. Davey for his explanation.
Mr. W. O. Wood might say that he had seen the engine at work at Sudbury; and he had tried it as far as he possibly could under varying loads. He first tried it by pumping the water under a heavy load, and then suddenly released the load. He afterwards stopped the engine, raised the steam in the boiler 20 lbs. above the ordinary working point, and then suddenly opened the throttle valve to the utmost extent. It was found that there was the slightest possible increase of speed at the commencement of the stroke, and then the engine settled down to its regular work, and went on to the number of strokes it was set for. Nothing could be more beautiful or more regular than the working of the valves.

The President asked Mr. Davey if, in the case of the application of his engine for the discharge of water to great elevations from the bottom of the pit, he made use of air-vessels? Had he ever tried them applied to his engines?

Mr. Davey said he had worked them in connection with air-vessels. The one which Mr. Wood had just alluded to at Sudbury delivers into an air-vessel. It is employed in working two sets of pumps, one at the bottom of the well, a single-acting 16-inch plunger pump, which delivers the water to the top of the well. From thence it is taken by means of a double-acting pump and lifted up to the service reservoir or depositing reservoir, as the case might be; and at the top of the well, on the upper side of the double-acting pump, was placed an air-vessel; but in the engines which had been made for draining collieries —placed underground to force the water to the surface—no air-vessel had been used at all. The pair alluded to in his paper, which were now being fixed at Clay Cross, employed to pump against 1,000 feet head, had no air-vessel. Nor did he think it advisable to employ an air-vessel in any case. There was a pause similar to that of the Cornish engine at the completion of each stroke, and the pumping is almost identical with that of the Cornish engine; and as the Cornish engines were better without air-vessels, and as they knew from experience that air-vessels in these engines were unnecessary, so he considered that they are unnecessary in his case. He might mention that in the last pair of engines which he spoke of, pumping with 1,000 feet head, they put the full head of water on the engines at the outset and suddenly threw it off whilst the stop valves were wide open, but the pistons did not strike the covers in a single case.

Mr. D. P. Morison asked Mr. Davey if his principle was applicable to winding engines as well as to pumping engines, because winding

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engines would appear to offer a still more excellent field for the adoption of the system?

Mr. Davey believed he could quite see his way to the application of the gear to the rotative engines. But although he had given no little study to the subject, yet, up to the present time, he had not sufficiently satisfied himself as to all the details as to be justified in bringing it before a scientific meeting.

Since the above discussion Mr. Davey has supplied two diagrams from the engine at Sudbury Water Works, which are given in Plate IX.

Mr. Emerson Bainbridge read the following paper, "On a New Description of Safety Lamp."
An investigation recently made by the author to discover the causes of the chief explosions in coal mines which have occurred within the past few years, shows that of the most important accidents no less than 39 per cent. were caused directly or indirectly by the use of naked lights, and the evidence points out that the whole of this large proportion of accidents would probably have been averted had safety-lamps been in use. In many of these accidents, the existence of gas could scarcely have been prevented by other means of ventilating than those adopted, since it was due to slight outbursts, to unavoidable disarrangements of brattices, or to carelessness of workmen, and whilst improved discipline may cause some reduction in the number of accidents from such causes, it will doubtless be ascertained that the more extended adoption of safety-lamps will be found to be the only preventive to any extent reliable.

The interesting records of the experiments conducted by the Safety-Lamp Committee, appointed by this Institute, brought to light the startling fact that none of the ordinary safety-lamps now used in English coal mines are safe, when exposed for a period of less than a minute to an explosive current moving at a velocity of 12 feet per second; that is, should a current of explosive mixture of 8640 feet per minute impinge upon a lamp hung in a working place, having an area of 16 square feet, an explosion would ensue in less than 50 seconds.

The insecurity of the safety-lamps in general adoption having thus been made manifest, the members of the Committee and others, designed several lamps which, when tested, would not explode, but nearly the whole of the lamps which have yielded this favourable result appear to be...
open to the objection, either of giving an inferior light, of being so complex as to make their first cost considerable, or of having the admission of air so arranged as to cause it to be difficult to keep the light burning.

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The substitution of lamps for candles in a colliery has usually met with considerable opposition on the part of the colliers, on the ground of the inferior illuminating power, and whilst the cost of lighting by lamps causes an extra expense to the colliery owner, the bad light given by the majority of those in use makes it, in many cases, difficult to pick the coals free from dirt.

The importance of the considerations enumerated above has, for some time past, had the careful consideration of the author, and after a large number of experiments, he now ventures to bring before the Institute a lamp which appears to meet, for the most part, the deficiencies referred to.

Whilst assisting at a number of the trials made by the Safety-Lamp Committee, the author had an opportunity of observing the defects causing the several lamps experimented upon to be unsafe. In the case of lamps having the vertical gauze surrounding the light, either wholly or at any one part, a current of explosive mixture playing upon the lamp had the effect of heating the gauze so much more quickly than it could radiate heat, as to destroy the principle by which the gauze is rendered safe. The gauze, hence, naturally and speedily attained a white heat, igniting the explosive mixture outside. Whilst the gauze of the Stephenson lamp has only an inch or two exposed above the inside glass, the Clanny lamp has several inches above the glass, and the Davy lamp is surrounded by gauze from top to bottom. The use of the gauze in the position it holds in these lamps is the chief cause of their having proved to be unsafe.

Another point of importance adduced by the experiments is worthy of note. On exposing lamps with a single gauze, and in which the air for combustion entered by the gauze, like the Davy, to an explosive current, the flame was elongated and continued burning, wholly filling the lamp with blue and yellow flame.

With a lamp, however, like the Stephenson, which has the gauze to some extent protected by an interior cylinder of glass, and in which the air is introduced at the bottom of the lamp, exposure to an explosive atmosphere causes an extra quantity of foul air to be formed in the glass cylinder; this falls upon the light and extinguishes it, and this action allows the Stephenson lamp to bear a current of about 240 feet per minute more than the other lamp before explosion ensues. The Clanny lamp also goes out in an explosive, but still atmosphere, owing to the air for supporting combustion entering the lamp some distance above the level of the flame.

[Plate X, illustrating Bainbridge's safety lamp]

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The observations recorded above, suggested to the author that if a lamp were constructed with no vertical gauze, through which a current could pass, and with the inlet and outlet of the air so
delicately balanced as to cause the quantity of air entering the lamp to be just sufficient for complete combustion, such a lamp would be safe. In pursuance of this idea, the lamp forming the subject of this paper has been constructed.

The Lamp, a sectional elevation of which is shown on Plate X., consists of a tapered glass cylinder surrounding the wick, and surmounted by a short brass cylinder of smaller diameter, at the top of which is a circular gauze which is screwed up from the inside. The plate at the top for sheltering the gauze is attached to the body of the lamp by small bars, in order to allow the heat given off by the lamp to be easily carried away. At the top and bottom of the glass, rings of a non-conducting material are used for the purpose of keeping the glass cool. The ring for screwing up the glass passes into a thread of a smaller diameter than that of the screw of the bottom of the lamp. This arrangement saves considerable time in screwing up the glass.

The air enters the lamp through a number of small round holes, which are covered by gauze attached to the inside of the lamp.

The various advantages which the form of lamp now brought under notice appears to possess, may be summarised as follows:—

1.—A. series of experiments which have been carefully made through the kindness of Mr. Lindsay Wood, at Hetton Colliery, to test the action of the lamp in the most explosive mixtures of gas and air, have proved it to be thoroughly safe, as shown by the Table No. 2, given below. Table No. 1 records the conclusions arrived at by the Safety-Lamp Committee with regard to the three chief Safety-lamps commonly used in this country.

[see in original text Table 1]

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[see in original text Table 2]

[see in original text Table 3 of experiments to test illuminating power and economy of burning.]  
It will be seen from Table No. 2 that at a low velocity of the explosive mixture, the lamp tried by the author was extinguished, and that from a velocity of 11.8 feet per second, to the extremely high velocity of 54 feet per second, no explosion in any instance ensued, but in every case the gas on entering the lamp burnt with a low, blue flame at the bottom of the lamp round about the air-holes, this flame only being about ¾ inch high. Thus a comparatively low temperature inside the lamp was maintained in each experiment.

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The trials were made both with the lamp referred to and with a lamp known as Hann’s, which is a modification of the Stephenson lamp, the failing point in the Stephenson being obviated by having an iron cap placed at the top of the gauze, thus protecting the lamp above the top of the glass. Mr.
Hann's lamp went out at each experiment till the velocity reached 54 feet per second, when an explosion took place, as shown in the table, at the expiration of 23 seconds. The flame occurring inside Mr. Hann's lamp during the application of the explosive mixture was a yellowish blue, long flame, becoming more yellow and longer as the velocity of the current was increased, and thus the liability of the glass to breakage was augmented.

2.—The manner in which the air enters and leaves the lamp conduces to the economy of burning. The air admitted goes direct to the lower part of the flame, and the heat of the brass cylinder above aids the draught. The experiments given in column No. 2 in this table were made to show the comparative economy of this lamp as compared with the Davy and Clanny lamps. In each experiment 2 oz. of oil were used, and the time occupied by each lamp in burning this quantity is shown.

3.—The mode of supplying the air to the lamp referred to above, together with the description of glass (blown), the author proposes to use, effects some improvement in the light, and experiments have been made with a photometer to illustrate this. These are given in the second column of Table 3. They show that for an equal amount of light given by the lamps, one-ninth, or about 11 per cent., more oil is used by the Clanny lamp than by the New Lamp. With regard to the light given by the Lamp it may also be observed that the height of the glass causes an increased width of the rays of light, such extra rays in the case of the Clanny lamp being lost.

4.—The simplicity of the Lamp, both on the whole and in detail, is such that it can be cleaned and trimmed in about one-third part of the time required for the Davy and Clanny lamps.

6.—The ordinary Clanny and Davy lamps require, including necessary waste, from 40 to 50 square inches of gauze for each lamp; the gauze has an average duration of about 9 months. The quantity of gauze used for the Lamp forming the subject of this paper, is about 5½ square inches. At a colliery having about 300 lamps the saving in this item alone would be worthy of consideration.

6.—The manner in which the lamp is kept comparatively cool, by having the top separated from the body of the lamp, and by having the glass protected by two non-conductors, has already been referred to.

The two lamps submitted are locked in different ways, one on the side and the other at the bottom. In the latter case the protuberance on the side of the lamp is removed, and the brass is thus somewhat easier to clean.

The objection which will doubtless be brought forward to the design of this Lamp will be that usually complained of with respect to the Clanny lamp, viz., the flame being protected by glass without gauze. As to the question of economy, this, as is well known, is not of much consequence, as the glass is generally broken through the carelessness of workmen, who pay for it. With respect to the question of safety, the author submits that he has been unable to learn that any explosion has ever occurred through the use of a glass lamp in place of a lamp surrounded by gauze, or of any accident by explosion which has occurred through the breakage of a glass lamp. As a matter of fact, the
manner in which, in a slow current or still atmosphere of explosive mixture, the lamp he has described either goes out so promptly or loses its illuminating power, may be considered an important point in its favour in this respect.

The first cost of the lamp is not high, being about 7s. 3d. each.

It has only been since the experiments recorded were made, and since the first part of this paper was written, that the author has discovered the principle of the lamp he has described to be nearly the same as that of the Belgian lamp known as Eloin’s. This lamp appears to have been tested by the Safety Lamp Committee, but only two experiments were made with it.

In conclusion, the author ventures to hope that in the lamp he has endeavoured to describe, the various advantages of increased safety, of low first cost, of small wear and tear, of economical burning, and of improved illuminating power, are such as will justify him in the supposition that the lamp will present some points of interest to this Institute.

Mr. Southern stated that the lamp question was one of very great interest, and its various points could not be too much discussed. He would like to ask Mr. Bainbridge whether he had tried it sufficiently to know whether the top part would or would not become very much heated in an explosive mixture; and with respect to the Stephenson lamp, whether it was not better protected in a wet pit than this one? He thought the writer of the paper said he was not aware of a case where a glass lamp had caused an explosion.

He (Mr. Southern) thought there were two or three instances of their having done so. One was at Monkwearmouth, but was not perhaps a clear case; another was at Rainton, where it was quite evident that the explosion was from a crack in the glass. The Stephenson lamp, supposing the gauze to be damaged, which was of course of rather larger diameter than that of the Davy, would be liable to explode; but it would be under particular circumstances that it would do so; and he, from the experience he had had, and which went over a great many years, would prefer the Stephenson to any other lamp that he had had to do with. The Davy he would not be at all afraid of, and would use it readily; but he recollected several cases where he had used Stephenson lamps during sudden eruptions of gas, and they had all gone out, and he had no doubt that a great many lives had been saved from that fact. The Davy, they knew quite well, would burn full of flame, and they knew quite as well too, that it would require a white heat to bring the flame outside the gauze, but he had not been able to come to the conclusion that it would be the same with the Stephenson—the Stephenson as used at present—where there is obviously sufficient space for the air to be admitted for the combustion where the gas is not too strong. The principal objection in connection with this lamp of Mr. Bainbridge was the glass and the brass top, the heating of the brass top, and the exposure of the glass to the wet.

Mr. Bainbridge said the points referred to by Mr. Southern, of course, would refer to every other lamp which had exposed glass sides. He might say that he was quite prepared to hear of some accidents having taken place from the use of a glass lamp; but in the case referred to at Rainton, a Clanny lamp was used, and the flame arising from the Clanny lamp when burning in an explosive
atmosphere, would doubtless break the glass and cause the explosion. Mr. Southern appeared not to have noticed that he (Mr. Bainbridge) had mentioned that the lamp described in the paper had the same feature as a Stephenson lamp in its action in a slow current of gas and air; the lamp goes out in two or three seconds. He had tried this lamp over and over again in that way, and found it went out as promptly, if not more promptly, than the Stephenson lamp. As to its being practically applied, he might say that he had had it in use now for about three months, and they had not found the heat at the top of the lamp to present any difficulty. The lamp was in use at a pit subject to dropping of water.

The President—And the glass was known to have come in contact with the drops of water when it was warm?

Mr. Bainbridge was not quite sure about that; but they used the Clanny lamp in the same pit. He might say that to anybody who thought the Stephenson lamp was the best, it was hardly worth while considering this one, because it had the same disadvantages, so far as the glass was concerned, that the Clanny lamp had.

Mr. Cochrane asked if Mr. Bainbridge would explain why the lamp went out in a current of four feet per second and did not go out in one of 54 feet?

Mr. Bainbridge said, up to five feet per second the lamp went out. When the velocity became higher than that, the low blue flame at the bottom of the lamp seemed to surround the lower part of the flame, which continued burning. When taken away from the explosive current it went out. He was not quite sure as to the reason why the lamp should remain in with a higher velocity than five feet per second; but, he should say, it was due to the current impinging upon the lamp supplying sufficient air to force up the foul air which, in a still atmosphere, comes down upon the light and puts it out.

The President—The current which came in contact with the lamp would be loaded with gas, the same as it was inside, and, therefore, it would not supply any reason for the lamp not going out.

Mr. Bainbridge—Yes; but as the current holds a certain quantity of pure air, such air would have the effect of pushing up the foul air.

Mr. Cochrane asked if Mr. Bainbridge had repeated the experiment at a low velocity to see whether the same effect was repeated?

Mr. Bainbridge said it was done a dozen times.

Mr. Morison said he had made a great many experiments with the Stephenson among other lamps, and the same thing occurred with it as with that used by Mr. Bainbridge; that was, in still air, or at a very low velocity, the Stephenson went out; but, if the velocity was above five or six feet a second, it continued to burn round the rim, and he agreed with Mr. Bainbridge that this was simply on account of the current passing through the lamp.
Mr. Wallace would merely suggest what he thought was the reason for certain changes taking place within a Davy lamp at different stages of the current. The current within the lamp from the bottom to the top was in part due to the temperature of the flame causing the air within the gauze to be lighter than the air without; and the quantity of heat produced by the flame will regulate the speed of the air through an orifice of a given size. Exposed to a rapid current, there might be the effect of an induced current at the top of the lamp and a direct current at the bottom assisting the passage of the air through the lamp. In a still atmosphere, or a comparatively slow one, this effect would not take place. The current within the lamp would then be due to heat. When the air passing through the lamp was of an explosive character, there was an excess of hydro-carbon and a lesser quantity of oxygen; consequently the temperature of combustion would be reduced; there would be a larger flame and a slower current. Then the lamp would tend to be fouled by its own products and become liable to be extinguished. The paper which had just been read went to show that a great many of the ideas associated with wire gauze had not been correct; that was, as far as regards the prevention of explosions. He had made a number of experiments in devising apparatus for burning carburetted hydrogen in large quantities; and he found that were the meshes of the gauze finer even than 35 per inch., it would not prevent explosions. When gas is turned into the bottom of a vessel having the top covered with wire gauze, a current immediately begins to pass upwards through the gauze. The first part of this current is pure air; presently it has a small proportion of gas, and ultimately it will be all gas. At a certain stage of the experiment the mixture will be in proportions to form a true explosive mixture; and if a light has been held above the gauze from the beginning, an explosion will take place capable of igniting the gas below the wire gauze through the meshes. This proved beyond a doubt that under certain conditions explosions would take place through the gauze in spite of all precautions. He would only add that it was evident that in the design of the new lamp the gauze was simply used at the part where the air is admitted and expelled, and ought not to be of more surface than would admit the air that was necessary to supply the flame, and the gauze above should be no larger than would allow the products of combustion to escape, and thereby balance the current, as Mr. Bainbridge expressed it, passing through the lamp; so that instead of using the largest quantity of gauze that can be placed over the lamp, both for the purpose of ventilation and light, the smallest quantity was used, and it was found to be the safest.

The President said, the point was of the very greatest interest to them all. He begged their particular attention to this question, and hoped they would give it their fullest consideration. They had no doubt that that lamp might be of very great service; but they must be exceedingly cautious; he thought there was no harm in using the expression even in Mr. Bainbridge's presence. They must be exceedingly cautious in using the new construction of lamp which exposed so large a space to the action of drops of water. He had on more than one occasion himself suffered from it, by the Clanny lamp breaking in his hand, by a sudden fall of water taking place and dropping upon the heated glass: it instantly cracked it; and if these cracks took place in a certain condition, and with a large surface of glass, such as in the lamp then before them, it might cause an
exceedingly dangerous accident. Therefore he would beg of them, before discussing the subject, to take seriously into consideration all the points wherein the lamp differed from those with which they already had had experiments performed. There was no doubt that this one gave them more flame, more light, and more economy. He would feel obliged if Mr. Bainbridge would explain that part of his paper where he said his lamp was benefited by the effects of that peculiar metal which he used at the top and bottom for enclosing his glass. He would like very much to have an explanation of the principle upon which the low temperature inside of the glass was obtained.

Mr. Bainbridge said he referred to the low temperature of the glass itself, the temperature of which was kept down by having a non-conductor both at the top and bottom, and by taking care that these non-conductors were so arranged that the glass did not touch the edge of the brass.

The President asked what was the non-conducting material?

Mr. Bainbridge said he had tried very fine felt and found it answer very well. Of course wood might do.

The President—But suppose it continued exposed for a length of time in an explosive mixture, even without a current, would that glass not eventually become so hot as to be very liable to fracture on exposure to falling drops of water?

Mr. Bainbridge quite thought that if the lamp continued burning, if it would burn at all, in an explosive mixture, the temperature would go lower, because the blue flame at the bottom was so very slight.

The President asked if Mr. Bainbridge thought the blue flame would separate from the wick? In the Davy lamp, when placed in an explosive mixture, the flame rises up from the wick and occupies the upper portion of the lamp. They would say the wick itself had no longer any flame at all; but if the flame was reduced and gradually lowered down, then it assumed its former burning powers. Did Mr. Bainbridge think this was so in his case?

Mr. Bainbridge submitted that the action of the new lamp in what was called a still atmosphere of gas need not be discussed, since the lamp went out in it immediately. He quite agreed that in a pit commonly called a wet pit, or rather a pit which was both wet and dangerous on account of gas, it was scarcely advisable to use the lamp described.

Mr. Cochrane said Mr. Bainbridge mentioned some peculiarity in the glass itself.

Mr. Bainbridge—Instead of being moulded, it was blown.

Mr. Cochrane suggested that Mr. Bainbridge might vary the experiment by burning the lamp in an explosive mixture, and throwing water upon it.
The President said that was a very necessary experiment. He hoped Mr. Bainbridge would be able to make that addition to his paper.

Mr. Bainbridge said he might make that experiment with any lamp.

The President—Only there is here a larger surface and a thinner glass.

Mr. Bainbridge—But the principle might be applied to any lamp having the same height of glass. In any case it should be remembered that the lamp goes out in an explosive atmosphere.

Mr. Cochrane begged to propose a vote of thanks to Mr. Bainbridge.

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

The meeting then ended.
Members—

Mr. Peter Donaldson, Alipore, Calcutta.

" W. S. Vaughan, Abbot & Co., Gateshead.

" Robert Hetherington, Coanwood Colliery, Haltwhistle.

" W. J. Grimshaw, M.E., Stand Lane Collieries, Radcliffe, near Manchester.

" Fountain Clarbour, 11, Mark Lane, Withy Grove, Manchester.

Student—

Mr. E. Hamilton, Tursdale Colliery, Coxhoe.

Mr. D. P. Morison read the following paper on "Fowler's Patent Apparatus for Loading and Unloading Pit Cages:"

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[Plates XI to XIV illustrating Fowler's hydraulic winding gear]

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FOWLER'S PATENT APPARATUS FOR LOADING AND UNLOADING PIT CAGES.

By D. P. MORISON.

The winding machinery of a colliery is, in many cases, called upon to perform an amount of work far exceeding that for which it was originally designed. Shorter hours of labour, combined with an increased out-put, render it necessary to push the engines to their greatest practical speed, and while it is quite possible to bring large quantities of coal to the pit bottom, the amount actually raised is often limited by the winding apparatus, which sometimes has to be superseded by more powerful and costly plant.

With the view of diminishing this inconvenience and obviating the necessity for spending the time and capital required for sweeping alterations, the arrangement about to be described has been invented and erected by Mr. George Fowler. In addition to incidental advantages hereafter-mentioned, it has for its objects:—

1. Increasing the efficiency of (by utilizing to the utmost) existing winding gear without the excessive wear and tear usually accompanying high speeds; and,

2. Reducing the first cost of winding-engines for new works by working them under more favourable conditions, requiring less power to perform a given duty.

These objects are effected by the use of auxiliary on-setting and pulling-off gear in loading and unloading the pit cages, enabling the time of the winding-engine to be devoted more to its legitimate duty of raising coals, and less to the unprofitable work of striking the cages.
The striking of the cages is avoided in the manner shown in Plate No. XI., representing the cage at bank, settled on the keps, and ready to be relieved of its load. The platforms AAA contain the empty tubs to be placed on the cage, and the platforms BBB are prepared to receive the loaded tubs.

The lowest of the three loaded tubs is drawn over the platform B on to the bank rails, and the lowest empty tub is pushed on the cage by manual labour in the ordinary manner. Simultaneously with this, however, the two upper empty tubs FF are thrust forward by the hydraulic rams C C, and displacing the two upper loaded tubs take their places on the cage. The catches for retaining the empty tubs on the cages are then all put into position by the movement of one rod (not shewn), and the cage is ready to proceed on its downward journey. The time required for these movements is of course precisely the same as would be necessary for a single-decked cage loaded with one tub. The actual pulling off and on-setting on the part of the banksmen now begins, but for these duties there is ample time while the cage is running, the principal object having been attained, namely, getting the machinery again at its proper work of winding.

The two platforms A and B are then allowed by the hoists D and E to sink into the successive positions necessary for changing. A is ready to be charged with empties, its decks being successively brought by the hoist to the bank level of rails, and B, having been allowed by similar means to bring its middle deck to the bank level, can be further lowered for the removal of the uppermost loaded tub.

Platform B, after being relieved of the weight of tubs and coal, is overbalanced by the counterweights WW (shewn on plan), and, steadied by the hoist B, rises to its former position.

The whole arrangement is repeated at the bottom of the shaft, the time available for changing being of necessity greater there than at bank, since the cage descends at once on the keps, without waiting for the reversing of the engine.

The rams C C for setting on the empties and pushing off the loaded tubs, as well as the hoists D and E for altering the level of platforms, are actuated by hydraulic pressure maintained by a small donkey engine, which pumps into an accumulator arranged in the usual and now well-known manner. The ram of the accumulator is about 6 inches diameter, with a stroke of five feet, which is found quite large enough for any demands made upon it. The speed of the donkey engine is regulated by the position of the ram, which opens and closes a throttle valve, without needing attention, so that the quantity of water pumped is exactly as much as is required. The same water is used over and over again, the exhaust from all the rams being discharged into a small reservoir; the waste is therefore extremely small, being only that arising from leakage, and it is proposed to prevent freezing in the pipes in winter by mixing methylated spirit with the water. About 500 lbs. pressure on the square inch has been found most convenient for working...
the rams and the hoists, but the experience of each special case would determine the pressure most suitable, which can be readily adjusted by the weights on the accumulator.

A valve, consisting of an ordinary three-way tap, is used for admitting the water pressure simultaneously to the rams C C, and is opened and closed by the on-setter.

After the rams have pushed forward the tubs, they are almost instantly brought back to their former position by the water pressure acting on the annular space in front of the small pistons with which they are provided. The valves for raising and lowering the platforms are at present worked by a man conveniently placed for the purpose, but they may be arranged so as to be under the control of the men employed in changing the tubs.

At the bottom of the shaft the accumulator and donkey engine are dispensed with, and the hydraulic pressure is obtained directly from the head of water contained in a pipe tapped into the tubbing. The suitable height at which the pipe should be attached to the tubbing is easily found when the pressure most convenient has been ascertained by trial with the accumulator. If, however, the desired position is not available, either by reason of the absence of tubbing, or in consequence of the head of water already in the tubbing being excessive, any greater height may be adopted, and the superfluous pressure negatived by turning up the exhaust pipe so as to discharge at a higher level than would otherwise be necessary. The water, after being used, is conducted to the sump, from which it is drawn with the ordinary sump water. In the case of a downcast pit it will be necessary to prevent freezing in the pipes and tubbing by the use of a steam jet or other means.

The saving of time is more considerable than would at first sight appear. In the case of a three-decked cage, changing the tubs in the ordinary way occupies of course exactly three times as many seconds as would be required for a single deck. But in addition to the time actually devoted to changing, there are the intervals necessary to raise the cage to a different level and settle it on the keps, during which the changing cannot proceed, and the banksmen can only look on while the cage is being brought into position. And these intervals are of necessity of considerable length, especially in the case of heavy winding gear, since the inertia of a large mass weighing many tons has to be overcome every time the winding engine is reversed. It is by transferring the idle intervals of time from the cage to the platforms that the principal saving is effected, for usually as much time is consumed in getting the two lower decks into place as would suffice to change the three tubs one after the other.

This will be made clearer by the following table, showing the manner in which the time is distributed to the various movements required to strike a three-decked cage and change the tubs.

It is the average result of many experiments made when no hindrance took place from accidental circumstances:

| TABLE No. 1. |
| Three-Decked Cage. |
1.—Settling on the keps 1 second.
2.—Changing No. 1 Deck 5½ "
3.—Lifting Cage 5 feet 6 inches 3½ "
4.—Settling on the Keps 1 "
5.—Changing No. 2 Deck 5½ "
6.—Lifting Cage 5 feet 6 inches 3½ "
7.—Settling on the Keps 1 "
8.—Changing No. 3 Deck 5½ "
9.—Lifting Cage to clear Keps 1½ "

28 Seconds.

TABLE No. 2.

Two-Decked Cage.

1.—Settling on the Keps 1 second.
2.—Changing No. 1 Deck 5½ "
3.—Lifting Cage 5 feet 6 inches 3½ "
4.—Settling on the Keps 1 "
5.—Changing No. 2 Deck 5½ "
6.—Lifting Cage to clear Keps 1½ "

18 Seconds.

With the aid of the hydraulic apparatus, most of the above items may be struck out altogether, and the table then stands as follows:—

TABLE No. 3.

1.—Settling on the Keps 1 second.
2.—Changing all the Decks 5½ "
3.—Lifting Cage to clear Keps 1½ "

8 seconds.
This (8 seconds) is the time actually occupied in changing a three-decked cage at Hucknall Colliery, with the apparatus described under favourable circumstances, which, for purposes of comparison, have been assumed for all three tables. The average time is 10 seconds, and the minimum 7 seconds.

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Taking the case of a pit 300 yards deep, the time of actual running in the shaft occupies (from trial) 35 seconds. The total time for each journey, including the changing of tubs, would be—for a three-decked cage worked in the ordinary manner $35 + 28 = 63$ seconds, or 57 journeys per hour. With the hydraulic apparatus the time would be $35 + 8 = 43$ seconds, or 84 journeys per hour. The efficiency of the winding engines would thus be increased nearly 48 per cent.

Applying the same reasoning to a two-decked cage, we have in the one case $35 + 18 = 53$ seconds, or 68 journeys per hour; and in the other case $35 + 8 = 43$ seconds, or 84 journeys per hour. The increased efficiency is then nearly 24 per cent.

The advantage is, of course, less obvious in this case, but the machine is simplified, and the first cost is less in about the same proportion.

It has been mentioned that the three tables have been compiled from observations taken while work was being carried on, without hindrance from the little causes of delay which often impede the changing at the pit mouth. They, therefore, show in all cases a quickness in the several movements which is common enough, but does not fairly represent the average during a day's work.

If, however, 10 per cent. were added to all the items in the tables to show a longer time given to each particular movement, the advantages of the new apparatus would be still more apparent, since the proportionate saving of time would be effected on the greater interval which would elapse while the cage was at bank.

Careful observation of the times actually required, in special cases, to perform the several operations, arranged as in Table No. 1, can be made, and from them a table may be made like No. 3; a comparison of the two will clearly show the saving that may be expected.

The increase in the quantity of coal raised with the aid of the gear now described and at work, amounts to about 300 tons per day, making a total of 850 tons per day.

It will readily be seen that if the winding capabilities of an existing engine can be increased 40 per cent., the power and cost of a new one to perform a given amount of work may be reduced in the same proportion.

Some of the incidental advantages obtained from the gear will be apparent from the following considerations:

To bring a three-decked cage into the different required positions, the winding engine has to be reversed six times, without counting the extra complication of striking the cage at bottom, and the final
reversing for the regular journey, which is necessary in all cases. For a single-decked cage, or any to which the hydraulic gear is applied, two reversings only are requisite. Thus four reversings at least are saved, each of which would on the average consume a cylinder full of steam (more or less, according to the accidental position of pistons), besides the clearance spaces and steam ports, which for two cylinders is about two-fifths more.

This space of a cylinder and two-fifths has to be filled with steam of full pressure before any movement of the cage takes place, as the inertia of the machinery and ropes has to be overcome. The saving being effected at least four times each journey is an appreciable quantity, and goes far to compensate for the extra demand made upon the boilers to supply steam for the more numerous journeys per day which are rendered possible. The advantage of reversing the engine and lifting the cage as seldom as possible, applies to the ropes with still more cogency, since the repeated snatching strains are avoided, which do more to shorten the working life of a rope than the regular running which is its proper duty. It is clear that all the lifting performed by the hydraulic hoists represents so much work, of which the ropes as well as the engines are relieved, and the economy thus resulting is expected to be an important one, the extent of which can only be shewn by further experience. It may, however, be suggested that an arrangement which admits of smaller engines and lighter ropes to perform a given duty, must also be directly conducive to economy in the consumption of steam, as the work required to accelerate the inert mass contained in the machinery generally is materially reduced. It should be remembered that, in rapid winding, this work of bringing up the speed of the engines is for the most part lost, it being absorbed afterwards by the break, and by the resistance caused by closing the valves of the engine.

The water pressure in the accumulator may be made available for other purposes as well as those in connection with the present subject, such as working hoists for raising coals to the screens, actuating the break of the winding engine when extra power is required, &c.

The economy in manual labour arising from the use of the new gear is worthy of consideration, even with regard to the cost per day, but when estimated in connection with the increased quantity of coal raised, it becomes important; as, besides the banksmen, the engine-drivers and firemen are working with better results from their day's exertions.

Mr. Newall invited discussion on this important paper.

Mr. E. Bainbridge said, he had had an opportunity of seeing the apparatus described by Mr. Morison at work once or twice, and was quite able to bear testimony to its value, especially in cases where a single tub on each deck is used; but he came to the conclusion that where there are two tubs on each deck, and where the cage has two or three decks, the amount of complication of brickwork at the bottom of the pit, and the sinking which is required to make room for three tiers of cages, was such as made the economy of the system doubtful. It occurred to him when he saw the apparatus at
work, and when he was deciding what kind of cages to have for a draught of 1,000 tons a day, that the best arrangement would be to have cages holding four tubs on two decks in preference to having them with three tubs on three decks. By this means four instead of three tubs are drawn at one time. Instead of having three movements for the cage at the bottom of the pit, the tubs could be changed without being moved, two tubs being put in at one level, and two tubs at another. At the top, he would suggest that as the weight of the single cage only would be on the drum, it would be very easy, whilst the bottom cage was being changed, to move the top cage twice; first, to take out the two bottom tubs, then the two lower tubs. He thought Mr. Morison had not mentioned one rather important point in favour of Mr. Fowler's system. In the ordinary winding of coals, the full cage, while being changed at the surface, is unbalanced by the empty cage; and hence the evil of the ordinary mode of changing the three decks, the full weight of the full cage upon the drum being unbalanced by the empty cage. A saving had been mentioned in manual labour, but he thought there appeared to be scarcely any saving of consequence in that respect. After the tubs were changed, by pushing the full tubs out, the full tubs, after they came to the level ground, had, in each case, to be pulled off by hand, and the empty tubs in the same way. It seemed to him that this required more manual power than where full corves are pushed out by the empty ones going into the cage. He did not know that any other point had occurred to him, except this, that Mr. Fowler, by his system, was enabled to get per hour the largest quantity of coal that had ever been drawn out of any pit in the district.

Mr. T. Bailes would like to ask Mr. Bainbridge if he had had any experience where they had been arranging the shaft for two tubs on each deck. Mr. Morison told them, if he understood the paper correctly, that the system was strictly applicable to a condition where there

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was little room, and where the tubs must be placed relatively one above the other, perhaps four in succession. He might mention that some shafts were so decidedly narrow that Mr. Bainbridge's suggestion, to place two tubs on a deck, could not be carried out. Might he ask if Mr. Bainbridge's experience had led him to view the system favourably under the conditions named?

Mr. Bainbridge—Under those conditions Mr. Fowler's system was quite applicable.

Mr. Cochrane said, Mr. Bainbridge had rather anticipated what he was going to say with reference to the saving of manual labour, and he would be glad if Mr. Morison would point out how the saving was effected; because the mere fact that with this apparatus more coals had been drawn than with any other arrangement was not sufficient. This effect would be produced exactly the same if there was a man at each level, pushing the tub out, and doing all by manual labour without the application of hydraulic apparatus, which evidently would be very expensive to work.

Mr. Morison said, he might mention in reference to the saving of manual labour, that he did not mean that the number of men had to be diminished; inasmuch as the same number of tubs had to be taken out of the platforms as would have to be taken out of the cage; but the saving in labour was that, in the case of a pit at present raising 600 tons, 300 more tons a-day could be drawn, with the same number of men. With regard to what Mr. Bainbridge mentioned, viz., a double landing at
the pit bottom, he might point out that it would take twice the number of men to load and unload the cages, besides involving the time of two changes, which he thought he had pointed out to be about 15 or 16 seconds, and he submitted that this would greatly do away with the simplicity of the apparatus.

Professor Herschel said, he would remark that he came unprepared with any observations, but a very apposite subject of consideration presented itself to him lately while reckoning up the amount of power necessary to move large winding drums when they are in the scroll form. They are very heavy; and the times which Mr. Morison had described as being necessary to lift the cage through a small space would no doubt be very great in a scroll drum; and he would like to ask Mr. Morison if the times he observed at the colliery in question were with the ordinary winding drum or with a scroll drum? Because, while the paper was being read, he had computed mentally, as accurately as he could, what would be the time necessary for one of these large scroll drums, weighing from 40 to 50 tons, to raise a cage, weighing one ton, three feet, and to allow that dead weight, acting on the rim, to bring the drum to rest again in about the same space and time.

The time, he found, would be six seconds or nearly six seconds, supposing the drum not to be started with an unsafe speed, and that the use of the break is not required; it would then be nearly six seconds in rising through about six feet, with a winding drum weighing between 40 and 50 tons. Mr. Morison told them that a time of 3½ seconds was actually obtained by trial, which would lead him to suppose that the times which Morison observed were produced by a winding engine, whose drum was not of the scroll but of the ordinary form, since in the scroll form, these times would be nearly doubled for the part of the time that the cage was in motion, although not for the time of loading it and of the tubs moving off, which, of course, would remain the same as before. In the next place, a point occurred to him about the use of scroll drums, which was peculiarly affected by this question, and it was this—that scroll drums are arranged so that in winding in or out, the two ends of the suspended rope, by hanging from larger or smaller circles of the spirals, as they diminish or increase in length, balance each other very nearly upon such a drum, independently of their varying weights: the long length of rope, hanging from the smaller convolutions of the scroll, has no greater power to turn it round than the short length acting upon its outer circumference. That was the principle of the scroll drum; and it made it necessary that the drum when the cages were at bank and at the bottom of the shaft should have the rope upon parts of the drum which are of different diameters. Now, in starting the cages again, if they have to be lifted up from one deck to another at each landing, the top cage will go a long distance while the bottom cage moves or rises only a short distance. Therefore the winding engine has to be moved a certain distance to bring the top cage to the landing, and then again a little distance to bring the bottom cage to the landing; and it has to make six motions to put the tubs upon a three-deck cage; and he had heard that, although in places where the drums were used they were found very effective in their action, yet a difficulty was experienced in the loss of time required to put the tubs upon the cages—that the cages had to be stopped six times to land three tubs upon each; and that each of these stoppages occupied a considerable time. He had thought it might be interesting, as bearing upon the question, to
mention this, as the scroll drums were no doubt a great improvement upon the ordinary mode of raising coal, as giving a much greater uniformity, and at present they seemed to be coming into notice as an improvement in winding gear.

Mr. Southern, with regard to what Prof. Herschel had said as to the scroll drum being so great an improvement on the old system, would say it had yet to be proved. He was not aware that they were on the increase in this district. The only one they had was at Boldon; and he had not heard that any more were to be put up.

Prof. Herschel said he would like to retract what he had said about the advantages of the scroll drum, because its enormous weight made it a question whether the speed with which it could be stopped and started was sufficient to produce any great advantage in point of economy. But as the scroll drums do exist, and that objection was brought forward by practical working men, he thought it showed that a real advantage would be gained by reducing a number of operations to a single one in the way Mr. Fowler proposed.

Mr. Morison might say that the drum and round rope at Hucknall, where the apparatus had been in operation, were of the ordinary type, and were exceedingly light, so that the time occupied in raising the cage off the keps, 3½ seconds, would compare favourably with the heavy drum and 6 seconds, which Mr. Herschel spoke of.

Mr. Bainbridge said, he did not know what reason Mr. Southern was going to give for the scroll drum not being more generally used in this neighbourhood; but he believed that there was no scroll drum yet made which had the same advantages, so far as the economy of power was concerned, as the best made round rope drum working with a counter-balance. All the diagrams which he had had the opportunity of seeing, taken from engines working with the scroll drum, had shown that the advantage of two different diameters of drum was quite counteracted by the immense difficulty there was, from the first, in moving the increased load of the drum itself. This load was so heavy that, in one case, to his knowledge, it increased the actual power necessary, to four times the calculated power required, to move the absolute load of coal and rope. He wished Mr. Morison had been able to show them from the indications of the six reversings, the exact loss of power there was by reversing the engine so often. If they could have had the whole of the power exerted in winding, from top to bottom, including the changes, divided into 100 parts, he quite thought that the loss on the changes would be represented by something like 30 to 35 parts. The

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full load of the working parts of the engine had to be moved in each case.

Mr. Newall asked if Mr. Morison would kindly undertake to obtain diagrams of the work done. It would be a great addition to his paper if he would.

Mr. Morison said he would endeavour to do so.

Mr. Lawrence said, as he understood this was not a discussion upon the scroll drum, he would not say more on that subject, except that he believed that what Professor Herschel wished to convey
was this, that in changing the tubs, where a scroll drum was in use, there was a greater difficulty than in changing two or three deck cages with the ordinary drum; because, as Professor Herschel observed, a great length of rope was moved at the top of the pit, and a very short length of rope at the bottom of the pit, but there were several mechanical contrivances to overcome this. With regard to the saving of expense with this system, compared with manual labour, he thought that if the tubs could be changed at the same expense as with men, and in less time, a very valuable saving was effected, and he thought that generally speaking, in the introduction of anything new, or of anything that could be done mechanically instead of by manual labour, they looked too much at whether it could be done cheaper than by manual labour in the first instance, without considering the saving due to the mechanical way of doing it. But if they could do one-fourth of their work mechanically at the same cost, and save one-fourth of the men for other duty, they would soon find there would be a very great saving; and he thought that this was one great point which ought to be looked to in introducing anything that could be done by hydraulic, steam, or compressed-air power. The motion seemed to him to be a very ingenious one; and he was surprised that no one had brought out such a thing before. He had seen places where there were two levels at the bottom of the pit; and he knew several designs that had been made where there would be three platforms at the top, and three at the bottom. No doubt, in laying out a new pit, that was easily arranged, and, of course, would answer the same purpose as the plan before them, only a man would have to be placed to each of these tubs instead of the rams. It appeared to be Mr. Bainbridge’s argument that he could do it as cheaply with men as with rams; but he thought that what he had just stated would shew it to be an advantage, if it could be done as economically. He had seen a drop staple at the bottom of the pit, so contrived

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aproperly as to bring the tub to the right level; but the most important advantage to be derived, was in the stopping and starting the engine. There was more damage done in the stopping and starting of the engines, and bringing the load into motion, than there was in any other operation of drawing; and, therefore, if this was only got over by two or three decks and platforms, he did not care whether it was done with men or with hydraulics, it would be a great advantage; but he did say that they should, in every instance, do away if they possibly could with manual labour. In some instances, at Monkwearmouth, for example, he believed there was a four-deck cage. Now, they have to move the engine four times before they can change; whereas, in this apparatus, with four platforms, it could be done at once. The arrangement with two or three platforms at bank, and long screens and short screens, incurred a very heavy expense; but this system got over the difficulty, because everything could be on the same level.

Mr. J. A. Ramsay said, he had recently seen an arrangement about to be adopted by Mr. Heckels, at Wearmouth Colliery, by which the eight tubs in a four-decked cage were changed in two settings down; the full tubs, twice two in each cage were pushed out by the empty ones, and vice versa, by manual labour.

Mr. Cochrane would ask Mr. Morison how the tub is secured in its place?
Mr. Morison said, the apparatus for locking the tubs in the cage was self-acting to a great extent. When the cage came to bank it was in a position for the empty tubs to push the full ones out. As soon as the empty tub was in place it locked itself.

Mr. Lawrence asked Mr. Bainbridge what was his objection to the tubs being one above the other.

Mr. Bainbridge said his objection was this:—Suppose a cage 11 feet long were employed, a large space would have to be excavated at the bottom of the pit to make room for the hydraulic cages, and for the arrangements for moving the tubs in and out of the cage. Therefore, when a cage 11 feet long was employed, a space of 55 feet in length would have to be provided were the system under discussion adopted. He would say, however, lest it should be thought that anything he had observed that day was meant to be prejudicial to this apparatus, that if he had a pit to lay out in which he was going to have a three-tub cage, with the tubs one above another, he should certainly adopt Mr. Fowler's arrangement.

Mr. Morison said that Mr. May was preparing at present

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an arrangement for the very combination which Mr. Bainbridge was speaking about, shewn in Plate XIII.; and he felt confident that instead of it being more expensive than that with single tubs, in proportion to the work it would do, it would be very much cheaper — probably two-thirds.

Mr. Lawrence said, when he asked Mr. Bainbridge the question, he was thinking of the bank and not down below. He quite saw that, as Mr. Bainbridge had stated, there would be a very great space indeed required to be undermined at the bottom of the shaft for the changing of the cages, but he did not see that Mr. Bainbridge had shown the space that would be required there by his apparatus.

Mr. Newall then adjourned the discussion until next meeting.

Mr. Newall asked Mr. Lebour whether he had any remarks to make upon his paper on the Geology of the Redesdale Ironstone district.

Mr. Lebour said, he had no further remarks to make; but had come there in order to answer any questions which might be put to him by members taking an interest in or having any special knowledge of the district, and he should be happy to do so.

Mr. Boyd would ask Mr. Lebour if he had had an opportunity of examining the district in the neighbourhood of Scremerston and the northern part of the county of Northumberland, and if he was able to identify the seams of mountain limestone which occurred there in such numbers and regularity, all the layers well defined for a considerable distance of miles over which they extended, and all in their relative thickness, keeping their relative distance from each other with those of the district of Redesdale, upon which the paper was written. The layers were so well known in the Scremerston district, that if a man hits upon the crop or otherwise of a seam he can tell whether it was the Bulm seam, the main seam, or any other in the district. Those who took an interest in the
geology of the district would be very much pleased if Mr. Lebour were able to do so. The outcrop takes a very winding course: it extends east by Bamborough, and through Dunstanborough, and then returns through the heart of the county up to the district of which the paper treated. He had no doubt these seams were capable of being identified, and would like to know if Mr. Lebour had taken the opportunity of doing so.

Mr. Lebour said, that although he had not worked systematically in the district of Scremerston, or even to any extent north of the

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Coquet, yet, from having geologized a little in that district, he thought he was able to say that as the beds there trend to the south, in a south-westerly course, a great change comes over them, not perhaps in the existence of the seams of coal or limestone themselves, but in the intervening sandstones and grits.

Mr. Boyd—Yes, and the width they occupy.

Mr. Lebour—And the width they occupy especially. Only quite recently, within the last two or three months, indeed, it had been suggested by the members of the Geological Survey who work this county that it is very likely that the great sprawl of grits which form the high country west of Rothbury, near Harbottle—the Harbottle grits, if he might call them so—thin out altogether and come almost to nothing before they reach Rothbury; and that, therefore, a very great thickness indeed of these beds must have intervened between at least two of the seams which are known to the north of Rothbury. The identification of these seams, until they are quite followed through, is, therefore, exceedingly hazardous. But some of the seams have been carried through to a great distance: for instance, the Shilbottle seam. He could trace the Shilbottle seam as far as he had traced any of the higher limestones of the county. He had it as far south as the South Tyne; and Mr. Topley could follow it to the north of the Coquet. He did not know whether it was south of the North Tyne; but could trace it to the north of the South Tyne, and to where it leaves the county altogether to the west.

Mr. Boyd—What is its name there?

Mr. Lebour—It had no name there, and it was exceedingly curious to observe how it varied in working southwards.

Mr. Boyd—These seams change their names in different districts.

Mr. Lebour—They sometimes lose their names altogether, and very often change them in a remarkable way. There was no doubt that a great many of the limestones, which are exceedingly numerous in the centre of the county, die out as they go north; in the neighbourhood of the North Tyne he would not say how many could be counted, but not very far from forty limestones he should think. Going further north nothing of the sort was met with; and it was very possible that although some of the limestones die out in going from south to north, some of the coals might die out in opposite directions; that might account for their not being identified to the south; but he might say
there was an enormous number of small seams in the whole of the central part of the county which had no names, which were exceedingly regular, he thought,

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and were very likely the representatives of these northern seams; but he thought it would be a very long time before any one could pretend to correlate them all. He certainly could do nothing of the kind at present.

Mr. Boyd said, he might add that, having written a paper on the same subject on the district which he had named as very likely to be connected some day with Mr. Lebour's district, his being the farthest north and west of the county, and his (Mr. B.'s) the farthest north, he felt very much interested in having those districts identified together; but in looking over his own paper again, he should feel very much inclined to alter it in one particular, as to a set of seams lying to the west of the thick sandstone which Mr. Lebour referred to, abounding to the west of Rothbury, and continuing north up the side of the Reedwater and to Bewick, and so on, travelling north from that district where they are possibly underset by the old red; he had a strong impression that this thick freestone would have been the outburst or termination of the whole of the mountain limestone series; but that a very deep depressing dyke taking place immediately to the west of Rothbury, there was very likely a recurrence of the same series of strata in the district to the west of Rothbury; and the actual seams all came in again there; and this thick freestone underlaid it at the under side of such recurrence. This was a theory he had got; and it was very likely that if Mr. Lebour continued his studies in the district, that this thick freestone would be found underly all the mountain limestone series of clays, freestones, and shales, and that it was the outburst of the whole of them. This dyke was probably about 100 fathoms, or even more, and ran north and south.

Mr. T. Bailes said, he had an opportunity a fortnight ago, of examining the district to the west of Alnwick, near Eglingham, and also to the west of that great dislocation of strata which Mr. Lebour spoke of; and he could see that the Scremerston main coal and the Cowper Eye seams were there classified and identified fully as far to the south as Eglingham, and the features there presented outcropping in succession, were similar to those met with further north; the strata with these beds of coal being thrown into position again by the fault, downthrow westward, which Mr. Boyd had alluded to.

Mr. Lebour said that in the district west of Alnwick, and also west of Rothbury, bordering on the grits, there was a tract formed not exactly of carboniferous limestone proper, but of the lowest member of the carboniferous series, which is known in Scotland as the calciferous sandstone, and which was well marked by beds of bad cream-coloured limestone — bastard limestone, as it was called; much like the cement stones of Scotland. These beds occur immediately below the Harbottle grits, of which he had spoken; and the base of these grits forms the summit of this lower set of beds; now these Harbottle grits thin out as they reach the Simonside grits, with

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which they must not be confounded, although they both come together seemingly in a line. He was
convinced that they were not the same grits, but that the Harbottle grits were at Harbottle—really
the base of the carboniferous limestone proper.

Mr. Boyd—Against the Cheviots?

Mr. Lebour—Yes; although about Alnwick, where if he was right these Harbottle grits had entirely
died out, the Tuedian grits, as Mr. J. Tate had called them, were, he believed, not easily separated
from the upper series.

Mr. Boyd said, the great reason why he had thought it necessary to call attention to the subject was,
that in his sections he gave a series of what he called the upper beds. If the theory he had this day
propounded, that these upper beds happened to have been set down by a dip dyke or fault to the
west, was right, then this was merely a succession of seams and beds identical with those occurring
on the top of this depression. One gentleman, for whom he was interested, had rather given him a
hope that he might some day or other have a borehole put down in the district of Chatton, that
being the valley of the Breamish and the Till; and if that bore-hole should prove anything, it might
very easily determine this very difficult question. He hoped he might get him to pursue it.

Mr. Newall said they were very much indebted to Mr. Lebour for his attendance there that day, and
for the attention he had given in preparing his paper; he presumed the meeting would at once
accord a vote of thanks to him.

Mr. Boyd begged leave to second the motion, which he did with great pleasure. They required a
great deal of intelligence to assist them in their explorations, and he was sure they could not be in
better hands than those of Mr. Lebour.

The vote of thanks was carried unanimously.

The meeting then terminated.

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PROCEDINGS.

GENERAL MEETING, SATURDAY, NOVEMBER 1, 1873, IN THE WOOD MEMORIAL HALL.

Mr. NEWALL, Vice-President, in the Chair.

The Secretary read the minutes of the last meeting, and reported the proceedings of the Council.

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

Members—

Mr. Peter Donaldson, Alipore, Calcutta.
Mr. W. S. Vaughan, Abbot and Co., Gateshead.
Mr. Robert Hetherington, Coanwood Colliery, Haltwhistle.
Mr. W. J. Grimshaw, M.E., Stand Lane Collieries, Radcliffe, near Manchester.
Mr. Fountain Clarbour, 11, Mark Lane, Withy Grove, Manchester.

Student—
Mr. E. Hamilton, Tursdale Colliery, Coxhoe.

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

Members—
Mr. R. I. Galloway, Hebburn Colliery, Gateshead.
Mr. James Hall, Coal Owner, Newcastle.
Mr. Adams, Mining Engineer, Cardiff.
Mr. Robert T. Bunn, Coal Owner, Newcastle.
Mr. George Clark, Jun., Monkwearmouth Engine Works, Sunderland.

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Students—
Mr. Charles Z. Buning, 90, Abbot Terrace, Gateshead.
Mr. Arthur Robert Sawyer, Towneley Colliery, Blaydon-on-Tyne.

The meeting then adjourned to the Lecture Room of the College of Physical Science, kindly placed at their disposal by Professors A. S. Herschel and A. Freire-Marreco; and

Mr. John Wallace read the following paper on "The Combustion of Coal Gas to Produce Heat:"—

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THE COMBUSTION OF COAL GAS TO PRODUCE HEAT.

By JOHN WALLACE.

The relative intensity of the heat of combustion may be measured by the quantity of fuel burnt completely in a given space. This truth under various forms of proposition gains continually increasing importance, with the growing public interest in the economy of fuel, and the efforts that are being made to obtain a nearer approach to the theoretical effect from the coal we burnt, counterbalance the steadily increasing cost of the materials for producing heat. The fuel to be treated on in this paper is Carburetted Hydrogen, or Coal Gas, and the conditions under which this gas must be burnt; and certain forms of apparatus designed for that end, will form the principal subject-matter. For the sake of brevity the word Gas will signify Carburetted Hydrogen, other gases will have their proper prefixes, and in all cases the gas is to be burned to produce heat.
The reports on experiments made to determine the relative value of two methods of burning gas, viz., with an admixture of air previous to combustion, and without it, give the most diverse results, and yet whenever gas has to be burned in quantity in a limited space and without forced combustion, the latter mode is invariably adopted. Bunsen, or atmospheric burners, may be divided into two classes:—First, the original form with an upright jet of gas and burner, in which the amount of air mixed previous to combustion is due partly to the force of the escaping jet of gas, partly to its levity, and partly to the draught caused by the heat of the burner tube. The second class of burner has a horizontal jet; the air mixed before combustion is due solely to the motive force of the gas, and varies more uniformly with the quantity of gas passing than in the first class. When the whole of the necessary air is combined during combustion, the result is a light-giving flame, and when the whole of

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the air is mixed before combustion, the result is an explosion. The Bunsen flame, therefore, occupies an intermediate position, and the amount of air mixed before combustion may vary to a considerable extent, but in all cases it must be below the exploding proportion, else the mixture becomes unmanageable. Not only should the proper proportion of air be mixed with the gas, but the mixture should be as intimate as possible. On examining two flames, one supplied with an intimate and the other with an imperfect mixture, the latter will be found to produce a roaring noise, while the other is silent. Both flames have the same temperature. The roaring is due to the imperfect mixture of the gas and air, some parts having the explosive proportion; and so the noise is caused by a rapid series of small explosions. The other flame is as silent as that of a candle, and shows the effect of intimate mixture of air previous to combustion. In a burner which has a circular mixing chamber, into which the gas and air enter at a tangent, and eddy round in cycloidal curves, with a decreasing velocity towards the centre, until they escape at the burner tube perfectly mixed, the appearance of this flame is so marked, as to be a reliable index of the state of combustion. Immediately above the burner tube is a brilliant green cone G, surrounded by an amber-coloured flame A (Plate XV.) This green cone is a hollow space within the flame, and the green colour indicates the surface of the cone where the combustion commences. It has been supposed that this green colour is due to the carbon in the gas, the idea having been taken from the colour of the carbon lines in the spectroscope. It has also been attributed to the nitrogen in the air mixed with the gas.* A lucifer match laid across the burner tube, is only burnt where the flame comes in contact with the atmosphere, and if the head of the match be dexterously put inside the green cone it will not ignite, although surrounded by a flame having a temperature of 3000° F.

* Experiments on this question have not had any very definite results. First, a mixture of gas and atmospheric air was burnt, and the flame examined by means of the spectroscope, showing a brilliant carbon spectrum, which increased in brilliancy as the proportion of air increased. The nitrogen spectrum could not be recognised, even the red lines which would appear at the lower temperature of combustion were not seen. Next a mixture of pure oxygen and coal gas was burnt, producing a much higher temperature, but no material change was visible in the spectrum. As the green colour only appears where combustion begins, and where there is a deficiency of oxygen, it is very probable that the spectrum is that of carbonic oxide.
A piece of copper wire nearly ⅛ in. thick, held just above the cone is readily fused, and gold, silver, or brass, melt even more readily.

The amount of air necessary to the complete combustion of gas of 16 candle power is 6.4 volumes nearly, of which a part is mixed beforehand, and the remainder combines during combustion. Now, as gas can only be burnt completely by being ignited in a thin sheet, or else divided into very small jets, when it receives all its air during combustion, it follows that in the Bunsen flame of half an inch or more in thickness a part of the air must be mixed previous to combustion, to compensate for the reduced surface of the flame in relation to its bulk or volume. The surface capable of taking up oxygen is confined to the base of the flame; the upper portion is giving off carbonic acid, at a temperature which increases its bulk to nearly 7 volumes, and effectually prevents the further combination of oxygen from the surrounding air, until its temperature is too low to sustain combustion. Therefore, the greater the quantity of gas passing through a burner of a given diameter, the nearer must the mixture approach the explosive proportion, it being very evident that this available surface of the flame does not increase in like measure.

It will be observed that the greater the quantity of air mixed previous to combustion, the smaller the flame becomes, it requires less assistance from the outer atmosphere, and is consumed more rapidly. The total amount of heat which would have been given off by a more bulky flame, is now produced in a space less than one-sixth of the other, and, recalling the opening sentence of this paper, "The relative intensity of the heat of combustion may be measured by the quantity of fuel burnt completely in a given space," it may reasonably be concluded that the flame is much hotter, even if the total amount of heat evolved be just the same. But before going further in this direction, it would be well to consider the appearance of the flame, as the amount of air in the gas varies. Taking a burner in which the air and gas are well mixed before combustion, it will be observed that as the proportion of air increases, the green cone becomes shorter and its colour more intense, and, as its outline is so distinct, it will serve to indicate the changes which take place in the mixture. The burner used for this experiment is similar in most respects to the tangent burner already described.

The tube is 7⁻¹₁₆ths internal diameter, and tapered to a thin edge at the top, so as to give the air a free passage to the base of the flame. The consumption of gas of 16 candle power, to be at the rate of 3 feet per hour, and the admixture of

[see in original text Tables I and II. Experiments on the proportion of gas and air mixed previous to combustion in Wallace's burner – 6-10ths of an inch and 15-10ths of an inch]

If the diameter of the burner tube be reduced without altering the quantity of gas passing from 7⁻¹₁₆ths to bare ⅜", the green cone becomes elongated and much less distinct. The force of the gas is too small to carry sufficient air along with it through the reduced opening, but if the pressure of the gas
were sufficiently increased, and the jet orifice reduced so as to let the same amount pass, the brilliant colour would again appear in the cone. So there must always be a certain proportion existing between the diameter of a burner tube, the quantity of gas passing through it, and the quantity of air mixed with the gas. When the mixture of air increases beyond 1½ volumes the flame disappears within the burner tube and burns without further assistance. By adjusting the velocity of the mixture so as to be equal to the rate of combustion, the flame remains stationary at any desired height in the tube. By varying the speed of the mixture, or the proportion of air, the flame will ascend or descend at will.

The increase of pressure on the gas has no ill effects on the burner when properly constructed. It will burn gas from ⅜ths of an inch to 2 feet and upwards of water pressure without producing a particle of solid carbon.

The bad name it has acquired for lighting within or striking back is entirely due to mal-construction. If the burner be an upright one, with the jet of gas passing straight to the flame, it will, unless of very small diameter, or of great length, be liable to strike back when turned low unless the supply of air is reduced at the bottom. This may be done by connecting the air-slide with the gas cock. A cam is fixed on the key of the gas cock, and is proportioned so as to give the gas as much air as can safely be mixed with it. When the gas is turned low, the slide closes in proportion, and the flame is as safe as when full on. The eccentric has a curve on the other side which gives a less amount of air to the gas and produces the reducing flame. That is a flame with a deficiency of oxygen, so that it will burn out the oxygen contained in a metallic oxide and reduce it to the metallic form. By quickly reversing the cock the cam leaves the air-slide closed, and gas passes unmixed to the flame. By constructing a burner in which the air and gas are intimately mixed, the tendency to strike down is greatly reduced, and as an additional precaution there should be a piece of wire gauze fastened beneath the burner tube which prevents any flame from passing through the mixing chamber to the jet, and to prevent any accidental lighting of the jet from without, it also should be cased in with wire gauze. The japanning of a burner thus constructed, and made of tinplate soldered together, and removed only one inch from the flame, would remain uninjured, notwithstanding that the heat of the flame was sufficient to melt copper. This was due partly to the thinness of the metal used, which will not conduct sufficient quantity of heat downwards to do mischief, and partly to the currents of cool air passing over and through the mixing chamber.

Very much has been said and written on the relative heating powers of the Bunsen compared with the light flame, but, as the reports seem to have depended very much on the sort of apparatus used in the respective experiments, the question cannot be settled until the construction and proportions of the Bunsen burner are thoroughly understood and agreed upon. From a purely logical point of view, the probabilities are in favour of the Bunsen flame. Granted that it gives off no smoke, and that the other does, then the former has the advantage of so much extra carbon consumed. Again, the smoke deposits on heating surfaces, forming a serious impediment to the heat; here is another point in favour of the Bunsen flame. Experiments have usually been made with vessels of water having clean bottoms; would it not have been better
to coat one of them with soot of an average thickness to represent the normal condition of a vessel used over a smoke-giving flame?

It was noticed that the Bunsen flame was a shorter flame than the other, and also that the more air there was mixed previous to combustion the shorter it became, and the less air it needed to complete combustion. Bearing in mind, then, that the nearer a substance to be heated is placed to the source of heat the more rapidly the heat passes into it, we find that a vessel of water can be placed nearer the centre of the flame without interfering with combustion, and thus it subtends a greater angle of radiant heat than if it were further off (see Plate XV.), and, consequently, there must be less loss by lateral radiation. Besides this, there is less risk of the flame being fouled in its own products of combustion, when the amount of air it takes up, while burning, is reduced to a minimum.

Having gone thus far into the subject, some tangible evidence may not unnaturally be expected. Here is the result of three trials made with the batswing against the Bunsen burner. A vessel with a flat bottom of tinplate, holding one pint of water, was placed over a batswing burner at a height chosen out of three trials as the best position. A similar vessel, with the same quantity of water, was placed over the Bunsen burner with the same precautions. The following table shows the time taken to boil the water in each case:

<table>
<thead>
<tr>
<th>Experiments</th>
<th>1st.</th>
<th>2nd.</th>
<th>3rd.</th>
<th>Average.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batswing</td>
<td>12 min. 43 sec.</td>
<td>12 min. 45 sec.</td>
<td>12 min. 48 sec.</td>
<td>12 min. 45 sec.</td>
</tr>
<tr>
<td>Bunsen</td>
<td>9 min. 32 sec.</td>
<td>9 min. 32 sec.</td>
<td>9 min. 33 sec.</td>
<td>9 min. 32 sec.</td>
</tr>
</tbody>
</table>

Showing an advantage of 3 minutes 13 seconds, or 25 per cent., in favour of the Bunsen burner.

The production of smoke, and the production of smells from gas flames, apart from their offensive and unwholesome character, always indicate a waste of fuel; it is, therefore, incumbent on all those who are interested directly or indirectly in the consumption of gas to give some attention to the subject of its combustion and the apparatus to be used for that purpose. Never since the establishment of gas works has there been such a demand for gas as at the present time; and every new discovery or improvement in the use of it opens a fresh and profitable field of industry. It is so convenient a fuel that its cost does not prevent it from being used in large quantities; and wherever a well-regulated and definite quantity of heat is wanted, gas has the preference over all other fuels. For small steam boilers it is much more suitable than coal, coke, or wood; a small fire being the most difficult of all to regulate properly. Indeed, it may here be a fitting place to make some comparison between the coal fire and the gas fire, in order to have a more exact notion of their relative values.

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A coal fire under a boiler is always in a state of forced combustion. The friction of the flues or the smallness of the grate area necessitates the employment of a chimney or a steam blast to carry off the products of combustion, and to supply the fuel with fresh oxygen. The relative quantity of air passing through the furnace depends upon the temperature of the chimney and the area of the openings through the fire or the furnace door. As the fuel is consumed there is a continual change in the form and area of the openings through the fire— in some cases the bars may burn bare, and in others be obstructed by slag. Every passing minute brings a change which no vigilance can correct, and stoking only aggravates the evil while the door is open. Passing too much air through the flues is as bad in its consequences as passing too little; and as small boilers receive much less attention than large ones, although they require more, it is evident that if stoking could be entirely dispensed with, and an apparatus substituted which would supply fuel and air exactly at the rate required, a uniformity in working would be arrived at which has hitherto been unattainable, besides saving the whole expense of stoking, which often costs far more than the fuel.

A furnace or burner to burn gas under a boiler must have the following qualifications:—

1. It must deposit no soot, and must burn gas in quantity on a limited area.
2. It must be on the Bunsen principle.
3. It must burn equally well at every rate of combustion, and be entirely free from striking back when turned low.
4. It must require little or no chimney draught to assist combustion, as it has been shown that the gas is capable of inducing air sufficient for admixture by its own motive force.

The same law which limits the size and form of gas-light flames, in order to avoid deposit of soot, applies to the method of mixing air with gas in a furnace. The whole supply of gas must he sub-divided into small jets, in order to induce a sufficient admixture of air. It is the surface of a stream of gas which enters into active combination with the air through which it passes; so, the smaller the jet, the greater the surface exposed in proportion to the quantity of gas passing. This is a matter of great nicety, for the motive force of the gas is so very slight, that any error in proportion will at once tell in the appearance of the flames. The sub-division of the gas supply has another good result— it effects a more complete admixture of the air induced by the gas, and produces a steadiness in the flames which allows them to be turned very low without some of them being extinguished before the others. A furnace of this kind, when placed below a boiler, requires the slowest possible draught, just sufficient to carry off the products of combustion. Such a furnace, capable of fulfilling these conditions, may be described as an example.

12 (or more) burner tubes of \( \frac{7}{16} \) inch diameter, arranged in a circle, project vertically from a cylindrical mixing chamber, into which the gas is introduced tangentially, drawing with it, by reason of its velocity, the necessary quantity of air through lateral orifices in the inlet tube. A perfect mixture is thus attained, as before described. Under the circular row of burner tubes is fastened a piece of wire gauze to prevent lighting down. Above, or on a level with the tops of the burners, is
fastened a disk with a row of holes, each of which is immediately opposite one of the orifices of the burner tubes, and is just so much larger in diameter as to leave an annular space round the top of each tube. A rim on the edge of the disk, and projecting about 1½" upwards, supports the vessel to be heated. The flames are thus shielded from air currents or other disturbance, and draw through the annular spaces all the air required to complete the combustion of the gas. By this arrangement the important advantage is gained of introducing the air at the base of each flame.

The increase of the heating surface of boilers seems to have had as much thought and ingenuity expended on it as any other problem in the whole realms of engineering. After looking through the patent records, a stranger might naturally wonder how it was that the majority of boilers retained such simple forms. A little practice would, however, soon show him that unless it can be swept and cleaned out, a boiler is only the worse for an elaboration of tubes and flues.

The deposit of tar and soot, which harden in every available corner, forming an excellent non-conductor, has been the ruin of many a well-meant scheme for boiler improvement. It will readily account for the extraordinary reports on the successful working of new boilers, which somehow never seem to be heard of afterwards. The more frequently a boiler fire is lighted up and allowed to cool down again, the more rapid is the deposit of soot and tar on the heating surfaces. A small boiler is most of all exposed to this contingency. The smallness of its parts also limits its construction to simple forms, so as to be easily cleaned. With a fuel that does not smoke, and from which the tar has been carefully removed, there are fewer limitations. The original heating surface could be depended on at all times, and the areas calculated from the results of coal or coke fuel would be found greatly in excess of what was required per horse-power. Again, since gas has been shown capable of being burned in quantity without forced combustion, the quick draught may be dispensed with, and the heat allowed the greatest time to pass through the heating surfaces into the water, besides greatly reducing the risk of drawing cold air through the flues. The furnace being constructed of metal, with its parts proportioned to its work, there could be no alteration of areas or openings during the combustion of the fuel.

By coupling the gas supply valve to a regulator, actuated by the steam pressure, and balancing the draught in the flues, by means of a descending outer flue of equal length to the ascending inner one, the speed of draught will always be in exact proportion to the amount of gas burnt; and the fuel will always be fed just as steam is required. It is probable that on analysis the spirit gases from such a furnace would give fewer traces of free oxygen than those from any coal or coke furnace used for the same purpose. It seems only now that engineers are beginning to learn how small a quantity of coal may be burnt to produce one horse-power per hour under a steam boiler. An eminent engineer lately astonished the public by the announcement that he obtains one horse-power per hour from one pound of coal. Now, recalling the experiments made by Dr. Letheby and Mr. F. J. Evans, it appears that 13 cubic feet of gas are the equivalent of one pound of coal in heat power. It follows that the cost of 13 cubic feet of gas is the price of one horse-power per hour if burnt under sufficiently favourable conditions. A small boiler would doubtless have to be very well designed and
constructed to produce the results just named; but the demand for a small motor, which shall, at the same time, be simple and reliable, is so well known that there is surely sufficient inducement to the mechanical engineer to go thoroughly into the matter. Before such a meeting as the present it will be quite unnecessary to say a word as to the probable demand for such a boiler and furnace.

The writer has hitherto been dealing with what might be called the

natural combustion of gas in contradistinction to forced combustion, and as it is often necessary to produce intense heat in small quantities, it is evident that the former method is not sufficient for the purpose. It has hitherto been customary to employ the motive force of a jet of compressed air to supplement the weakness of the gas pressure and bring the fuel into sufficiently small compass to produce intense heat. If, instead of compressing the air, the gas be compressed, then the same result may be arrived at, viz., the burning of an increased quantity of fuel in a given space. The gas will induce more air in proportion to its bulk at high than at low pressures, and so perfect combustion is secured. It has been observed that when the air and gas have been intimately mixed before combustion the flame is silent; this is also the case when gas is used at high pressures. The roaring noise of a brazier's blowpipe is caused by the meeting of the air and gas just below the flame. They have, therefore, really no time to mix properly, and the result is a straggling flame, which it requires great experience to control.

Gas has come to be so extensively used for brazing, where heat has to be applied on limited surfaces, that a little attention to the construction of the blowpipe would amply repay any one who has to use it frequently.

The fusing point of brass varies greatly. It decreases with the cheapness of the metal, and very often the difference of fusing point between the metal to be soldered and the metal used as solder is so small that the utmost care will sometimes fail to prevent the work from melting together. This is particularly the case when bellows are used to force the air with a constantly varying pressure.

Plate XVI. shows an apparatus intended to illustrate the foregoing-remarks; it is far from perfect, but it will show that gas may be burnt at a greatly increased pressure and induce all the air necessary for admixture previous to combustion. The induced current in this experiment is made to do the work of a pump or bellows, and operates in many respects similar to the well-known Giffard's injector.

A small steam boiler A, with a gas burner below, supplies power in the form of a jet of steam, which is made to force gas through a condenser B, where the steam separates in the form of water from the gas. The water remains in the receiver while the gas passes on to be burnt. To counteract the cooling effect of the moisture with which the gas is saturated, it is made to pass through chloride of calcium before going to the burner. The pressure of steam in the boiler is 8 lbs. per square inch. The quantity of gas passing through the burner is 32 feet per hour.
The pressure of the gas from the mains is 1½ inches; and the pressure of the gas in the receiver is 30 inches of water.

The steadiness of the flame is in a great measure due to the regularity of the pressure of the gas, which will remain the same as long as the supply of steam and gas continue.

The pressure of the gas may be augmented by increasing the pressure of the steam, and thus ensure at once a force and regularity which it would be difficult to obtain in any other manner.

In the same way air may be compressed and dried to serve blowpipes throughout a factory using gas at the main pressure.

It is of as much importance in most cases to control and regulate heat when once obtained as it is to produce it. This is particularly the case as regards dwellings, conservatories, and other buildings where comfort, convenience, or circumstance requires a regular temperature. To have such a power at command would, doubtless, cause many persons to prefer gas as fuel who at present object to it for various real or imaginary reasons. A regulator to control the temperature produced by the combustion of gas must, as a first necessity, be automatic and reliable, and the simpler the better. Many attempts have been made to regulate the consumption of gas according to the temperature it; some of them have, very probably, only lacked the publicity necessary to ensure the success of a worthy invention. The desirability of a good regulator is only too evident from the constant complaints that are made of the waste of gas through the carelessness or extravagance of persons who have charge of gas stoves. Too much heat is just as inconvenient as too little, so a regular temperature at once secures convenience and economy.

Plate XVII. shows a regulator which is intended to meet the requirements of such an apparatus when attached either to a Bunsen or light burner. A change of two degrees Fahrenheit will cause it to work, adjusting, extinguishing, and re-lighting the burner according as heat is required for weeks or months together.

The expansion of air gives this apparatus the controlling power to regulate the flow of the gas to be burnt. It is preferred to other means, because of the extreme mobility of air and the ease with which it may be adjusted by simply opening and closing an air valve. The mode of action is as follows:—a thin copper vessel, of a certain capacity, contains the air which is to regulate the gas by its expansion. The vessel A is coated with a dead black to render it the more susceptible to absorption or radiation of heat, and it has a small valve, the purpose of which will be presently described. A small pipe B leads from the expansion chamber to one end of the syphon C containing mercury. The other area D of the syphon is of the same form, and a bell-mouthed tube is suspended over the mercury, at about ¼" from its surface. The gas passing to be burnt enters the cup D, and passes over the surface of the mercury into the bell-mouthed tube, and thence to the burner, in the direction of the arrows. A by-pass takes gas to a very small constant flame attached to the burner. As the air is confined in the vessel A, the tube B, and the cup C, any increase of volume will depress the mercury in C, raise the level in D, and decrease the space below
the bell-mouthed tube through which the gas escapes, and if the air continues to expand, it will close it completely. Then the surface of the mercury around the bell-mouthed tube is acted on by the gas pressure, while that within the tube is relieved, so the mercury rises to a height within the tube proportionate to the pressure of the gas, as at E. The area of the mouth of the tube is such that, until the mercury touches it, sufficient gas may pass to give a small supply to each flame in the burner. Otherwise if some flames went out before the rest there would be an escape of unburnt gas. When the air in the expansion chamber contracts, the mercury begins to leave the bell tube, although it is still at a higher level within, as shown in shading, until its gravity overcomes the pressure of the gas, when it falls clear of the tube, allowing a free rush of gas sufficient to supply all the jets of the burner, which are simultaneously ignited by the constant flame. All that is necessary in order to set this regulator is to open the valve on the expansion chamber and light the burner. When the place to be heated is brought to the desired temperature the valve is closed, and the enclosed air has a volume due to this temperature. Any deviation from it will affect the volume of the air and cause a corresponding adjustment of the gas. If the gas were turned slowly on and slowly off there would be an escape and a nuisance each time it was lighted or extinguished; but in this case the supply and cut-off are sudden, while the regulation is gradual.

With an apparatus of this kind a conservatory, for instance, can be heated with the greatest nicety. As sure as the thermometer falls below a given point the gas will be turned on and lighted; and when the sun affords sufficient heat it will be extinguished.

It is very difficult in treating a subject of such magnitude as the present one to bring sufficient of it within the limits of a single paper for discussion. Each separate branch grows in importance as we examine it; but as the object of this paper is to show that gas of any quality can be burnt on Bunsen's principle, in properly constructed burners, with certainty and safety, and in a manner capable of control to suit various circumstances, the details of its application must be reserved for some future occasion.

It will not, however, be out of place to remark that it is on the proper combustion of gas that the fate of its application to household purposes depends. The prejudice against the substitution of gas for coal in cooking is not difficult to overcome, its relative economy for that purpose is established beyond denial, its convenience is equally admitted. But the sickening smell from badly constructed gas burners is past all endurance, and nothing can reconcile people to it. It is a great pity that the gas companies, who have brought the construction of the gas-meter to such perfection, should have allowed the manufacture of gas cooking and heating apparatus to fall into the hands of the most ignorant class of mechanics, who are to blame for nearly all the bad repute attached to the system. There are certainly a few exceptions to the rule, but the numberless failures, particularly of burners constructed after Bunsen's principle, which must be present to the mind of every one who has had any experience of them, will bear out this statement. Gas companies are by degrees taking the matter in hand, because they find it provides duty for their mains in the day time; but mischief is already done, which it will take years to undo. The increasing cost of coal and of household labour
render it highly probable that the same success awaits the domestic applications of gas, as has already established the sewing machine; and had the gas apparatus been in equally competent hands, there is no doubt that it would long ere this have been one of our domestic institutions.

It is to be hoped that among the numberless schemes for gas manufacture at present, the public may ere long be provided with a gas which shall be sufficiently cheap and plentiful to be used both for lighting and heating in private dwellings as well as for trade and manufacturing purposes in workshop or warehouse. Gas is the perfection of fuel. It can be produced from materials unfit for burning in small fires or furnaces, and when made it can be lighted in a moment and burnt with the utmost regularity.

Instead of decreasing our resources for materials from which to make it they appear to increase, especially as regards shale and petroleum. It may therefore be said that the materials are already at hand, the market open, and an unlimited demand assured for any good and cheap hydrocarbon gas. The process of manufacture and the apparatus alone remain to be decided on.

At present the system most in favour appears to be that of producing two gases—one with an excess of hydrogen, and the other with an excess of carbon, and then mixing them. But judging from the results it is evident that the temperature and pressure necessary to effect a chemical combination have been very little thought of, and the schemes have all come short of their intention. The process of purification is also far from satisfactory. It is expensive, and sufficiently unsettled to be the subject of the most diverse opinions. Three or four years ago an apparatus was patented which employed jets of steam both to draw the gas from the retorts and purify it; but here again the combining temperature and pressure were forgotten, and moreover the inventor seems to have lacked the mechanical ability to apply his idea properly, so the scheme which contains all the elements of a great invention has sunk into the limbo of failures.

It is hoped that the influence of technical education may soon be manifest in its effects on these and similar problems which so nearly affect our national prosperity. Now there are many distinguished engineers who are all ignorant of chemistry, and many famous chemists who are without mechanical education, even of the simplest practical kind. The present chaotic state of the system of gas manufacture is due in great measure to this cause, and nothing but the equal co-operation of the twin sciences of chemistry and mechanics will discover the process and the apparatus which shall provide us with a cheap, safe, and useful gas fuel.

The lecturer explained the Tables I. and II., which gave the results of the experiments made to ascertain the amounts of air mixed with gas previous to combustion. The appearance of the cone noticed in the paper was taken as an index of the proportion of the mixture. The pressure of the gas in the experiments given in No. I. Table was 6-10ths of an inch; in those of No. II. Table, an inch and a half, and the results confirmed the previous ones. The experiments were made to determine exactly how much air was induced previous to combustion, and to account for the difference in the appearance of the volumes; and the table gave it exactly. The amount of air to the gas came out a great deal less than was previously supposed. The amount of air necessary
to the complete combustion of the gas varied as the amount of carbon contained in the gas. This experiment had been made upon Newcastle gas of low illuminating power. Lest he might be misunderstood he would state that his paper referred particularly to small boilers below one-horse power—a boiler which was very much in demand for large cities where a small amount of power was required. He would never propose to manufacture coal gas to burn under a large boiler, for however carefully constructed a furnace might be, gas fuel was more expensive than coal. But there were circumstances under which it was more economical to burn coal gas, even at the present price, than coal, and in London particularly there were numbers of small boilers working steam hoists and things of that kind, and burning coal gas even at the London prices; and in almost every instance they gave the greatest satisfaction. It was in cases like this where the expense of the stoker was greater than that of the fuel.

The boilers were fitted with regulators by which the pressure of steam in them adjusted the amount of the gas. When the pressure rose towards the blowing-off point, the gas was turned down; the consequence was the boiler did not blow off. The boiler in almost every instance would require to be an upright one, with internal flues, and hot-spent gas passing down the outside of the boiler and out at the bottom. A system of burning gas under large boilers would of course require to be different from this; but different gas would have to be used. Carburetted hydrogen gas was never burnt under large boilers, and he should be the last to propose it.

Mr. Wm. Boyd said, the comparative cost in the market of one pound of coal and of 13 cubic feet of gas should be compared against the cost of producing one indicated horse-power by the two systems—even extending this one pound to two pounds, a result which was constantly obtained, the absolute money cost of producing one indicated horse-power was of course very much in favour of the combustion of the coal as against the combustion of the gas, putting the question of convenience on one side altogether.

Mr. Wallace—Yes, under present conditions; but in order to have a basis of argument they had to take the extreme capacity of both fuels. He had endeavoured to show that gas could be burnt, in small quantities especially, to greater advantage and more completely than coal. Of course a great deal of work remained to be done. The shape of the boiler remained to be decided; but they must know the capability of a fuel

before setting to work to experiment with it; and to him gas seemed to offer a field well worth considerable research and attention.

Mr. Bunning said there was another and most important advantage arising from the use of gas. In a large warehouse, worth perhaps several thousand pounds, if a small steam engine is erected, driven by an ordinary boiler and coal furnace, the rate of insurance is increased all over the building. Whereas, by introducing a small steam engine, and using gas, this extra expense would not be necessary. This would in almost all cases turn the scales in favour of the consumption of gas, and, therefore, he considered the subject a most important one.
Mr. Nelson thought that instead of one pound being required per horse-power, three or four would be nearer the mark; but he should imagine that it was more practicable to burn gas in small boilers than coal, because gas might be regulated automatically, to a great degree, by such an arrangement as Mr. Wallace had shown, and the stoking of coal could not be arranged automatically, but was in a very great degree under human control.

Professor Herschel said, there was one point upon which perhaps he would be able to get information from Mr. Wallace. It was mentioned to him (the professor) many years ago, when he was at Glasgow, that gas had been used as a fuel by mixing it with air in certain proportions, keeping it stored up in gas holders, he thought with equal proportions of air, and burning it in the same way as common gas, and that it was used in that way as a heating power, and was a very great improvement on the ordinary gas for fuel. In the only experiment on the heating power of gas which he had been able to discover, the heating power was quite as high as Mr. Wallace had stated; and he would like to know if it was on trustworthy experiment or calculation that they had the high heating power which he gave. The practical experiments with Newcastle gas which he had met with, place the heating power at about 33 cubic feet, doing as much as a pound of coal, i.e., a pound of gas doing the same work as a pound of coal: each pound of fuel evaporating 12 lbs. of water. The experiments were a few years old, no doubt; but he would like to know from Mr. Wallace how far they could be relied upon.

Mr. Wallace said, the only gas which he had seen mixed with atmospheric air was gas produced from oil, generally dead oils, in the distillation of tar; and to be able to burn it in the common burner to produce light it was necessary to mix ten per cent. of air with it. A gas of very rich carbon properties might require 50 per cent. of air. But in order to burn it to give light, gas of a carbon strength beyond a certain point, could not be used, or else the carbon was deposited in its solid form. Therefore it was well to mix about 10 per cent. of air with oil gas, in order to burn it even to give light. The authorities which he quoted for the value of 13 cubic feet of gas were Mr. F. J. Evans, a man very well known in London; and also Mr. Hartley, who read a paper on the subject three years ago at the Association of gas managers.

Mr. Newall said, of course when Mr. Wallace or Professor Herschel spoke of gas, they meant carburetted hydrogen. They did not refer to any other kind of gas, such as hydrogen alone?

Mr. Wallace—No.

Mr. Newall said, he saw a large boiler in Manchester two years ago, of about 20 horse-power, which was heated for some months by using creosote. A jet of creosote was forced through a small tube, that tube being surrounded by a steam tube; in fact, it was an injector. The steam drew the creosote from a vessel which was heated slightly; and the result was a very long flame under the boiler—a flame about 30 feet long from one tube; and this raised steam for manufacturing purposes. It promised good results; but from some cause or other the experiment became so expensive that it was given up.
Mr. Wallace said he thought that if they compared gas fuel with coal fuel they must take into consideration the most convenient form in which the fuel could be burnt. When coal had to be burnt in small quantities it was impossible to get anything approaching the theoretical results from it. To do that it must be burnt in bulk. But gas was a fuel which could be burnt properly in any quantities. That was one of the great advantages of it. It could not only be burnt properly but it could also be burnt at a uniform heat; so that where heat was required in small quantities and at a uniform rate, gas offers advantages which no other fuel could be said to possess.

Mr. E. F. Boyd proposed a vote of thanks to Mr. Wallace for the ingenious mode in which he had illustrated a most interesting subject. After the paper had been printed they would be better able to comprehend the subject.

The motion was carried by acclamation, and the meeting separated.

[Plates XV to XVII illustrating gas burning apparatus]

PROCEEDINGS.

GENERAL MEETING, SATURDAY, DECEMBER 6, 1873, IN THE WOOD MEMORIAL HALL.

R. S. NEWALL, Esq., Vice-President, in the Chair.

The Secretary read the minutes of the previous meetings the minutes of the Council, and the following Report from the Colliery Engineers' Committee:—

"Your Committee, after giving the subject of admitting colliery engineers as members of the Institute, upon a reduced rate of payment, a careful consideration, recommend that no exception should be made in the Rules of the Institute to meet their case, but that they be received on the usual terms."

The Chairman said, before adopting the report, he would ask the meeting whether they approved of it. It was a very important matter. Of course they would be glad to add to the number of their members; but the consideration of expense formed a very important element of the case. The cost of each member of the Institute was about a guinea and a half, and therefore it was not advisable to reduce the subscription below what it is—viz., two guineas; but if any member had any remarks to make upon the report, they would be very glad to hear them.

No one rising to reply, the Report was agreed to.
The following gentlemen were then elected:—

Members—

Mr. R. L. Galloway, Hebburn Colliery, Gateshead.

Mr. George Clark, Jun., Monkwearmouth Engine Works, Sunderland.

Mr. Adams, M.E., Cardiff.

Mr. R. T. Bunn, Coal Owner, Newcastle-on-Tyne.

Mr. James Hall, Coal Owner, Newcastle-on-Tyne.

Students—

Mr. Charles Z. Bunning, 90, Abbot Terrace, Gateshead.

Mr. Arthur Robert Sawyer, Towneley Colliery, Blaydon-on-Tyne.

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

Members—

Mr. Henry Henderson, Pelton Colliery, Chester-le-Street.

Mr. David Tyzack, Warkworth, Acklington, Northumberland.

Mr. William Jackson, Cannock Chase Collieries, Walsall.

Mr. M. S. Hall, M.E., Woodlesford, near Leeds.

Mr. Thomas Blandford, Corbridge, Northumberland.

Mr. Walter Gardner, M.E., Stonehouse, Rugeley.

Mr. Joseph Mitchell, Jun., Coal Owner, Worsbro’ Dale, near Barnsley.

Students—

Mr. W. S. Harris, Marley Hill Colliery, Gateshead.

Mr. John Bruce, Marley Hill Colliery, Gateshead.

Mr. R. W. Berkley, Marley Hill Colliery, Gateshead.
Mr. Wm. Johnson, Strangeways Hall, &c, Collieries, Wigan.

Mr. F. B. Atkinson, Haswell Colliery, Fence Houses.

The Chairman regretted to say that Mr. Hurd, who had been announced to read a paper on "Hurd and Simpson's patent air-compressing and self-acting Coal-Cutting Machinery for straight work, long-wall, and pillar and stall work," was not present. He therefore called upon Mr. Simpson to read his paper.

Mr. J. B. Simpson then read the following paper "On Natural Pits in the Coal Measures of Belgium:"—

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NOTICE OF NATURAL PITS IN THE COAL MEASURES OF BELGIUM.

By M. F. L. CORNET and M. BRIART.

(Translated from the French by John B. Simpson.)

In working coal the miner often meets with irregularities in the strata commonly known as "faults." These have different degrees of inclination to the horizon, their lengths varying exceedingly, but they generally follow a direction more or less straight. At the point of contact with these faults, the shales are often striated and distorted, occasionally covered with a thin coating of pholerite, and the adjoining coal is earthy and friable.

Faults sometimes only break the strata, at other times there is a space between the two sides of the fault, and in that case it is filled with debris from the coal measures. At other times these debris are mixed with rocks differing from the coal-formation, and identical (in Belgium at least) with those which constitute the cretaceous deposits—such as sands, clays of the Aachenien system, and marls, chalk, and flint of superior strata. Up to the present time it is not on record that there have been found in the coal faults of Belgium, sands, clays, or other substances of the tertiary period.

Sometimes faults only interrupt the continuity of the layers for a distance equal to the breadth of the fault; but this case is very rare. A fault is mostly accompanied by a depression or upheaval of the strata—that is to say, that on one side of the fault, each particular layer is at a higher or lower level than it is at the other. Faults occur frequently in the coal-formation, and generally in all primary strata. They are also met with, though not so frequently, in secondary and tertiary rocks. On the other hand, certain phenomena, for a long time known by and described under the name of natural pits, although numerous in the cretaceous and tertiary formations of Belgium, seemed,

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until the present, never to have been met with in primary formations.* These facts have, nevertheless, been well proved by actual explorings in the Belgian collieries, but they were only
known to a few mining-engineers and coal owners whose work had been interrupted by their occurrence, and no description of them has heretofore been published. These phenomena seem to have no resemblance to the ordinary faults, except in the nature of the rocks with which they are filled. They do not seem to have been owing to any movements of the earth, are never accompanied by an upheaval or depression of the surrounding strata, and only appear in the same layer, their length and breadth being nearly the same. They are in reality pits of curvilinear section, more or less regular, traversing the various strata obliquely or perpendicularly. The matter which fills up these cavities consists of pieces of coal, shale, coal-grit, and cretaceous rock confusedly mixed up. Sometimes there are spaces filled with water, and the water immediately rushes into the workings when one of these natural pits is met with. This encounter is always unforeseen, for nothing in the nature and condition of the seam of coal indicates the approach of anything unusual. It has, however, been observed that the fissures of the coal and of the rocks, surrounding the natural pits, are sometimes thinly coated with crystals of iron pyrites and carbonate of lime, which are also found on the debris which fill up the pits.

Up to this time eight natural pits have been met with in the explored part of the Hainaut coal-fields. The description of some of these can, to a certain extent, be applied to all. It is proposed to commence with the one most recently discovered, which has been studied in more of its details than the others.

NATURAL PIT MET WITH IN THE COLLIERY OF BASCOUP.

The coal seams worked in this district belong to the inferior portion of the Hainaut Coal Basin. In some places the coal-formation appears

* Natural pits are very numerous in the chalk marls of the Maestricht beds. They are also met with in the white chalk of Hainaut, filled with green sands analogous to those which form the base of the Landenien system. The origin of these cavities in the limestone rock may, up to a certain point, be explained by the action of chemical agents dissolving these rocks; but this explanation meets with more difficulty when it is applied to account for the natural pits in siliceous or argillaceous rocks found in those tertiary sands, which are worked principally for the manufacture of glass. These pits are sometimes four or five yards in diameter, and are filled with a very fine argillaceous sand, as white as the surrounding sand above alluded to, but entirely useless for glass working. Their depth is unknown.

at the surface under a variable thickness of soil, but it is chiefly covered with strata (mort-terrains), varying in thickness, and belonging to the cretaceous, tertiary, and recent formations. Towards the end of 1864, the works of this colliery had proceeded in the "Veine de l'Olive" to a point 1,312 yards eastward of its drawing shaft (St. Catherine). The seam was in a very regular condition, and nothing indicated the neighbourhood of any derangement whatever, when, all at once, the waters rushed in at the face of the principal heading with such violence that the workmen had hardly time to save themselves. It was thought that they had reached some old inundated workings. For many hours the
quantity of water was very great, but the next day the feeder had greatly diminished and they were able to reach the point A, Plate XVIII., where the water had rushed in. To ascertain the nature of the derangement met with, it was decided to continue in the same direction. In this way they went through the remains of coal, shale, and coal-grit confusedly mixed up, more or less distorted, coating them with very small crystals of carbonate of lime and of pyrites, and leaving between them numerous hollows. After having gone through 16 or 17 yards of this debris, the regular strata were again met with. It was shown that the derangement had not produced any throw in the coal seam. In order to be able to re-establish the workings on the other side, the air-way B was continued, which it was expected would have to be driven through the debris; but this excavation did not leave the seam, and when a communication was made between the galleries A and B, Plates XVIII. and XIX., on the other side of the interruption, they found that it did not extend far to the north, and was nearly semi-circular in shape. The working of the lower portion of the seam, which took place a little later, proved that the interruption also did not extend far to the south. It then became evident that, instead of a fault, a natural pit had been met with of elliptical section, the larger axis being 31 yards and the smaller one 18 yards long. In 1866, the workings of the "Grande veine du Parc," Plate XIX., fig. 2, at a higher level than the "Veine de l'Olive," Plate XIX., fig. 1, circumscribed the natural pit again. The lesser axis of the elliptical section was found about the same length as in the "Veine de l'Olive," but the larger axis was considerably longer, being 52 yards. Its direction was also varied. In the "Veine de l'Olive" it lay sensibly in the direction C D of the greatest inclination, whilst in the "Grande veine du Parc" it makes an angle of 25° with this direction. The debris in the natural pit, at the level of the "Grande veine du Parc" was the same as in the "Veine de l'Olive;" but it was remarked that the seam and the surrounding rocks were slightly depressed near the sides of the pit. In this depressed portion, the coal and the shales are impregnated with crystals of pyrites like those which coat the material which form the filling up. This depression of the stratified rock at the level of the "Grande veine du Parc" is attributable to the tender and flexible nature of the shales which surround this seam; the shales of the "Veine de l'Olive," where such depression has not been observed, being much harder and more resistant. By the working of these two seams, it is inferred that the axis of the natural pit of Bascoup makes an angle of 66° with the horizontal plane, and with the stratification plane an angle of about 96°. It seems evident that this pit reaches the surface of the coal-formation; but it is impossible to say whether it penetrates the thickish tertiary deposit which overlies it. A great number of seams are going to be worked below the "Veine de l'Olive," which will enable further information to be obtained as to the depth of this derangement.

NATURAL PIT IN THE COLLIERY OF SARS-LONGCHAMPS, AT LOUVIERE.

The working shaft, "Bonne Esperance," now abandoned and filled up, was sunk some time ago, by the Coal Company of Sars-Longchamps. After having gone through 24 yards of recent formation and of tertiary sands, belonging to the Landenien system, it then penetrated the coal-formation, and appeared regularly stratified until a depth of about 102 yards had been reached, Plate XX. At this
level, a mass of debris was met with which was separated from the coal-formation by a very distinct line of demarcation, traversing the pit obliquely. It was at first thought that this line of separation was the face of a fault inclining southwards, and it was hoped that, after having gone through a certain amount of debris, the pit would reach the other side and would again meet the stratified rock. But this hope was not realized, for the pit, although sunk to 322 yards, was still in the same material. Horizontal exploring galleries, directed north and south, were then made at different heights in the pit. At a little distance they met with the very nearly vertical sides of the coal-formation in its regular condition. In this way they explored several seams, and demonstrated in a satisfactory manner that the irregular ground in which the pit "Bonne Esperance" was sunk, was

<table>
<thead>
<tr>
<th>Seam</th>
<th>Depth Below Surface</th>
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<tr>
<td>Huit Paumes</td>
<td>153 yards</td>
</tr>
<tr>
<td>Six Paumes</td>
<td>258 yards</td>
</tr>
<tr>
<td>Grande Veine</td>
<td>298 yards</td>
</tr>
<tr>
<td>Gargai and Joligai</td>
<td>322 yards</td>
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</table>

And the seam Gargai and Joligai, united 322 "

The explorings in each of these seams are represented in horizontal projection in Plate XXI, figs. 1 and 2, and Plate XXII., figs. 1 and 2, where it will be seen that in the Six Paumes and Grande Veine the workings have entirely surrounded and made known the natural pit, which has a rough elliptical shape, the axes being respectively 102 yards and 69 yards in length at the Grande Veine. The workings of the united seams, Gargai and Joligai, have also nearly surrounded it. As to those of Huit Paumes, coal has been worked only on its southern side. These facts have enabled the vertical section of the natural pit to be traced as shown in figs. 1 and 2, Plates XXI. and XXII. Below the seam, Huit Paumes, this derangement is nearly vertical; above, it inclines slightly to the north in an opposite direction to the dip of the coal seams. It has not been ascertained whether the natural pit penetrates the layers of tertiary sand which cover the coal-formation. These strata are, however, represented as having no relation with the occurrence which has affected the coal-formation. The debris of the natural pit in the colliery has only been observed at a single point at the level of the seam Gargai, and there it is composed exclusively of remains of coal, of sandstones, and coal-measure shales, very much broken up and full of pyrites. The sandstones have been nearly converted into sand, and the shales into plastic clay.

To conclude, the natural pit of Sars-Longchamps, like the one at Bascoup, lies in the middle of a vast surface of coal of perfect regularity, in which faults are very rare and unimportant.

**NATURAL PIT AT GRAND-HORNU.**

The portion of the basin, situated east of Mons, contains all the seams known in the coal-formation of Hainaut, comprising the seams of close-burning coal which are found in the bottom of the basin,
as well as those containing cannel coal lying at the top. It is estimated that this deposit, so rich in fuel, attains the enormous thickness of 6,560 feet, and that its base lies at certain points 7,872 feet below the level of the sea. Considered generally, the direction of the seams is about from east to west. The middle of the basin is formed by great "plateures" running east and west, of which the northern portion,

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known as the "Comble du Nord," inclines southward, whilst the southern portion, or the "Comble du Midi", inclines towards the north. The line of intersection of the two "dips" has received the name of "La Naye", which, considered vertically, describes several great bends corresponding to immense depressions or troughs, in which rest the beds of coal.

The level galleries, driven in to these beds, tend to describe ellipses around these curves, of which the axes diminish as the workings in the same bed go deeper.

Three of these troughs are actually known; and what is a remarkable fact, they all have equally great thicknesses of unconformable strata. The thickness of these covering deposits, however, are at a minimum above the convexity of the Naye. One of the troughs, which is not well known yet, seems to have its centre under the territory of the town of Mons, where the strata, formed of cretaceous and tertiary layers, are from 437 to 540 yards thick. Another one, covered by 211 yards of cretaceous rock, has been perfectly explored by workings under the village Quaregnon.

The third one, at least, as far as it is explored, is situated west of the village of Hornu, and there the upper rocks are at least 328 yards thick.

The important works to which coal mining has given rise west of Mons, have been but little opened until the present time beyond the inclines of the "Comble du Midi" and the folded portion which terminates this dip to the south.

The direct working of the "Comble du Nord" has been prevented by the enormous thickness of the watery strata which outlie it, and in penetrating into it, by open workings from the "Comble du Midi," some little distance south or north of the Naye, a zone of coal was met, so beset with faults, that the workings which were made there were unsatisfactory and had to be abandoned. This zone of dislocation extends parallel with the Naye or the whole explored length of the basin—its breadth is still unknown.

The works of pit No. 12, of "Grand-Hornu," Plate XXIII., have been for a long time opened on the Naye, not far from the disturbed zone, and in the upper series of the formation.

The cover which, at pit No. 12, is 90 yards thick, increases rapidly in thickness towards the west. The boring, No. 3, made 1,000 yards west of the pit, has passed through,

<table>
<thead>
<tr>
<th>Tertiary Beds</th>
<th>22 yards.</th>
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<tbody>
<tr>
<td>Cretaceous</td>
<td>290 &quot;</td>
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</table>
This boring has not reached the coal-formation, but it may be presumed, judging by the usual thickness of the marl in the working pits of Grand-Hornu, that at this point the cover is about 328 yards thick.

The explorations at the depths of 400 and 500 yards, Plate XXIV., fig. 2, have been driven westward about 656 yards, and have proved and worked several inferior seams, as well as those of Grand-Moulin, Veine à Forges, and Veine à Chiens.

As may be seen by Plate XXIV., fig. 1, and Plate XXV., fig. 1, the workings have circumscribed and traversed at different heights, two natural pits of irregular elliptical section, of which one, A, Plate XXV., fig. 2, seems to widen with its depth—the large axis of its section being 116 yards in diameter at the depth of 489 yards, and 146 yards in diameter at the depth of 498 yards.

The axis of this pit makes an angle of 84° with the horizontal plane. The natural pit B, which lies 82 yards south of the first one, is smaller than A. Its large diameter does not exceed 57 yards, and its axis forms an angle of 86° with the horizontal plane, and seems to widen towards the south-east, or in an opposite direction to pit A. Up to the contact with the two natural pits, the surrounding seams of coal and shale retain their condition; but a few yards from it their fissures are filled with imperfect rhombooidal crystals of carbonate of lime. The material in the pits consists chiefly of fragments of coal very much damaged, covered with efflorescences of the double sulphate of alumina and iron and of crystals of carbonate of lime mixed with remains of cretaceous rock, very abundant at a depth of 439 yards, but rare at 498 yards. These last remains consist chiefly of marl and fragments of calcaro-siliceous concretions which characterise the strong beds of the cretaceous basin of Hainaut. Large crystals of carbonate of lime, perfectly rhomboidal in shape, have also been found similar to those often met with in the fissures and cavities of the carboniferous limestone and Devonian rocks of Belgium.

The two natural pits of Grand-Hornu have not been followed below the Veine à Chiens nor above the Grand-Moulin; but the remains of rocks which they contain prove sufficiently that they continue to the unconformable covering, and that they have more or less affected the layers which form its base. It would be of the greatest interest to be able to study the way in which they penetrate these cretaceous layers, and it would be of great help in determining their age. Unfortunately, there is very little chance of this. Not so with the study of their depth, which may take place at a time not far distant,

as explorations through the strata are actually being made in the pit at a depth of 555 yards, and in the direction of the two natural pits.

A third natural pit has been met with in the workings of the Grand-Hornu Company, some distance eastward of pit No. 12. Others exist in a royalty near Jemmapes; also in the collieries at Louviere and
La Paix, and of Haine St. Pierre, in the central district, but there is not sufficient information to enable them to be described. Besides, what has been said about the natural pits of Bascoup, Sars-Longchamps, and Grand-Hornu, is sufficient to indicate the existence in the coal-formation of phenomena, which have the greatest analogy to the natural pits of the second and tertiary formations from which they only differ by their much greater dimensions.

Mr. Simpson stated that this paper was sent to him by the authors a few years ago, after their visit to this district. The meeting would perceive that they had abstained from offering any opinion as to the way in which these natural pits had been formed. He himself had not been able to form any theory which would satisfactorily account for these curious phenomena, but he hoped that Dr. Page, who was present, would be able to give some information on the subject.

The Chairman said they were very much indebted to Mr. Simpson for this interesting paper. It seemed a most difficult thing to account for such phenomena as those referred to; probably Dr. Page would favour them with his views upon the matter.

Dr. Page said, that as Mr. Simpson had referred to him, he had risen to reply, but really he was about as much in the dark, and perhaps more so, than Mr. Simpson. In his geological experience, he had never met with natural pits, or filled up swallow-holes, of such depth and magnitude. He was aware of soft dykes, composed of miscellaneous debris washed in from above; but as Messrs. Cornet and Briart observed, soft dykes had generally a definite direction, and therefore these natural pits, from their circular and circumscribed shapes, could not be associated with this class of phenomena. Then they had occasionally in the coal formation deep narrow gorges or old stream-courses—the "wash-outs" of Nicholas Wood—filled with boulder clay and debris from above; but on investigation, these wash-outs were found to be of limited depth, and often traversed the country for miles in linear directions. The natural pits of Belgium could not possibly be classed with these. There was a third phenomenon of this kind. Rounded pot-holes were not uncommon in some districts, varying from 4 to 20 feet in depth, and filled also with wash from above. On examination, however, a rounded boulder of hard rock was usually found at the bottom, showing that these pots had been formed, like those alongshore of the present day, by the rotating and grinding motion of the boulder continually deepening the pot in which it was enclosed. The natural pits of M. Briart were on too gigantic a scale to be compared with these. Again, in the chalk formation, there were numerous pipes or pot-holes, often of considerable depth and dimensions, caused by carbonated waters percolating downwards, and dissolving out the soft and homogeneous chalk rock. These pipes, however, were restricted to the chalk beds, and never passed downward through a succession of different strata, as in the case of these natural pits, which passed indifferently through sandstones, shales, and coals. Fourthly, there were the swallow-holes of the mountain limestone—such as those of Western Yorkshire and Derbyshire. These swallow-holes were often of great depth and diameter, and many—like that of Weathercote, for instance—received streams which disappeared in their depths, and re-appeared several miles distant in the lower
country. If such swallow-holes ceased to receive water, and subsequently became filled up by wash from above, they would present appearances very similar to the natural pits described by Messrs. Cornet and Briart. With regard to the age of these curious perforations, the fact of their containing debris of sandstone, shale, coal, and fire-clay, shows them to be posterior to the hardening and consolidation of the coal strata. The fact, also, of their enclosing fragments of chalk and chalk-marl, proves them to be subsequent to the chalk formation; but the description was not so clear regarding the tertiary beds. The crystals of carbonate of lime mentioned by M. Briart, could be accounted for by the percolation of solutions from the chalk, and the iron-pyrites, by solutions of iron and organic matter from the superficial coverings. Had there been any volcanic phenomena described by the authors, a solution of the problem might have been sought for in outbursts or necks of trap such as occur in the Scottish coal-fields. Such necks might have been dissolved out, as is often the case with felspathic dykes, and the pipe left been subsequently filled up with debris. As there was no mention of associated traps, one could not fall back on this explanation. The only idea that suggested itself to him was something of this kind: if the Belgian coal-field rests on limestones of great thickness, like those of Derbyshire

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and Yorkshire, it might be possible for these limestones to be dissolved away, as in the case of swallow-holes, and the superincumbent coal strata and chalk beds, losing their support, would then fall in by degrees and fill up the cavity, thus producing a "natural pit." Such fallings-in frequently take place when a sit or creep occurs in coal-workings; and he had seen a sit many yards in diameter, and more than a hundred feet in depth, filled up from bottom to top, very much in the fashion of the Belgian phenomena. If the Belgian field, however, rested upon schists or other rocks, and not on limestones, this hypothesis would be of no avail. Altogether, these natural pits were new to him, and, he must confess, a great puzzle. More information, however, was needed—first, as to the nature of the subjacent formations; second, as to the pits passing up to the surface through the tertiary strata; and lastly, as to the nature of the cheeks or walls of the orifices. If information on these points could be obtained by Mr Simpson, it would greatly assist in solving the riddle.

Mr. Bewick thought the concluding remarks of Dr. Page were very much to the point, because until they knew what was the nature of the lower part of these holes, and upon what the coal measures there rested, they were completely at fault. The swallow-holes described by Dr. Page were exceedingly numerous in every limestone formation that he had come across. Within the last few weeks he had seen thousands of them in a limestone equivalent to Jurassic limestone (some of which were of enormous size), covering acres of surface which had become depressed and settled down, forming what is not unlike a large amphitheatre; through these the water flowed and came out at some distant place. They had such holes in many parts of this country—in Northumberland, West Durham, Yorkshire, Derbyshire, Somersetshire, in fact everywhere where the mountain limestone forms the surface rock. They had cases in Somersetshire—at Priddy, for instance—where the waters at certain mines disappear altogether, and it is not known where they come out again. The only way that he could suppose that the holes described in the paper could have been formed in the coal measures without a fissure (and as he gathered from the paper, there was not the slightest dislocation; but the holes were simply somewhat irregular pits, properly so called, because they
approached a circular form) was that they should have settled down into the limestone which it might be supposed was underlying the strata, and in which were fissures. He knew of a great many cases in which the limestone was overlaid by the newer formations such as those he spoke of having recently seen, where

the upper beds had settled down. The regularity with which these pits appeared to be formed was extremely interesting, and astonished him more than anything else; because, through such a considerable depth, he should have expected that some of the softer beds of rock or clay would have fallen away, and formed an irregular and somewhat zigzag hole. But that did not appear to be so, and therefore he could only look upon the phenomena as at present unaccountable.

Mr. Lebour said, a case in point occurred to him—that of a swallow-hole in West Yorkshire, which was to be found in the millstone grit about 250 feet above the first bed of limestone in the mountain limestone; so that there they had a case somewhat similar to this—an actual swallow-hole passing through thick bands of sandstone or grit and ending in limestone, as Dr. Page had suggested, and as he (Mr. L.) thought was the only explanation that could be arrived at from the sections given. One point to be noted was that these natural pits were nearly all at right angles to the original line of the coal beds. Therefore it was unlikely, he thought, that these swallow-holes would be found penetrating the cretaceous and tertiary beds which appear to be horizontal in these cases. He was not aware of any swallow-hole not at right angles to the bedding. It had been said by Mr. Bewick and Dr. Page that these pits do not coincide with faults, but in one case a pit does coincide with a kind of fault—with a change of angle in the dip of the beds, at all events; and it was just possible that in other cases a fissure, or the bending down of the beds, may have been the original cause of the swallow. But until it be shown that the sides of these natural pits do slope inwards towards the middle of the pit, he could see no reason to imagine that the coal measures had sunk into an underlying pit in the limestone. It seemed quite impossible that there should be no slight dip round the walls of the pit; and really the whole thing seemed a complete puzzle so far as he could make out.

Mr. Bewick said, it was explained that there were really no faults.

Mr. Lebour—One of the sections shows something of the kind.

Mr. J. B. Simpson—In one sketch there is a slight change in the inclination of the beds near the natural pits, as Mr. Lebour mentioned; but the writers of the paper did not draw attention to the fact.

Mr. Bewick said, the case which Mr. Lebour referred to in Yorkshire was, he had no doubt, a swallow-hole; very likely, one of a series defining a line of fissure or a vein, as commonly occurs in Yorkshire. In the limestone these swallows run for a considerable distance, and the fissure extends, perhaps, for miles in a more or less direct course.
He had never himself known the millstone grit subside as in the case referred to by Mr. Lebour, nor had he ever met with any other similarly hard strata becoming depressed in this manner.

Mr. I. L. Bell said he would not for one moment have it supposed that he could afford any better explanation of the phenomena which seemed to have puzzled so eminent a geologist as Dr. Page, but he would suggest to him if it were not possible that gases in the water acting as a solvent might have produced those holes—whether it were not possible that a great quantity of elastic fluid coming up in an opposite direction, might not in time have worked out the excavations in question. He did not know whether Dr. Page had examined the fumarols at Ladarillo in Tuscany, from which boracic acid was obtained, as they were all aware, in considerable quantities, and which afforded the only source of uncombined boracic acid known. Now, in that district there was an immense volume of elastic vapour, partly steam and partly gas, constantly escaping from numerous apertures in the ground. He apprehended that if from any particular part in the strata there was an immense evolution of gas of this character, its first operation would be to make a mere crevice, as it were, in the rock. As the sides of that crevice gave way, then they might have the action described by Dr. Page, of a boulder rock excavating its way downwards. These fragments of the rock would be turned round and round, constituting a grinding action in the cavity itself, and he had no doubt at all that if these rocks were examined, and they could see clearly the size of the holes made there, they would find cavities of considerable size—no doubt filled up, as they might expect, with the debris of rocks through which steam and permanently elastic vapours had passed. He would just throw out that as a hint to Dr. Page to consider whether, under such circumstances, an opening might not be made by the gases passing upwards from the strata below.

Dr. Page said they had undoubtedly a very good illustration of what Mr. Bell suggested in the geysers of Iceland; in the great geyser, for example, which Bunsen gives as 96, and Captain Forbes as about 134 feet in diameter, they had 130 feet of a perpendicular circular cavity, through which boiling water comes. Now, there might have been, subsequent to the coal formation, discharges of heated water and gases from below which might work out in course of time such openings as these natural pits. But all the sandstones, and shales, and so on, described as filling them, would naturally be carried away and dissolved; and the difficulty remained as to how they got filled up with their existing debris; besides, hot springs generally leave siliceous or other incrustations, and, according to M. Briart’s description, no such depositions were present.

The Chairman said it appeared to him that if these sections were correct, one fact went against the theory just announced—namely, the pit appeared to be of a very much larger section lower down than it was next to the surface. It was three or four times the size at the bottom that it was at the top; and the straight sides were, as Dr. Page said, the puzzling things of the whole affair.

Mr. I. L. Bell said that was precisely what he should have expected to have taken place if his hypothesis was the correct one, namely, that the elastic vapour, as it escaped, would necessarily impinge with greater violence upon the first point, and that violence having partially expended itself,
the vapour would escape more gradually. With regard to the absence of silica in the water itself, that depended upon a great many other circumstances. The heated vapours might escape, without necessarily dissolving the silica. He did not see anything which would enable the water per se to dissolve the silica. It was perfectly well known that pure water was not capable of doing that under any circumstances. Of course, if alkali was present, silica would be dissolved. But, so far as the bell-shaped form of the apertures was concerned, he would submit that it was far more likely that, if the vapour was coming from below, and escaping, as he said before, from a condition of intense compression, they would be more likely to find it hollowing out a greater cavity at the point of escape than near the higher point.

Mr. E. F. Boyd would merely make a remark bearing testimony to the fact of a crevice being sufficient to take down a large body of water through a rock of considerable thickness and forming cavities, and then becoming filled up. The instances he would give were near to Hemsley, and he thought they were in the upper oolite. There they traced some of them as far as 70, 100, and 120 feet. They followed crevices not much wider than a man's body; and these crevices had distinct bottoms to them, which were very nearly level with the bottoms of the rivers at the extremity of the mountain in which they were found. Of course, it would be very easy to account for their depth in that case; but Dr. Page's theory was one very well worthy of attention—namely, that they penetrate so much deeper than any discharge which they could get in the shape of a river current, that some other action must take place upon a lower level, probably in the underlying limestone.

Dr. Page said they might get a score of hypotheses, and it would be worth while to have as many as they could; they might thus arrive at the truth, or at least some approximation thereof; but the moral to be drawn from that paper was obvious enough. They had disturbing phenomena of many kinds occurring in their coal-fields—dykes, faults, fissures, intrusive traps, bedded traps, ash-beds, wash-outs, natural pits, and the like; but these were merely local and accidental occurrences which had to be studied and overcome, and the more minutely they were described and studied, the greater and more certain would be the miner's victory and triumph over them.

Mr. I. L. Bell said that at one of the collieries in which he was interested they were at present sinking through a whin stratum. He believed the pit was probably within 60 or 100 feet of a spur of the main dyke, but of that he was uncertain; however, they were going through the whin. They had now gone through five feet; and it might interest Dr. Page or other members of the Institute to visit it. Of course, if anyone wished to do so, he would be very happy to show anything there was to be seen. But there was one circumstance, not an unexpected one of course, namely, the entire change which had been occasioned in the nature of the overlying rock. He was now having some analyses made both of the whin and of the rock lying immediately above, portions of which, it was curious to find, consisted partly of carbonates. He need not remind those present that earthy carbonates, meeting with a great degree of heat, lost, under ordinary circumstances, their carbonic acid. When they had got through, he intended having the sections preserved and presented to the Institute, with analyses of the strata passed through, and he had no doubt they would be interesting.
The Chairman conveyed to Mr. Simpson the thanks of the meeting for his interesting paper, and to those gentlemen who had taken part in the discussion. Before parting he would ask Mr. Bewick to give them a paper descriptive of what he had seen during his late visit to the coal-fields of Germany; he was sure it would be extremely interesting, and he hoped he would do so.

Mr. Bewick said that during his recent absence abroad, he had gained much valuable information, and if he could possibly spare the time it would give him great pleasure to make a communication such as had been suggested by the Chairman.

The Secretary read the following paper, entitled “On raising coal from great depths by means of atmospheric pressure, on the system of M. Z. Blanchet,” translated from the French:

[Plates XVIII to XXV, illustrating natural pits in Belgium]

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ON RAISING COALS FROM GREAT DEPTHS BY ATMOSPHERIC PRESSURE, ON THE SYSTEM OF MONS. Z. BLANCHET.

(Translated from the French by the Secretary.)

The extraction of coals from great depths of 1,000 yards or more has been for a long time an object of study for all mining engineers.

It was one of the questions proposed by Mons. S. Grüner, in 1855, in his recital of the object for which the Société de l'Industrie Minérale was instituted and of the works it had undertaken.

Many suggestions have been made on this subject, and many systems have been projected and tried. To this end it was proposed to place several machines, one above the other, in the pit—to replace vertical pits by immense inclined planes—and after the trials of the apparatus of Mehu, and the propositions of Guibal, Schütz and others, to utilize the pressure of the atmosphere or that of compressed air, in a similar way to the railway at St. Germain, and the hoist of St. Jacques à Mont Lucon. Of these suggestions, the atmospheric system has not yet been applied to mines. This system carried out by means of a vacuum, as in the tube of St. Germain, and provided with a slit with valves running the whole length of the tube, did not seem to be sufficiently safe to use in a pit. It was thought that a tube of a large diameter would take too much space and be too expensive, and that a small tube, with a number of tubs, one above the other, would be unmanageable from the difficulty there would be of changing the tubs, both at bank and below; and, also, it was thought that the tube should be bored like a cylinder from top to bottom to enable the piston to work with the requisite smoothness, which would render the manufacture too costly.
The atmospheric system carried on by means of compressed air presented the same difficulties in changing the tubs, and it was thought would also require a bored-out cylinder.

All these points were considered without pushing the experiments further. The question did not seem to press for an immediate solution as it was not necessary at the time to work mines of 1,000 yards depth. When the necessity did present itself, the question became one of great importance and became solved in consequence. This was the case at Epinac, where the Hottinguer pit was commenced on the 26th May, 1863, and the seam was reached on the 17th Nov., 1871, by a gallery 120 yards long through the strata above the seam at a level of 674 yards. This pit is now sunk to about 763 yards to cut the seam directly, which it had before gained through a gallery at a depth of 374 yards. The pit is at a distance of 1,093 yards from the highest point of the workings to the rise, the level of which is 490 yards. It has opened out an area of 988 acres and 1,400 million cubic feet of coal, which it reached at depths varying from 530 to 1,090 yards.

The problem was, how to commence working the pit without waiting to sink a second or upcast shaft, and yet secure the requisite ventilation which, of necessity, would have to be considerable to reduce the temperature in the workings, which otherwise would reach from 90 to 120 degrees, to guard against all accident from fire-damp, and to avoid the use of ropes.

This problem has been solved by Mons. Blanchet, director of the collieries and railway at Epinac. This engineer, carrying out the idea of using the pressure of the atmosphere to extract coal from pits of great depth, more especially with regard to the pit at Hottinguer, thought of substituting, for the second or upcast shaft, a wrought iron tube, and making this tube a cylinder in which a piston, with the cages suspended, should traverse by the action of the air without the use of ropes. This tube was put inside the first pit which was large enough to hold it without inconvenience, being about 18 feet diameter. He decided upon extracting air from the tube, because this did not produce heat, and he succeeded by exceedingly simple means in causing the ascent and descent of the nine tubs placed one above the other in the cage and putting them out at bank and below with facility and ease. The whole project was tried on a model made to one-tenth the size required for the pit. This model was sent to the Exhibition at Lyons, and was submitted to the most severe and independent criticism. It was made in the workshops of the Société des Houillers.

The following is a description of the apparatus that is now being made at Creuzot for the Hottinguer pit, the action of which is illustrated in the diagram, Plate XXVI.

A cylindrical tube 63 inches diameter and about \( \frac{5}{16} \) of an inch thick, made of plate iron, rivetted together with butt joints and countersunk
rivets, runs from top to bottom of the pit. It is made in about 20 feet lengths and joined together by means of flanges and bolts. Each length is hammer to a perfectly cylindrical form upon mandrils passed through for that purpose.

It was thought for some time that these tubes would have to be bored out, but the experiments at Epinac have shown that, made as described above, the ordinary lubrication of the tube is sufficient to render it tight at the pressure and temperature required.

This tube is placed in a special compartment of the pit, from the sides of which it is isolated. It is supported every 10 feet by buntings similar to those used for supporting the pumps. These buntings are so arranged that at any time a single tube can be withdrawn without disturbing the others.

To render the whole independent of any movement that might take place in the pit, the buntings are not firmly built in the sides, but are free to slide upon two smaller buntings in the lining. The piston is made in two parts, one at the top and the other at the bottom of the cage. The top piston is made of two platforms at such a distance apart, that, in passing by the doors to admit the tubs, one shall always be in an uncut portion of the tube in order that the pressure shall remain constant when the piston is passing these doors. The lower part of the piston below the cage is made of one platform, and, if necessary, isolates the space occupied by the cage from the atmosphere below. A valve is placed in this platform which can be opened when men are riding to afford them the necessary air for breathing. It also carries a centrifugal parachute A, to prevent the too rapid descent of the cage in case of accident.

The top plate of the piston carries a spring buffer B, which diminishes the shock when the valve C above is struck by the ascending piston. The piston is of simple construction. It can be made of wood protected with iron, packed with India-rubber at the edges, and covered with leather secured by bands of brass, or soft metal composed of a mixture of lead, zinc, tin, and antimony.

The cage D is made in the usual way, and is constructed to hold nine tubs, one above the other, each containing about 20 cubic feet, the whole carrying about 4½ tons of coal.

The total weight of piston, cage, tubs, and coal is 26,450 lbs., or about 12 tons, spread over the surface of the piston which has about 3,117 inches area. This gives a pressure, per square inch, of \[
\frac{26450}{3117} = 8.4 \text{ lbs.}
\]

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When the pumping engine has reduced the air above the piston to 15 - 8.4 = 6.6 lbs per square inch, the piston will commence its ascent with a speed dependent upon the speed of the exhausting cylinders. These exhausting cylinders are 108 inches diameter, or 63.6 square feet area, and nearly 10 feet stroke, the two together exhausting 2,514 cubic feet per stroke, or 430 cubic feet per second, the engine making about 10 strokes per minute. The load will rise in the tube, which has a section of 21.5 square feet, with a speed of \[
\frac{430}{21.5} = 20 \text{ feet per second.}
\]

With machinery of this power it would take about 52 strokes to reduce the pressure above the piston to 6.6 lbs. per square inch, and cause the cage to ascend, which, with a speed of about 200 feet a minute, would occupy about 2½ minutes. The extracting engine would continue to work
during and after the ascent, and considerable advantage would arise from having a reservoir of convenient size from which the apparatus could extract the air during the descent of the piston.

When the piston has to descend, the exhaustion from the tube is stopped, and its connection with the extracting engine is severed by means of doors or valves E, and the air is allowed to press upon the top of the cylinder by means of a regulator F, so that its pressure can be augmented till it reaches the point where it will cease to sustain the weight of the cage without the coal, or till it reaches 26,450 lbs. the weight of the cage and coal, less 10,080 lbs. the weight of coal,

\[
\frac{16370}{3117} \text{ area of piston} = 5.21 \text{bs}
\]

Valves and doors G are so arranged in the tube that the air is taken up from the return air course on the ascent of the piston and delivered outside the mine on its descent through H. Each descent, therefore, discharges a volume of foul air equal to 70,632 cubic feet in a tube 3,270 feet long, which, of course, is replaced by fresh air descending into the mine.

In order to get the tubs in and out, three double doors I I I are cut in the tube, both at top and bottom, and these correspond to three levels of the heapstead. The full tubs go out of the doors at one side, and the empty ones go in at the doors on the other.

The whole of the nine tubs are changed by three movements of the cage. At the top the first movement changes the 1st, 4th, and 7th tubs, the second movement changes the 2nd, 5th, and 8th tubs, and the third movement changes the 3rd, 6th, and 9th tubs. When the cage is at the bottom, the first movement changes the 3rd, 6th, and 9th tubs,

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the second movement changes the 2nd, 5th, and 8th tubs, and the third movement changes the 1st, 4th, and 7th tubs.

In order to keep the cage steady and opposite to the doors for inserting and withdrawing the tubs, three double sets of stops are introduced so that they can be thrust into the tube and withdrawn by means of one lever. These stops are numbered 1, 2, and 3, from top to bottom. When the cage is confined between the stops K 3 of the two sets, the tubs 1, 4, and 7 can be handled. When the cage is confined between the stops K 2 of each set, the tubs 2, 5, and 8 can be handled; and when the cage is confined by the stops K 1 of each set, the remaining tubs 3, 6, and 9 can be handled. The top stops prevent the cage ascending, and the bottom stops prevent it from descending. The cage with its piston is then confined between the two sets of stops during the whole time the tubs are being changed, and is moved up and down with the greatest facility by means of equilibrium pipes and cocks as will be described.

At the bottom of the pit the equilibrium pipe L goes from the bottom of the tube to a point sufficiently high to be above the piston during the whole time the tubs are being changed. When the cock M in this pipe is shut the pressure of air in the bottom keeps the piston up against the top stops, and when the cock is open, and the main inlet and outlet valves N H shut, the air below is
rarefied to the required point to allow the cage to fall on to the bottom stops. Between the top and bottom set of stops there is a play of about one inch.

At the top of the pit the tube has two pipes P and O, each provided with stop cocks F and Q. The first communicates with the atmosphere and allows air to enter above the piston and cause it to descend. The second is in communication with the exhausting engine and is arranged to increase at will the amount of vacuum, above the piston, to enable it to rise with the cages as each successive group of tubs is withdrawn.

By means of special arrangements, either electrical or otherwise, the position of the cage in the tube, during its ascent and descent, is clearly indicated both to the men at bank and below.

When the cage ascends, the doors I I I for changing the tubs are shut, together with the door on the pipe H which communicates between the bottom of the tube and the top of the mine, and when the cage arrives at the top it is made to stop—first, by automatically shutting at U the communication with the exhausting engine at E; secondly, by lifting the valve R and admitting the pressure of a certain quantity of air on the piston; and, thirdly, if the ascent still continues,

by lifting the valve S at the top of the tube and allowing the free entry of the atmospheric pressure.

When the cage descends it forces the air from the bottom of the tube through the escape valve H to the surface. When it comes near to where it has to stop it automatically closes the escape valve at T, and compresses the air in the bottom of the tube. The air can then be admitted from the underside of the piston into the partial vacuum above the piston by means of the equilibrium pipe L and cock M, so as to lower the cage upon the stops at will. The pressure above and below the piston is indicated by pressure gauges.

All the movements of the cage are effected with the greatest ease. An accident could not possibly arise unless all the doors of the apparatus were open, which it is almost impossible could occur. In order, however, to effectually guard against any possibility of danger, a centrifugal parachute A is attached to the bottom of the cage. This parachute is composed of circular hoops of steel nearly the diameter of the tube, furnished with wooden brakes where they approach the side of the tube and are driven round by friction wheels fixed to the piston and running against the tube. The bands are free to move up or down upon their axes, and if their speed exceeds a certain limit the hoops will become oval and the wooden brakes will press against the sides of the tube, and by their friction prevent the too rapid descent of the cage.

RESULTS OF THE EXPERIMENTS AT EPINAC.

The experimental tube submitted to the Universal Exhibition at Lyons, was 6¼ inches diameter, made of sheet iron barely one-tenth of an inch thick, and bolted together, in lengths of 39 inches, by means of flanges and India-rubber washers. It was fixed upon a wooden scaffold about 95 feet high; at the bottom were two exhausting cylinders, 12 inches diameter and 15 inch stroke, worked by a
steam engine indicating 12 horse-power. Under these conditions the experiments proved that a weight of 264 lbs. could be raised at the rate of 20 feet a second, which gives a useful effect of 264 x 20 x 60 / 32,000 = 9.8 horsepower, upon 12 horse-power expended, which is equal to 80 per cent., a much higher result than can be obtained by using ropes.

The depression of the barometer, while the piston was going at this rate, was equal to from 18 to 20 inches of mercury. This corresponds to a weight of 294 lbs., whereas the weight lifted was only 264 lbs.— the difference, 30 lbs. is, therefore, the amount of friction produced in the tube, causing about 10 per cent. loss. This is very small, especially as the friction increases inversely with the size of the tube.

The weight of 264 lbs. is thus divided—

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piston</td>
<td>32 lbs.</td>
</tr>
<tr>
<td>Cage</td>
<td>37 &quot;</td>
</tr>
<tr>
<td>Empty tubs</td>
<td>9 &quot;</td>
</tr>
<tr>
<td>Load</td>
<td>186 &quot;</td>
</tr>
<tr>
<td>Total</td>
<td>264 lbs.</td>
</tr>
</tbody>
</table>

With a tube of 63 inches diameter and a section of about 21½ square feet, or 3,117 square inches, the weight lifted would be divided as follows:—

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piston</td>
<td>5,000 lbs.</td>
</tr>
<tr>
<td>Cage</td>
<td>6,450 &quot;</td>
</tr>
<tr>
<td>Empty tubs</td>
<td>5,000 &quot;</td>
</tr>
<tr>
<td>Coal</td>
<td>10,000 &quot;</td>
</tr>
<tr>
<td>Total</td>
<td>26,450 lbs., or 12 tons.</td>
</tr>
</tbody>
</table>

Each lift would raise 4½ tons of coals from a depth of 3,270 feet, and would take about seven minutes, namely:—

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changing tubs at bottom</td>
<td>0' 30&quot;</td>
</tr>
<tr>
<td>Lift</td>
<td>3' 0&quot;</td>
</tr>
<tr>
<td>Changing tubs at top</td>
<td>0' 30&quot;</td>
</tr>
<tr>
<td>Descent</td>
<td>3' 0&quot;</td>
</tr>
</tbody>
</table>

This would give 8½ lifts, or 38 tons per hour, or 380 tons per day.

The quantity could be doubled by having another tube connected with the first, without increasing the power of the engine, which would work with much less resistance in drawing the air from the
top of the ascending piston and letting it on to the top of the descending piston instead of into the atmosphere. The tubes thus arranged would also make the ventilation more regular.

There is nothing in this system to prevent the water being taken from the mine, either in the usual way, or by substituting water-boxes for tubs as is sometimes done with ropes. These boxes could be filled by means of a pump before being put into the tube, or the tube might be made without a bottom and the box lowered directly into the water.

**COMPARISON OF THE RELATIVE COST AND ADVANTAGES OF THE ATMOSPHERIC SYSTEM.**

With a single pit of great depth, under all systems, there is an absolute necessity of having some duplicate means of getting at all parts of the shaft in case of accident occurring to the usual means of drawing. To effect this, there must either be a second auxiliary winding engine, which should have the same relation to the large winding-engine as the old whims bore to the horse-gin, or the horse-gins to the crab engines. This auxiliary engine should in no case be dispensed with, as an accident might happen at any moment which might render it indispensable.

Besides this auxiliary winding engine, which, in the present case, it has been decided to make of from 90 to 100 horse-power; the atmospheric system requires an exhausting engine of about 600 horse-power, with two cylinders 39½ inches diameter and about 6 feet 9 inches stroke, working two extracting cylinders of 108 inches diameter and 10 feet stroke. With regard to the pits at Hottinguer, the relative expense of three different modes of extracting coal may be considered—

1st.—With a duplicate pit and winding engine.

2nd.—With winding engine and a metal tube, instead of a second shaft.

3rd.—With tube and exhausting machinery.

The expense of each system may be taken as follows:—

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<tr>
<th>System</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
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<tbody>
<tr>
<td>Staying</td>
<td>£1,000</td>
<td>£1,000</td>
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<tr>
<td>Second Pit</td>
<td>20,000</td>
<td></td>
<td></td>
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<tr>
<td>Auxiliary Engine</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
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<tr>
<td>Guides, &amp;c</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
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<tr>
<td>Winding Engine</td>
<td>6,200</td>
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<tr>
<td>Fan</td>
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<tr>
<td>Tube</td>
<td>-</td>
<td>6,000</td>
<td>8,000</td>
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<tr>
<td>Ropes</td>
<td>4,000</td>
<td>4,000</td>
<td></td>
</tr>
<tr>
<td>Exhausting Engines</td>
<td></td>
<td></td>
<td>9,000</td>
</tr>
<tr>
<td>Foundation</td>
<td>£37,200</td>
<td>£23,200</td>
<td>£24,000</td>
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The figures show that the first system, with ropes and a new pit, is by far the most expensive; and the second system, which replaces the second pit by a simple tube, still using ropes, is not very much less costly than the third, which provides for a complete atmospheric apparatus and exhausting machinery. In fact, it requires an addition of only £800.

The system then appears to possess the following advantages, as far as regards the Hottinguer pit:—

1st. — It enables the pit to be worked five years sooner.

2nd. — It increases the ventilation and decreases the temperature of the mine.

3rd. — It admits of sinking to any depth.

4th. — It saves £2,000 a year in ropes.

5th. — It enables more coal to be raised than with ropes.

6th. — It allows the whole inside of the pit, not actually occupied with the tube, to be free for repairs and for alterations, making new landing stages, &c.

7th. — It utilizes more advantageously the power required to raise the coal.

The Chairman said it appeared to him to be a very important paper — to himself especially, because, if all Mr. Bunning had stated was correct, "Othello's occupation was gone." However, he thought there was still plenty of room left for other schemes than this. As far as he recollected, he thought the project was not a new one. He could not at that moment call to mind where he had seen an account of a similar invention which was exhibited some years ago in this country. The proposal bore a very strong resemblance, indeed, to the pneumatic tube, which is now used very largely by the Post Office. For instance, there is a line of railway in a pneumatic tube between the Euston Station and the General Post Office, which is worked every hour of the day, and worked, he believed, most
satisfactorily: it does an enormous traffic without any risk of accident. For coal mines he had not the least doubt but that some plan of the sort could be very advantageously employed; and he believed if carried out by some gentlemen who had money to spare for such an expensive apparatus it would answer in the end. He would be glad to hear any remarks upon the subject.

The Secretary said that he first heard of this mode of raising coal, at Cardiff, in the presence of Mr. Menelaus, from M. Rubin, a French gentleman,

who was connected with the Creuzot Ironworks in France, who told him that he was then employed in making these large 63-inch tubes for the purpose of being put down at the pit described in the paper, and that although the apparatus had not been at work yet, it was actually in the course of being made, and a large sum of money was being expended in producing it. Therefore, it was not a mere idea that had been begun and would end in an idea; but it was an idea that would eventually most certainly be carried out. Whether or not it would be successful, of course was another matter.

The Chairman added that, some years ago, he was one of about a dozen who subscribed £500 each to make an experiment on a large scale for sending railway carriages through a tunnel by atmospheric pressure. The plan was carried out at the Crystal Palace successfully. The tunnel was built of brick, and was formed to fit as correctly as possible a diaphragm or piston fixed to the outside of one of the railway carriages. Round the diaphragm was fitted a sort of brush, which was supposed to prevent the air from rushing through rapidly, and formed a sort of packing. With this arrangement considerable speed was attained. Ultimately the apparatus was taken down after the experiment was finished.

Mr. I. L. Bell remarked that if any gentleman had any doubt as to the power of air under the circumstances to raise a load, he had only to go down to Middlesbrough, and he would find (to his certain knowledge) 500 or 600 tons a day drawn to the top of the blast-furnaces by a tube into which is fitted a piston, from under which piston the air is drawn. The apparatus itself was on the surface of the ground; but of course on principle it was exactly the same as if it were in the pit. The piston, in lifting the load, travels down the tube, and is connected with the load by ropes passing over pulleys; and in this way the whole of the charges of the blast-furnaces were drawn to the top. It was true, the height was only 80 feet; but, of course, what could be done for 80 feet could be done for 800.

Mr. H. Lawrence said, in the instance which Mr. Bell pointed out, there were counter-balancing cages, and the load had simply to be lifted.

Mr. I. L. Bell: Still, this was merely a question of size.

Mr. H. Lawrence said, in the case described by the Secretary there was no counter-balance whatever. He certainly did not dispute that the thing was possible; he had no doubt it might work, but he fancied pitmen would have to be made to suit the process. He did not think that
any ordinary pitmen would trust themselves in the cage. Again, the wear and tear of the piston would be very expensive; the slightest wear in the tubes would be objectionable, for they would have to be exceedingly true; the necessary repairs to keep them in good condition would require a great amount of money to be spent, and in a very short time they would wear to such an extent that the keeping up of the tube and making the pistons tight would become impossible. He felt very much interest in the invention, which was very ingenious, and he was very much obliged to Mr. Bunning, for his part, in bringing it before the Institute, but he certainly thought there were a great many obstacles yet to be overcome before they could make sure of getting coals out of very deep pits by the process.

Professor Herschel said there was one objection which Mr. Lawrence had pointed out, to which he would like to draw attention—namely, the absence of a counterpoise. Now, Mr. Bunning had pointed out that something very equivalent to a counterpoise was intended to be used with the proposed system; in fact, that the empty cages are balanced and prevented from descending too rapidly by an amount of vacuum kept above them. The vacuum for this purpose is not so great as would be required to raise them up when full, so that the weight of the empty cages in descending is allowed to produce a certain partial vacuum above them. This partial vacuum has merely to be increased in order to raise the cage afterwards with the full tubs instead of with the empty ones, so that it is only the difference between the weight of the full tubs and the empty cage which has to be raised to the surface by the engines that produce the vacuum. The full pressure of the atmosphere is not admitted to let the cage and tubs down, but just sufficient to let them go down at the required speed with the empty tubs; and the small quantity which is let in has afterwards to be withdrawn when the full tubs are set on. He thought the system was especially adapted to meet the contingencies of very deep mines. In mines of ordinary depth, he did not anticipate the probability of its superseding the very convenient means of raising coal which they had at present. He thought the Chairman's apprehensive prospect in this respect might be considered as very distant. The objection arising from the constant wear and tear of friction inside the pipe was a serious consideration; but oil and grease do a great deal, and if they looked at the wire rope used as guides in a very deep pit, like that at Monkwearmouth, which he had visited that week, they would find that although these wire-rope guides are used in the upcast shaft, where the dirt from the furnace must certainly be of a very destructive kind, and increase the friction very much, it did not appear that the wear was very great.

Mr. A. L. Steavenson thought they would have to postpone the discussion until they had the paper before them, as without it, it was difficult to follow all the figures which Mr. Bunning had given.

The Secretary said, one question arose respecting these deep pits; that was, the rope might ultimately arrive at such a length as would preclude its supporting its own weight. Then, he apprehended they would use taper ropes; but taper ropes might, after all, be unmanageable, on
account of the difficulty of turning them round the pulley; so that when the time arrived anticipated by Sir Wm. Armstrong, when coal would have to be got from extreme depths, there would still, perhaps, be found employment for such an apparatus as that he had described.

A vote of thanks was given to Mr. Bunning for his paper, and the meeting then separated.

[Plate XVI. Diagram of general arrangement of tube in pit]

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PROCEEDINGS.

GENERAL MEETING, SATURDAY, FEBRUARY 14th, 1874, IN THE WOOD MEMORIAL HALL.

I. LOWTHIAN BELL, Esq., M.P., Vice-President, in the Chair.

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

The following gentlemen were elected:—

Members—

Mr. Henry Henderson, Pelton Colliery, Chester-le-Street.

Mr. David Tyzack, Warkworth, Acklington, Northumberland.

Mr. William Jackson, Cannock Chase Collieries, Walsall.

Mr. M. S. Hall, M.E., Woodlesford, near Leeds.

Mr. Thomas Blandford, Corbridge, Northumberland.

Mr. Walter Gardner, M.E., The Stone House, Rugeley.

Mr. Joseph Mitchell, Jun., Coal Owner, Worsbro’ Dale, near Barnsley.

Students—

Mr. W. S. Harris, Marley Hill Colliery, Gateshead.

Mr. John Bruce, Marley Hill Colliery, Gateshead.

Mr. R. W. Berkley, Marley Hill Colliery, Gateshead.

Mr. William Johnson, Strangeways Hall, &c, Collieries, Wigan.
Mr. F. R. Atkinson, Haswell Colliery, Fence Houses.

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

Members—

Mr. J. Hugh Penman, 2, Clarence Buildings, Booth Street, Manchester.
Mr. J. J. Lackland, C.E., Port Mulgrave, Saltburn.
Mr. John Johnson, Ruabon Coal Company, Ruabon.
Mr. Edward Brown, C.E., 27, Cromwell Street, Newcastle.

Students—

Mr. William Kelsey, Engine Works, Sunderland.
Mr. Joseph Dodds, Ironmaster and Coal Owner, Stockton.
Mr. George Forster, M.E., Osmondthorpe Colliery, near Leeds.
Mr. John Smith, Ross Bridge and Douglas Bank Collieries, Wigan.

Mr. G. A. Lebour then read the following paper, entitled "Notes on Further Researches on the Natural Pits of Hainaut, with remarks on their probable origin":—

NOTES ON FURTHER RESEARCHES ON THE NATURAL PITS OF HAINAUT, WITH REMARKS ON THEIR PROBABLE ORIGIN.


When Mr. J. B. Simpson’s valuable translation of Messrs. Cornet and Briart’s paper on the "natural pits" observed by them in the Province of Hainaut was read before the Institute, on the 6th of
December of last year, certain surmises were made as to the origin of these so-called pits by several members of the Institute, more particularly by Dr. Page, Mr. Bewick, and Mr. I. Lowthian Bell. The explanations suggested were avowedly of a speculative nature, and were necessarily so from the fact that many of the data, essential to coming to any decided opinion on the subject, were wanting. Several of these gaps in the evidence were pointed out by Dr. Page; they were as follows:—

I.—It had not been ascertained by the authors whether the "natural pits" continued upwards beyond the Coal-measure beds, in which alone they had been detected, and pierced the overlying Cretaceous and Tertiary strata, and even the nature of these deposits was, in some of the cases at least, unknown. This was a point of much importance with regard to the age of the "natural pits."

II.—It was not stated in the paper whether the calcareous beds of the Mountain Limestone occurred beneath the "Coal-measures" at the points at which the "natural pits" were situated. This, and a knowledge of the depth of the limestone, if present, below the pits, was again a point of importance as to the possibility of the "swallow-hole" theory being the right one.

III.—It was desirable to know whether observations, made since the paper was published in 1870, had shown any tendency in the "natural pits" to narrow downwards, or even to stop altogether.

IV.—Lastly, it was remarkable, as indicative of the difficulty of the subject, that the authors themselves attempted to give no explanation whatever of the phenomena which they so minutely described.

Deeming it a pity that the discussion of the paper should be resumed on a future occasion under the same disadvantage of imperfect evidence from which to argue in favour of this or that theory, the writer communicated with M. Cornet, one of the authors of the paper in question, putting the foregoing points to him, and received in answer a very full and courteous reply, an account of which is now presented.

The answers are arranged in the same order as the questions, to prevent undue repetition.*

I.— "At Bascoup the Coal-measures are covered by Tertiary sands and clays, the Cretaceous rocks being absent. At this place it is not known whether or not the natural pit penetrates the superior deposits."

"At Sars-Longchamps," on the other hand, where "the overlying formation belongs also to the Tertiary period, household wells sunk in the neighbourhood seem to demonstrate that the 'natural pit' does not penetrate into the Tertiary beds."

"As to the two 'pits' of the Grand-Hornu, I think that they are prolonged into the Cretaceous formation, for there have been found in them, at depths of 1309.359 feet, 1486.248 feet, and 1666.695 feet, blocks of Cretaceous rocks (indurated green marl, flint and white chalk), mixed with debris of Coal-measure rocks. It is evident that if the 'natural pits' of Hornu had been anterior to the Cretaceous formation, and if they had been able to remain open, without falling in, until the time
when the first beds of that formation were deposited, they would have been totally filled up by the green marl, which we call Diève, and which forms the base of the Cretaceous formation at Hornu. There would then not have been found blocks of flint or of white chalk."

To make this point clearer, M. Cornet then refers to a diagram, Plate XXVII., Fig. 1, lettered from A to G, from below upwards, and showing the composition and arrangement of the Cretaceous strata at Hornu.

A. is the Coal-measure series upon which lie the secondary rocks unconformably.
B is a sandy green marl (known locally as Tourtia), from 3 to 6 feet in thickness.

* The sentences actually translated from M. Cornet’s letter are within inverted commas.

[Plate XXVII illustrating the natural pits of Hainaut]

C is an argillaceous green marl (known locally as Diève), 19 to 33 feet thick.
D is a blue marl with chert (called locally Fortes-toises), 13 to 23 feet thick.
M. Cornet remarks:—"The beds C and D are quite watertight, and prevent the waters in the upper strata from descending into the Coal-measures."
E is a coarse chalk, with large nodules of flint (known locally as Rabots), 13 to 19 feet thick.
F, "craie glauconifère," is the equivalent of the British lower chalk marl, and is 3 to 10 feet thick.
G, white chalk (no thickness given).

"In the 'natural pits' of Hornu," continues M. Cornet, "have been found indurated blocks of the marl C, siliceous concretions (chert) from the bed D, flints from E, and blocks of white chalk from G, the whole being confusedly mixed up with very much decomposed rocks of the Coal-measures, and forming a very compact argillaceous conglomerate, through which water could not find a passage."

"At Quarégnon, about two miles and a half from Hornu, a large 'natural pit' has been met with, more than 196 feet in diameter." Messrs. Cornet and Briart did not describe it in their original paper, as they had not sufficient details respecting it. M. Cornet, however, says:—"We know, nevertheless, that this 'pit' contains also blocks of white chalk and nodules of flint; but the mixture of these, and of the Coal-measure rocks, does not, as at Hornu, form a compact conglomerate impervious to water. This is why the pit of Quarégnon gives passage to much water, whenever it is tapped by a level, in working the coal."

This completes the answer to the first question raised.

II.—The answer to the second question is short and to the point.
"The Carboniferous limestone," says M. Cornet, "is to be found everywhere at the base of the Coal-measures of Hainaut. At Bas-coup and Sars-Longchamps it lies about 1300 feet below the lowest known point in the 'natural pits.' At the Grand-Hornu it is more than from 4300 to 5900 feet below that point."

III.—The answer to the next query is shorter still:—

"The bottom of none of the 'natural pits' has yet been reached, and no narrowing of the diameter downwards has been observed. On the contrary, one of the two 'pits' of Hornu widens out very considerably downwards."

IV.—In reply to the last, and perhaps the most important question, M. Cornet writes:—

"After having long considered the subject we

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admit the theory of M. d'Omalius d'Halloy, who considers the 'natural pits' as being canals which have given passage to matter coming from the interior of the earth, and which has contributed to form the stratified formations."

What this theory of M. d'Omalius d'Halloy is, will be perhaps more clearly perceived from the following quotation translated from his report upon Messrs. Cornet and Briart's paper*:—"If," says M. d'Omalius, "[as is generally admitted] rocks have come from the interior of the earth in a pasty or viscous state, why should not pulverulent or gaseous matter have come out of it also, capable of being mixed or dissolved in the waters, and of forming precipitates in them? This opinion seems to me the more admissible, since we see gases and ashes as well as lavas poured out of our volcanoes. On the other hand it is pretty generally admitted that the materials of veins are derived from internal emanations. Now if those emanations, when they were enclosed in cavities, were able to produce the lime, the quartz, and the other minerals of veins, why should not those which may have spread into the waters have given birth to a portion of the beds which form the terrestrial crust? In adopting this view, the diversity of the layers and the purity of some of them are easily explained."

"One of the principal objections brought to bear against this theory is, that the canals which might have given vent to those materials are not seen. I answered to that objection that the 'natural wells or pits' found in the Tertiary and Secondary formations†, may be looked upon as being some of these canals; but it was retorted that these pits were only pockets filled up from above. I am far from disputing the existence of the pockets; but, besides the fact that there are pits of which the bottom has not been reached‡, I have had occasion to show that the terminations of pits, which it was thought had been determined in cuttings, were only apparent bottoms, and were due to the fact that the pits took directions different from those of the walls of the cuttings."

"It was also said that no pits were to be found in the Primary formations, to which I made answer that the pits must be very rare in
If M. d'Omalius d'Halloy refers here to "Swallow" or "Pot-holes" in the newer beds, I must say his argument is, to say the least of it, very much strained at this point.

Such as the famous "Neckers" in Kent, for instance, of which wonderful stories as to the depth are told. I have never met with a fathomless pit.

Members of the Institute will not fail, if they were present when Mr. I. Lowthian Bell gave his views on the subject, to perceive the similarity between them and those of the eminent geologist quoted, M. d'Omalius d'Halloy.

It is not to be supposed that any one will now uphold the swallow-hole theory of the origin of the natural pits, a "creep" felt through more than 6000 feet being a more than unlikely occurrence. The internal emanation theory seems to gain credibility from the additional facts submitted, but why should the emanations have been chiefly of a gaseous nature? What gas, having found a vent of any kind, would or could, of itself, scour and erode the sides of such vent to such an extent as to convert it into a canal of 100 feet or more in diameter?

It was suggested by our Secretary, Mr. Bunning, that plugs of trap might once have filled these pits, but to this it may be objected that if so, the sides of the pits or canals would show signs either of dipping towards or away from their centres, or would appear baked or altered in their structure from having come in contact with the molten rock. These objections, the writer would submit, are not fatal ones, and he hopes to show briefly in the following attempt to trace out a history of these "natural pits" which, he ventures to think, will account for and agree with all the facts of the case, no agencies being called into play other than such as are sufficiently proved to have worked, and indeed to be at the present time bringing about geological phenomena.

It becomes necessary, first, to consider the relative age of the "natural pits," and M. Cornet's new researches furnish us with materials sufficient to arrive at a tolerably safe conclusion on this point.

Nowhere do the "pits" penetrate the Tertiary deposits overlying them, and there is no evidence of even fragments of Tertiary rocks being
found in them. This would tend to show not only that the "pits" existed before the advent of the Tertiary epoch, but also that they had been filled up, and, with less cohesion perhaps, were before that time in the same state as that in which they are now found. The fact that they contain, at considerable depths, even debris of each one of the Cretaceous beds underlying the tertiaries, proves that they were open after the deposition of these beds, and that the debris are in most cases indurated, further showing that the filling of the pits did not take place until after the consolidation of the white chalk. Moreover, M. Cornet's remark that had the pits been open at the time of the deposition of the Lower Cretaceous marls they would have been filled up by them, is obviously correct, supposing, that is, that nothing was being ejected from the pit. The supposition, that the clearing out or opening (not necessarily for the first time) of the pits, and that their subsequent filling up, took place in post-Cretaceous times, but before the deposition of the lowest of the overlying Tertiary deposits, cannot be far wrong. Assuming this to be the case, it will be well to bear in mind that the unconformity existing between the Coal-measures and the base of the Cretaceous series represents an enormous amount of denudation, and a corresponding enormous space of time: the time, namely, which was necessary for the deposition and removal of the entire thickness of Permian, Triassic, and Jurassic rocks. It will thus be seen that the "pits" are comparatively recent.

It being well known that the Carboniferous rocks are so frequently traversed by contemporaneous sheets of interbedded trap, as well as by intrusive dykes of later age, there is every reason to suppose that the Carboniferous rocks of Hainaut are no exception to the rule, but that as the region is not a dislocated one, the trap did not occur in the shape of dykes (which invariably run in fissures and often in faults), but forced its way up through isolated canals until it overflowed the surface of the then existing land or sea bottom. This may have taken place at any period from the deposition of the upper part of the Coal-measures (now denuded off) to the dawn of the Cretaceous era. Plate XXVII., Fig. 2, illustrates the state of things at that period; the canals C C—which, it is presumed, were of much smaller diameter then than the "natural pits" are now—being filled with trap. The next stage is reached when denudation had removed the upper sheet of trap, probably in much later times, and the canals remained as simple cores or plugs of trap. It is fair to assume that at the point of contact along the walls of these cores the sedimentary beds would be baked, altered, tilted up or down and much dislocated, by the intrusion of the trap; but there is no reason to believe, judging from the instances within our knowledge, that the effect of the trap would extend more than a very trifling distance from the point of contact. This second stage is shown in Fig. 3. It will be seen that now the core of trap would be surrounded by a kind of ring of dislocation and disturbance.

It now remains only to find an agent capable of abstracting the trap cores; and this, it is submitted, was in all probability one of which there is always a plentiful supply for all geological operations—namely, water. Water from below acting upwards in the form of springs, to which passage was given by the circular lines of dislocation surrounding the trap plugs. This water might either come from the vast stores of the much-fissured Carboniferous Limestone, in which case it would be highly charged
with carbonic acid, or it might come warm and charged with other gases, and as a more powerful solvent, from greater depths. In either case, with the enormous amount of time at disposal, the decomposition of the enclosed trap, which even pure water might in course of time effect,* would not only be likely, but almost a necessity. This once accomplished, the dislocation ring would by degrees be removed or fall in, the slight denuding action of enclosed water accounting for the fact of the comparatively small width of the chasm. In this manner the cleanness of the walls of the "natural pits" is accounted for; and it must not be objected to this, that no water-formed incrustations, &c, are found covering these sides, since, to quote Bischof, "The impossibility of the deposition of solid matter by the water of ascending springs may be readily conceived. The conditions under which deposits take place—evaporation of water, escape of carbonic acid, cooling of hot water, higher oxidation of iron and manganese—cannot be imagined to take place in the channels of ascending springs. This deposition does not take place until the water has reached the surface."†

This third stage is shown in Fig. 4, and it may be considered to last an exceedingly long time, during which the Cretaceous beds were deposited, the filling up of the pit or well by these beds during their deposition being prevented by the existence of the spring, although doubtless all the time the sides were falling in incessantly. Until some


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time before the deposition of the Tertiary beds, the springs were either choked up or found some other channel, and the falling in of the now hardened Cretaceous rocks of their upper walls crumbled in with the rest of the rubbish now filling up the "natural pits." Where the included debris are more closely cemented than in other cases, the uniting matter must be sought in water deposits from above. The last stage is shown in Fig. 5, where the "natural pit" is seen filled up, of its full width, and ready to receive the covering of intact Tertiary sands and clays which it now possesses.

In conclusion, it should be stated that the figures in the plate are merely diagrammatic, and are not in any way representations to scale of any particular "natural pits."

Mr. Lebour said that since the last paper was read there had been a communication made respecting the South African Diamond fields to the Geological Society of London, and it appeared that in these fields there were a great many trap-necks very similar in size to those which formed the subject of Mr. Simpson's paper. Some were still full of trap, in others the trap had been emptied out, but these were filled up again with fragments of mica schist and metamorphic rock, which formed the upper strata in these regions; and it is in these pits, so filled up with the debris of the mica schist, that the diamonds are chiefly found.
Mr. J. B. Simpson said, that since the interesting discussion on this subject at the last meeting, he had received a communication from M. Briart, giving additional particulars, and it would perhaps be better that this should be read before proceeding with the discussion on Mr. Lebour’s paper. The communication is as follows:—

"I ascertained after the publication of our notice that several new natural pits had been discovered in our province, but I was completely ignorant of the circumstances which characterised them. I have now, however, procured the following information respecting them:—

"I.—A natural pit of great dimensions has been explored at the collieries of Bien du Coeur, at Quarégnon.

"II.—Another natural pit has been discovered at the collieries of Produits, near Jemmaffes, at the depth of 655 yards. Its section is an irregular circle of 65 to 87 yards in diameter. It is filled with debris from the coal-measures, mixed with that from the superior cretaceous rocks.

"III.—I have recently discovered at the collieries of Mariemont a natural pit of lesser dimensions, but from 20 to 30 yards in diameter. It is not yet entirely surrounded by the workings, but it offers this remarkable peculiarity—it is composed of pieces of lignite, of sands, and clays, mixed with debris of coal-measures, analogous to the lignites, sands, and clays, which compose the Aachenean system, or the inferior stratum of the cretaceous rock in our province. This pit has been found at about 436 yards in depth. It is to be observed that the coal-measures come to the surface in this part of the coal-field, and that the village of Baure, two and a half miles distant, is the nearest place where the Aachenean system is met with.

"IV.—A natural pit was met with some time ago at the colliery of Haine St. Pierre, near Mariemont. It is of somewhat irregular shape, from 31 to 42 yards in diameter, and possesses this curious and remarkable peculiarity, that it has not been met with in a higher seam to that in which it has been circumscribed. At all events, the plan of the workings of this upper seam, which was worked some time ago, has no trace of such an occurrence. This is so strange, that I must bring it to your notice under great reserve. It might be explained by the negligence with which pit plans were formerly kept; nevertheless, I must own this explanation is unsatisfactory, and it is probable that this natural pit did not extend to the seam above. Such are the new facts which have come to my knowledge. It is rather remarkable that none of these phenomena should have been noticed beyond the Province of Hainaut. The reason probably lies in the want of observation on the part of the Mining Engineers. As regards the natural pits described in our notice, there is nothing new to say about them; only the two pits of Hornu have been met with at a lower level, where they exhibit no new features, but continue to be filled as above, with debris of the coal formation mixed with that of the cretaceous rocks.

"As regards the theory of these curious phenomena, I am not astonished to hear that much discussion has taken place amongst the members of your Institute, in the endeavour to arrive at some probable explanation of their formation. The natural pit of Haine St. Pierre, which I have just
mentioned, tends to point to the interior of the earth as the cause of these geological phenomena, and to the supposition that these subterranean excavations have been filled up by the successive sinking of the overlying formation. The fact that the

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dimensions of these pits increase with their depth is in favour of such a theory, as also that the seams of coal they pass through are occasionally depressed for a short distance around them.

"We intend to publish a supplementary notice on the subject, and will be happy to send you a copy."

Mr. Simpson, alluding to M. Briart's remarks as to the existence of a natural pit which passed several coal seams but which did not pass some of the higher seams which had been worked over it, stated that if this can be proved to be the case, then it is quite clear that the theory advanced by Mr. Bell at the last meeting, as to the excavation having been originally formed by gases from below, is the correct one; but, at any rate, it seems to carry with it the most reasonable method of accounting for these phenomena. With respect to M. Briart's remarks, he has omitted to mention one very important matter—viz., the depth of this natural pit, and the nature of the material it contains. It would appear self-evident that the matter could not be the debris of the cretaceous rocks, and one would incline to think that the excavations should have contained nothing at all, or, if anything, something of igneous origin.

Dr. Page said, that in dealing with geological phenomena, the first great point was to obtain correct observation and description; and he thought the descriptions of the matter under review were not yet sufficiently full to enable them to arrive at a satisfactory conclusion. Mr. Lebour's hypothesis was a very ingenious one, but many difficulties lay in the way of its acceptance. There were no examples in other fields of so many trap-necks occurring without some of them being left in a more or less disintegrated state; there were no instances of so many eruptions as must have taken place in the Belgian coal-field, without causing dislocations and disturbances among the strata. There were also grave difficulties connected with the dissolution of so many masses of trap. Discharges of carbonic acid from below were out of the question, and if some energetic gases had been the agents, they must have left traces of their operation on the surrounding rocks. Again, if the statement sent to Mr. Simpson was correct, some of these necks did not pass entirely through the coal strata, and how could Mr. Lebour reconcile the action of an eruptive mass with this stopping short in its upward course? One thing was clear, something had been removed from these natural pits, and the coal-strata had fallen in downward to fill up the space. If trap, some of it might yet be found in the deeper portions; if limestone or

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other rock had been removed from below, the same appearances would have presented themselves. Altogether, he did not think that any hypothesis advanced in the absence of more information could be a satisfactory one.

Mr. Lebour thought that the additional information obtained by Mr. Simpson, so far corroborated his (Mr. Lebour’s) views respecting the formation of these natural pits. With regard to the upward stoppage of some of them at a seam in the coal-measures, it must be borne in mind that no doubt at one time the seam represented a land surface, and the trap might have been dissolved out of it by water charged with gases before the deposition of the superincumbent beds and seams. Of course, he did not advance this theory as a certainty, but merely as an hypothesis which might be held until something better could be suggested.

The Chairman remarked that what had been said respecting the solvent power of water, suggested the reflection that after all its appreciation depended very much upon the power of the human faculties. For instance, if the solvent power of water over silica or any other substance which was considered entirely insoluble in water had to be determined, the silica would have to be weighed before its treatment with the water and the loss of weight after the treatment would be the amount dissolved; or, failing to get any appreciable result by this process, the water would be tested to ascertain if it held any silica in solution, and this would show the great difficulties that had to be overcome before any satisfactory solution of the problem was aimed at, owing to the imperfection of human nature to appreciate, and of the instruments employed to detect the more minute operations of nature. It was well known, the assistance the spectroscope had given to chemists and physicists, by proving beyond doubt that there may be quantities of matter present in substances which had before entirely defied human comprehension to discover. Under these circumstances, he would scarcely undertake to say that there was any substance which a priori could be stated to be absolutely insoluble in water. It might be soluble to the extent of one billionth part of its weight in a billion of years, but this was a quantity which, of course, could not be appreciated. Then with regard to gases, carbonic acid would have an immediate effect upon lime, but as far as he knew it would be utterly powerless over basalt or any other form of silicate. But there was nothing to prevent the presence of fluorine in the water, for they found fluoride of calcium was by no means a rare mineral. Who could tell that the decomposition of fluoride of calcium at a very high temperature might not have taken place? There was

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good reason for believing that every substance they knew of—even water—if subjected to a sufficiently high temperature, became dissociated. Now, fluoride of calcium might follow the same law, and a sufficient quantity of fluorine might be set free, which would at once act on the silica, and account for the removal of the trap-rock. Again, the mere erosive power and mechanical action of water in enormous quantities at extreme pressures and over illimitable space of time would most probably be very considerable. He thought, however, Dr. Page was quite right in requiring more facts before accepting any explanation.

Mr. Bewick would ask whether the water which according to theory had dissolved the trap would not also have had considerable effect upon the adjoining rock?
Mr. Lebour said in reply, that if water was the agent that had destroyed the trap, it would doubtless also have acted upon the surrounding strata, for it was not at all probable that the holes as they are found now, represented the original size of the trap column, in reality they were much enlarged, and this would account for the strata not being bent upwards or downwards as they neared the pit.

Dr. Page remarked, with regard to the trap-rock theory, it must have been a very quiet accommodating sort of trap to have come up without a distorting dislocation of the strata. In the case of dykes, there were pre-existing fissures; but here, there were eruptive necks of trap which had made a passage for themselves without that disturbance of the strata which is caused when similar eruptions take place in districts with which we are more intimately acquainted.

Mr. Lebour replied that even near at home there were many cases of trap-dykes piercing beds of coal without distorting them. These beds were charred within a foot or two of the dyke, but often they had scarcely been changed at all. One dyke especially, was touched by the coal which abutted straight against it, and here the coal was only charred to a distance of about two inches, beyond which neither the sandstone above nor the coal was at all altered as far as the eye could detect.

Dr. Page added that this was simply because there were pre-existing fissures which were filled up from the trap from below. But in the case of the pits at Hainaut there were no traces of such fissures, and the circular perforations must have been made anterior to the eruption of trap, or they must have been made by the eruption of the trap itself.

Mr. Frederick Hurd then read a paper "On Hurd and Simpson's Patent Air-compressing and Coal-cutting Machinery":—

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HURD AND SIMPSON'S COAL-GETTING AND AIR-COMPRESSING MACHINERY.


By FREDERICK HURD.

The author proposes to give a description of a number of arrangements for getting coal and compressing air, that have been successfully at work for some years at different collieries, which it is considered will be of interest to the members of the Institute.

The general scope of the several arrangements will be better understood by reference to the plates.

Plate XXVIII. is engraved from a photograph, and gives an outside view of one of the coal-cutting machines adapted for undercutting the coal by means of an eccentric wheel with cutters at its edge, driven by two specially constructed air engines, of 6-inch cylinder and 12-inch stroke, the whole being carried upon a suitable bogie on wheels made to run upon a tramway line along the face of the coal.
Plate XXIX. shows a modification of the machine for cutting in any direction. It will be seen that the arm B, carrying the cutter, is made to turn upon the axle A attached to the frame work of the machine, this centre can be raised up or down and the power communicated to the cutters by means of the bevel wheels, as will be readily understood by reference to the plate. This machine, which can cut in both the roof and thill, and can also nick at the ends, is peculiarly adapted for narrow work.

It is thought that no very detailed description of the machine is necessary, as its construction is so simple that the use of the different parts can be understood at a glance. It may, however, be as well to remark that the wheel D, Plate XXVIII., is provided with cutters which are placed eccentrically; the wheel goes round in the direction of 

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the arrow. The cutters can start from the face and work themselves into the nick, and are so arranged that each group of three cuts the top, centre, and bottom of the groove or nick, as at a b c. The cutter wheel is driven by a bevel wheel, the teeth of which, in fact, are cast with it, but are placed underneath to protect them from dirt and are not visible in the plate. There are other means provided for driving the cutter wheel, but it is not necessary to describe them here. The cutter wheel is carried by a thin but strong steel arm B, the hidden end of which is provided with a wheel through which, by means of gear, motion is communicated to it by hand, and it is made to enter the coal or to withdraw from the groove, or take a direction in front of, or at either side of the machine. The cutters being eccentric to the wheel they act with greater effect during one half of the revolution than they do at the other half revolution, and while the smaller radius of the eccentric is towards the coal, the machine is drawn forward in the direction of the arrow by a self-acting hauling rope or chain which is wound round a drum and actuated by the machine. The leading end of the machine is kept in position on the rails when at work, by a roller B fixed to a differential lever A, with self-acting adjustment to adapt itself to the inequalities on the face of the coal, and this arrangement prevents the machine from getting off the rails when under-cutting. These machines are sufficiently portable and compact to run on the ordinary rails into any part of the pit, and can be taken up or down the shaft in the ordinary cages used for winding the coal.

Plate XXX., Fig. 1, shows the method adopted for heating and expanding the air supplied to the machine. The air coming from the compressor is made to pass through a retort E containing a perforated crucible C, made of saponite or other suitable material, charged with ignited fuel (charcoal and scrap iron); a check valve B is provided to prevent the return of the heated air, which passes through D to the machine.

Plate XXX., Fig. 2, shows an apparatus for upheaving the bottom coal after the top portion has been under-cut and removed, and consists of a cast steel or metal wedge shovel X, which is forced forward by the screw Y, and the screw is worked round by the lever Z and catch Z\(^1\) acting in the toothed wheel Y\(^1\); the catch Z\(^2\) can be reversed, so that the wedge shovel can be withdrawn as well as pushed forward. The end of the screw Y works in a socket which abuts against one of the props B, and the adjustable stay C serves to increase the resistance to the pushing of the screw.
Plate XXXI., Fig. 1, shows an elevation, Fig. 2 an end view, and Plate XXXII. a plan of the portable air-compressor, which is so arranged as to compress the air at the bottom of the pit by means of horse or hand labour, or by means of steam, as may be found most convenient; a special form of engine having been constructed for this purpose.

The arrangement described in the plates is adapted for horses, which are harnessed to the levers O O in the usual way. These levers give motion to a vertical shaft O₁, which drives the crank shaft S by means of the wheel and pinion B and S₁. This crank shaft gives motion to two pistons K₁ and J₁ working in cylinders K and J. The pistons work in water, which acts as a lubricant, and insures the full amount of air admitted being forced into the receiver or air chamber; the compressed air is forced through the valves M M and pipe M₁ into a suitable air chamber A₂, which is placed in the frame A. To the upper end of the crank shaft S is fixed a mitre pinion, which works the shaft N provided with tappets W for opening the admission valves L L as soon as the pistons begin to move in the direction for admitting air to the cylinders. To fix the machine securely in the seam, a prop or rod O₂, provided with a head T, passes through the centre of the axis O, and at the bottom it is provided with a screw O₄ and a foot O₅; by moving the nut O₃ the screw fixes the foot against the thill of the mine and the head R against the roof, thereby securely steadying the machine.

Plate XXXII. shows an arrangement for working air-compressing machinery at bank, that has been in successful operation for some years.

In ordinary air-compressing machinery, where the compressing cylinder is worked direct from the steam cylinder, it is practically impossible to work expansively, for the chief strain in the compressor is at the end of the stroke. The present arrangement obviates this, and allows the employment of expansion to any extent in the steam cylinder, by placing the compressor in such a position that the steam is exerting its full pressure when the resistance in the compressing cylinder is at its greatest. The position of the parts in the plate shows that the air has just been delivered, and that the engine at the moment of this delivery is at its point of greatest power. The engine is also aided, at the moment of greatest strain in the compressor, by a very heavy lever A, the centre of gravity of which is falling at that portion of the stroke, but which is lifted by the engine when it has comparatively little else to do, during the early stages of the compression. The intake pipes for the air are conducted outside the building and terminate in a bell-shaped rotating cowl, the opening of which always faces the wind. By this means advantage is taken of the force of the wind outside to increase the initial pressure of the air.

Recent practice in the use of these machines has proved that above 150 yards can be under-cut in 10 hours, an amount of work which is at least 30 times as great as an experienced workman can do in the same time; but this is a minor advantage compared with, the great safety it affords the miners. By these machines the coal is under-cut at night, and in most cases falls without a shot or a wedge.
being required, so that the miner begins to fill and send out his wagons at once without the necessity of holing the coal himself, which, when the weight is on the face, is a dangerous operation, and necessitates great vigilance on the part of the workmen. As a rule the miners know to a few seconds, by the sound, when the coal will part, but yet they are sometimes caught.

Again, in nearly all cases the speed of the machine is so great that the coal can be under-cut and got before the weight of the roof gets on to it. Thus, seams formerly known for their bad roofs are comparatively safe.

In many cases the miner (in order to prevent him from making more slack than is absolutely necessary) is only paid for the round coal he sends out, and in some cases he is paid for the slack at lower rates; when this is the case a great portion of his time is occupied in riddling his coal before filling, which gives more time for the weight of the roof to come on the face for the next under-cutting.

Taking the average of coal seams, the usual mode of working involves a reduction of one-third of the quantity gained, into slack, which, of course, is a very serious loss; whereas by the machine the average loss in a three feet seam does not amount to more than the one-eighteenth part of the whole. In seams where there is a thin band of stone or dirt the machine can be made to hole in such band—the debris of which can be cleared away before the main coal is brought down, which would enable the coal to be brought to bank cleaner and with much less trouble.

In the perfected machines which are at present in use, the speed of work with a pressure of air of 20 lbs. to the square inch, may be reckoned at 30 yards per hour in medium hard coal—the groove made being three inches wide and a yard deep. Taking stoppages into account for removing and adjusting the machine, the average may be taken at one-third less. If it is convenient to have a working pressure of 50 lbs. to the square inch the cutting rate can be increased to one yard per minute. This extra rate, however, is not economical,

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on account of the additional wear upon the cutters, although the machines are of sufficient strength to resist the increased rate without breakage or heating. With respect to the replacement of the cutters, it may be remarked that they will run from six to eight shifts of nine hours each, without sharpening, in the very hard stone coal which is being under-cut for the Wigan Coal and Iron Company, with an air pressure of 20 lbs. to the square inch, and the average rate of progress seven yards an hour. The usual price charged for under-cutting a medium hard coal by contract is 1s. 6d. per yard, the contractor finding the necessary machines and one workman to each, and the miners laying the roads and preparing the faces, which must not be less than 30 yards in length. If worked in pillar and stall, the rates are increased in proportion to those paid to the miner; this system is not only expensive but very dangerous, and involves costly ventilating arrangements, and it may be predicted that it will certainly go out of use by the adoption of machinery; first, because it is much easier to ventilate a straight face; and, secondly, because the coal, when under-cut, comes down before the roof has had time to settle, and this to such an extent that at many places where pillar and stall work is carried on, under the impression that the roof is so bad that faces of 30 yards could
not be maintained with safety, it has been found that when the seams had been struck to boundaries, and worked up half board and half endways-on and under-cut by machinery, they have been worked with an open face of 1,000 yards in length with more safety and better ventilation than before. In reference to the work done by the heading, tunneling, or straight work machine, shown in Plate XXIX., the contracts are based on different terms and with reference to the forward yardage only. For example, the contract price for making three cuts one yard deep in medium hard coal, that is to say, two side cuts and one bottom cut (or if preferable a top cut) in a heading five feet six inches high by nine feet wide is from 10s. to 15s. a yard forward. When these cuts are made, if necessary, an inch and a-half drill is adjusted to the machine, and in two minutes a shot hole three feet deep is made. The machine is then run back a short distance when a shot is placed and fired. During the whole time ventilation is kept up by a slight outlet of compressed air, which arrangement saves the expense of bratticing.

The average time occupied in making the cuts, with 20 lbs. pressure of air, in such a heading, is 63 minutes, which is about five times the speed of driving it by manual labour, which only gives at best about 3 to 4 yards in 24 hours.

The air-compressing machinery, shown in Plates XXXI. and XXXII.,

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has been designed to obviate the very great expense of laying down the pipes to transmit the compressed air from bank to the machines in the face. The compressing machinery, here shown, can be placed conveniently near to the face of the coal and can supply air to machines to undercut a large area without being moved. It is worked by horses, or by a specially worked steam generator which the author intends making the subject of a future paper.

During the time that these machines have been at work, much has been done to perfect their details and to render them adaptable to the various requirements of getting coal. Many obstacles, formerly considered unsurmountable, have been successfully overcome, and the most encouraging results have been obtained. The author is glad to find that the members of the Midland Institute of Mining Engineers have appointed a committee of twelve to investigate the subject and test the various machines for getting coal now at work; and it is to be hoped that this action on the part of that Institute will give a new impetus to the use of such machinery, and that the time is not far distant when the danger, fatigue, and waste of coal-getting will be thereby very materially reduced.

A short discussion followed the reading of this paper, in which various opinions were expressed as to the percentage of power in compressed air a certain amount of steam-power would produce when combined with the special compressing apparatus described in the paper. Professor Herschel suggested the necessity of having the actual work expended in steam and realized in air tested by experiments with the indicator, and the discussion was adjourned to give Mr. Hurd an opportunity of trying the necessary experiments.

The Chairman then proposed a vote of thanks to Mr. Hurd for his valuable paper, which was cordially responded to, and the discussion on Mr. Wallace's paper, "On the Combustion of Coal Gas to Produce Heat," was then resumed.
The Chairman, whilst admitting that the subject was well worth consideration, still thought that if even small engines were constantly working it would be found more economical to supply the steam by means of coal fires rather than by means of gas. If, however, the engine was only required from time to time, the gas had this advantage,

[Plates XXVIII to XXXIII illustrating Hurd and Simpson's coal getting and air compressing machines]

that it was always ready, and a considerable heat could be obtained in a very short space of time without trouble, which could be as easily destroyed when not wanted.

Mr. Wallace thought that there were other advantages besides those just enumerated. Coal gas might be burnt without any solid particles, such as soot and tar, being developed, so that the heating surfaces of the boilers remained clean and could always be depended upon to the same extent as when new. This was exceedingly important where small boilers were used, and where the flues, tubes, and passages for conveying the heat to the water were necessarily restricted in area, and, therefore, difficult to clean. Again, a small boiler required very regular attendance in order to maintain the steam at a uniform pressure. Now, gas was a fuel which could be supplied in proportion exactly as it was required. He was well aware that it was only under certain conditions, and with small engines, that coal gas could be used with advantage as a fuel, and it was especially adapted for large towns, where its use enabled steam to be employed in warehouses and public buildings with no more danger than accompanies the usual application of gas. Of course it was utterly inadmissible for large pumping, winding, or mill engines.

Mr. Eaton asked whether Mr. Wallace had ever studied the question of applying unpurified gas as a means of producing heat under boilers. Such gas, for instance, as is made by Siemens’ process, and brought directly, and totally unpurified, to the place where the heat was required.

Mr. Wallace said, that the gas in that instance would be carbonic oxide, which required much less oxygen to burn it, and was much easier burnt in quantities than the carburetted hydrogen treated of in his paper. It would be quite unsuitable for burners, such as he had described, and would have to be burnt under totally different conditions.

The Chairman did not think that carbonic oxide would be in practice applicable to the purpose named, on account of its expense, for there was a loss of fully one-third of the heat-developing constituents of the coal in making the gas itself. Mr. Siemens himself admitted that loss, but he recovered it by being able to utilize the greater part of that which remained in the gas in his so-called “regenerator;” but, notwithstanding this loss in the early part of the process, he was inclined to think that the use of carbonic oxide would be found cheaper than that suggested by Mr. Wallace, but whether it would be more convenient was another question.
PROCEEDINGS.

GENERAL MEETING, SATURDAY, MARCH 7th, 1874, IN THE WOOD MEMORIAL HALL.

A. L. STEAVENSON, Esq., Vice-President, in the Chair.

The Secretary read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were then elected:—

Members— Mr. J. H. Penman, 2, Clarence Buildings, Booth Street, Manchester.
Mr. J. J. Lackland, C.E., Port Mulgrave, Saltburn.
Mr. John Johnson, Ruabon Coal Company, Ruabon.
Mr. Edward Brown, C.E., 27, Cromwell Street, Newcastle.
Mr. William Kelsey, Engine Works, Sunderland.
Mr. Joseph Dodds, M.P., Ironmaster and Coal Owner, Stockton.
Mr. Geo. Forster, M.E., Osmondthorpe Colliery, near Leeds.
Mr. John Smith, Rose Bridge, &c., Collieries, Wigan.

Students—
Mr. Charles C. Leach, Bedlington Collieries, Bedlington.
Mr. Edgar P. Rathbone, Duke of Norfolk’s Colliery Offices, Sheffield.
Mr. T. B. Bewick, Haydon Bridge, Northumberland.

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

Members—
Mr. Theodore Borries, Quay, Newcastle-on-Tyne.
Mr. Matthew Heckels, Boldon Colliery, Durham.

Mr. Joseph Stokoe, Houghton-le-Spring, Fence Houses.

Mr. John Parkin, Rosedale Mines.

Mr. T. F. Walker, 58, Oxford Street, Birmingham.

Mr. Edward Ross, Tondu Coal Works, Bridgend, Glamorgan.

Mr. C. Holmes, Kilton Mines, Brotton, Saltburn-by-the-Sea.

Mr. Charles Swan, Low Walker, Newcastle-on-Tyne.

Mr. Charles Mitchell, Shipbuilder, Newcastle-on-Tyne.

Mr. John Dakers, Old Durham Colliery, Durham.

Mr. George Saint, Llangennech Collieries, Llanelly, South Wales.

Mr. C. A. Shute, Westoe, South Shields.

Mr. R. F. Martin, Colliery Office, Whitehaven.

Mr. J. L. Spours, Victoria Colliery, Howden, Darlington.

Students—

Mr. Charles F. Scott, Monk Bretton, near Barnsley.

Mr. Edwin F. Burnley, Briggs, Son, and Co.'s Colliery Offices, Whitwood.

Mr. G. H. Bulman, Haswell Colliery, Fence Houses.

The Chairman stated that it must be a source of great satisfaction to the members to find their numbers increasing so rapidly, and that so many gentlemen who had acquired distinction in the pursuit of their several professions were seeking admission to the Institute.

Mr. T. F. Hedley then read the following paper "On the Valuation of Mines for the Purpose of Local Taxation:"—
The increasing importance of the question of Local Taxation, and the difficulties which are supposed to exist in applying the statute laws in force and the expounded law of rating to the valuation of mines for the purpose of assessment to the local rates, has led the author to submit his views on this subject to the members of this Institution for their consideration and discussion, and, in doing so, he has endeavoured to divest his observations as much as possible of all technicalities, so as to avoid any unnecessary mystification of the subject, in which so many members of this Institution are directly and largely interested.

In considering the question reference will be made—First, to the statute laws in force for the valuation of property; second, to the expounded law, or the decisions of the superior courts on the statutes in force; and, thirdly, the writer will endeavour to apply the statutes and the decided cases to the valuation of mines for the purpose of local taxation.

The rates for the relief of the poor are levied under the statute 43 Elizabeth, chapter 2, section 1, by which it is enacted that the "overseers of the poor shall raise, weekly or otherwise, by taxation of every inhabitant, parson, vicar, and others, and of every occupier of lands, houses, tithes, improper proportions of tithes, coal mines, or saleable underwoods in the said parish, in such sum and sums of money as they shall think fit, a convenient stock of flax, &c, to set the poor on work, and also competent sums of money for and towards the necessary relief of others being poor and not able to work," &c.

By several subsequent statutes expenses connected with counties, municipal corporations, the police, burial boards, registrations, &c, have been made "legally chargeable" on the poor rate, so that the cost of the relief of the poor only forms one of many items now levied and collected under the name of "The Rate for the Relief of the Poor."

By 6th and 7th Wm. IV., cap. 96, sec. 1, it is enacted that, after the 21st day of March, 1837, no rate for the relief of the poor in England and Wales shall be allowed by any justice, or be of any force, which shall not be made upon an estimate of the net annual value of the several hereditaments rated thereunto; that is to say, of the rent at which the same might reasonably be expected to let from year to year, free of all usual tenants' rates and taxes, &c, and deducting therefrom the probable average annual cost of the repairs, insurance, and other expenses, if any, necessary to maintain them in a state to command such rent. Provided always, that nothing herein contained shall be construed to alter or affect the principles or different relative liabilities, if any, according to which different kinds of hereditaments are now by law rateable. This enactment introduced no new principle of rating.
Section 3 enacts that the Poor Law Commissioners may order a survey and valuation of the messuages, lands, and other hereditaments liable to poor rates in any parish; and section 4 gives the person or persons appointed to make the survey and valuation, power to enter, view, examine, survey and admeasure all and every part of the messuages, lands, and hereditaments to be surveyed and valued.

The 15th and 16th Vic., cap. 81, sec. 9, empowers the committees appointed under this Act by the Courts of Quarter Sessions to order the whole or any part of a parish to be valued, and they may appoint one or more person or persons to make such valuations; and the person or persons so appointed may at all reasonable times enter upon, view, examine, survey and measure all and any lands, houses, or other property, within such parish, &c, in order to ascertain the value at which the same ought respectively to be charged. And by section 45, every person obstructing a surveyor, or other person, in the execution of his or their duty, under this Act, is liable to a penalty not exceeding £5.

It is important to observe that the powers and authority of the person or persons appointed to survey and value, under the 6th and 7th Wm. IV., cap. 96, and the 15th and 16th Vict., cap. 81, are limited to entering, viewing, surveying, and measuring the hereditaments liable to be taxed, but the person or persons so appointed have power or authority to call for or examine any private book or books of accounts, in order to ascertain the profits of trade.

The 15th and 16th Vict., cap. 81, sec. 7, empowers the County Rate Committees, by their order in writing, to require assessors and others to appear before them, and produce assessments, &c., and to be examined on oath, and answer such questions as the committee may put to them; and the 25th and 26th Vic., cap. 103, sec 13, empowers the Union Assessment Committees to require assessors and others having the custody of books of assessment of any taxes, parliamentary or parochial, to make or transmit copies of, or extracts from, such books, and the committees may require such persons to attend before them, and to produce books of assessment, &c. But the 26th and 27th Vic., cap. 33, sec. 22, enacts that the powers conferred upon the Committees appointed under the County Rate Assessment Act and the Union Assessment Committee Act, 1862, shall not extend to authorize or empower the Committees to require any assessor, collector, or other person employed in the assessment or collection of the income tax, to make or transmit, or to permit any other person to make, copies or extracts from any assessment or any document relating to the assessment or collection of the income tax upon profits of trade, for or in respect of any quarries, mines, iron works, gas works, or other concerns in the nature of trade or manufacture, chargeable under Schedule A of the Income Tax Act, or to attend before the said committee, to produce such assessments or other documents, or to be examined by or before such committee, touching or concerning the same. The committee, therefore, cannot ascertain from public documents anything relating to the profits of quarries, mines, trade, or manufacture.
By the 3rd and 4th Vic., cap. 89, sec. 1, it is enacted that from and after the passing of this Act, it shall not be lawful for the overseers of any parish, &c, to tax any inhabitant in respect of his ability, derived from the profits of stock-in-trade, or any other property, for or towards the relief of the poor; the liability of any parson or vicar, or of any occupier of lands, houses, tithes, coal mines, saleable underwoods, to be taxed for or towards the relief of the poor, was not to be affected by this Act; that is, that such lands, houses, tithes, coal mines, and saleable underwoods, should be taxed under the provisions of the 6th and 7th Wm. IV., cap. 96, at the rents at which the same might reasonably be expected to let from year to year.

It is important to observe that the words of the Parochial Assessment Act are the rent at which the hereditaments might reasonably be expected to let from year to year, and not the rent at which the same are actually let. Although "rent paid may be prima facie evidence of value, it cannot be taken as the one fact exclusive and conclusive of the amount from which by the statute the rateable value is to be arrived at," as "the estimate, according to which the rate should be calculated, shall be, not the actual rental paid, but the rent at which the premises might have been reasonably expected to let at from year to year," and it is "the rent which would be paid, not by an actual tenant, but by the hypothetical tenant which must decide the value;" and "if a property be improved in value, it is immaterial whether the improvement be made by the owner or occupier. The bargain between the owner and the occupier may be varied on that account, but the occupier is liable to be rated in respect of the improved value," as "the value of the thing rated must be the concurrent annual value during the period for which the rate is made;" and although, "in point of form, there may be no rent, but a payment of interest, the interest is in effect rent;" and "if property has a local ascertained value, it is rateable on that value, irrespective of profits, which may or may not be derived from it elsewhere;" "and it is immaterial whether the occupation be profitable to the occupier or the owner, the occupier is rateable," and "there is a fallacy in the argument in confounding the rateable value to the poor with the remunerative value to the occupier;" and "a party holding property, in its nature rateable, is not discharged from his legal liability because he does it at a loss;" and "the assessor must take into his consideration all the circumstances that would influence the minds of the parties to a negotiation, as to the rent to be asked or given at the time of making the valuation."

"From the gross estimated rental must be deducted the probable average annual cost of repairs and insurance and other expenses, if any, necessary to maintain the hereditaments in a state to command such rent," but "extra expenses occurring in particular years for repairs and maintenance cannot be allowed, as, if deductions were made in this way, it would open the door to every species of fraud." But "nothing should be deducted from the rent for tenants profits, as it is supposed that a tenant would take the profits into his own calculation in considering the rental;" or "if the occupier or tenant undertakes the repairs, insurance, and maintenance of the hereditaments, the rent, if a fair criterion of the annual value, will be the rateable value, and the probable average annual cost of the repairs, insurance, and maintenance undertaken by the tenant must be added to the rent in order to arrive at the gross estimated rental."
Where, from the nature of the properties, "in practice a yearly tenant can rarely be found, a hypothetical tenant must be assumed and the terms of the hypothetical tenancy are not difficult to be

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conceived; the occupying tenant must be assumed to pay adequate remuneration to a contractor for land and fixed capital vested therein, and the local rateable value will be such a sum as would pay the rent of the land profit of fixed capital therein."

The foregoing are as brief extracts, from the statutes in force for the valuation of property and several of the decisions thereon, as it is possible to give in order to place the matter fully before the members of the Institute, and it now remains for the author to apply the principles laid down to the assessment of mines.

Coal mines only being mentioned in the statute of Elizabeth, all other mines are exempt from local taxation except as hereinafter explained. The following observations will, therefore, be exclusively confined to coal mines.

Coals, like minerals, when severed from the seams and veins from which they have been worked, are clearly stock-in-trade, and, therefore, the profits and losses arising from the sale of such coals when severed cannot be considered, as it is immaterial whether the coal mine be profitable to the owner or the occupier; the occupier is liable to be rated. This is clearly laid down, not only in the old case of the King and Parrott, where a mine was worked at a loss and held to be rateable, but also by a very recent case, the Queen and Aylesford, where the parish officers sought to ascertain the profits of a chalk pit for the purpose of assessment, but the Court of Quarter Sessions refused to allow the question to be put, on the ground that it was an enquiry into the profits of trade, and the Court of Queen's Bench decided that the justices were right in disallowing the question; and Mr. Justice Blackburn said the rateable value of the chalk pit is what a tenant would be likely to give who took the pit from year to year; and so it is with a coal mine, it is the rent the tenant would be likely to give for the coal mine from year to year that must determine the value of the mine, and not the profits made by selling the coals.

No doubt coal mines were originally worked in the same way as lead, copper, and tin mines are still worked, that is for a part of the produce of the mine, but the development of the coal-fields and the experience acquired in working coal has enabled the persons possessing coal mines, and the persons working them, to ascertain their local money value, either to buy or sell, mortgage, or let from year to year; and at the present day coal mines possess an ascertained local value which enables them to be bought and sold, mortgaged, or let from year to year with as much certainty as surface lands or other property.

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In the Counties of Durham and Northumberland the coal is let at certain yearly rents, for a specified number of "tens" of coal, with "tentale" rents upon all coals worked beyond the specified quantities.

In Yorkshire and Lancashire the coal is let at yearly minimum reserved rents per acre, and acreage rents upon all coal worked beyond the quantities specified for the minimum rents.

In other parts of England and Scotland, and in parts of Wales and Ireland, the coal is let at minimum reserved yearly rents for specified quantities, at a price per ton, and tonnage rents upon all coal worked beyond the specified quantities.

But in some parts of Ireland, in South Staffordshire, and in other places in England and Wales, the coal is let for certain rents and proportions of the selling price of the coal at the pit's mouth, such proportions varying from one-sixth to one-sixteenth part of the selling price of the coals.

It may be taken as a fact that coal mines have now well-ascertained local values, and, therefore, coal mines must be valued and assessed in the same manner and to the like extent as other hereditaments possessing ascertained local values.

The author will, therefore, take as an illustration of the principles which, in his opinion, ought to be adopted in the valuation and assessment of a coal mine, the case of the valuation and assessment of a farm, in the valuation and assessment of which no difficulty exists.

The land per se has an ascertained local value, which is determined by the situation of the land, the nature and quality of the soil, the description of the crops it will probably produce, the cost of production, and the amount of capital the tenant will have to invest to work the land.

But in order to work the land, the land must be fenced and drained, there must also be a farm house for the farmer, cottages for the servants, and farm buildings suitable for the stock and crops.

The farm, in fact, consists of two parts, that is, first, the land, second, the farm house, cottages, and farm buildings necessary for working the land. The land is the direct source of profit, but the farm house, cottages, and farm building's produce no direct profit, although they indirectly conduce to the profits of the farm.

In practice the owners of lands fence and drain the lands, and build the farm houses, cottages, and farm buildings, suitable for the farm, and let the land, farm houses, cottages, and farm buildings, together at one rent. And where farms are bona-fide let from year to year, the rent paid is taken as the criterion and measure of the annual value of the farm. But if a farm is held under a lease, and the occupier improves the farm either by drainage or other works, or adds to the farm house or farm buildings, the rent reserved under the lease is no criterion of the annual value of the farm, and the occupier is rateable on the improved value; because, if the owner of the land had made the improvements to the farm or additions to the buildings, he would have required, and the tenant would have been willing to pay, either more rent than the rent reserved under the lease or interest on the capital expended in the improvements or additions, and such
increased rent or interest on the capital expended would be the annual value of the farm, and not the rent reserved under the lease.

So if the owner of the land leased the land in its natural state, and the tenant fenced and drained the land, and erected the farm house, cottages, and farm buildings, the rent of the land per se would not represent the value of the farm, or the rent at which it might reasonably be expected to let for in its improved condition, and the rent therefore would be no criterion of its value for assessment.

As it is with a farm, so it is with a current-going colliery.

The coal per se, like the land, has an ascertained local value, which annual value is, like that of the land, determined by the situation, the quality and description of the coal, the probable amount of capital to be invested to win the coal, and the probable cost of working the coal. But in order to work the coal, land must be occupied, shafts must be sunk, or adits driven, engine houses must be built, and engines erected, to bring the coal to bank.

A colliery therefore consists of two parts, that is, the coal per se, and the land, shafts, buildings, and machinery necessary for working the coal. The coal like the land is the direct source of profit. The shafts, buildings, and machinery, like the farm house, cottages, and farm buildings, produce no direct profit, but indirectly conduce to the profits of the colliery.

If in practice the owner of the coal paid the rent of the land occupied by the colliery, and sunk the shafts, put up the buildings, and erected the machinery necessary for working the coal, and let the whole together from year to year at a bona-fide yearly rent, the rents of the land and coal, and the shafts, buildings, and machinery, would be the annual value of the colliery as a current-going concern, but in practice the owner of the coal seldom pays the rent of the land, sinks the shafts, puts up the buildings, or erects the machinery necessary for working the coal, consequently the tenant of a current-going colliery is rarely to be found, therefore a hypothetical tenancy must be assumed, and in conceiving the terms of such hypothetical tenancy, it is necessary to consider how coal is usually let.

In practice the coal per se is let for a long term of years, the lessee covenanting to pay the rent of the land occupied by the colliery, to sink the shafts, put up the buildings, and erect the machinery necessary for working the coal. Under these circumstances it is not difficult to conceive the terms of a hypothetical tenancy, for the occupying tenant must be assumed to pay, in addition to the rents of the coal and the surface land, adequate remuneration or fair interest to the lessor, or to a contractor for the fixed capital invested in the shafts, buildings, and machinery; and the local rateable value will be such a sum as will pay the rents of the coal and land, and the remuneration or fair interest on the capital invested in the shafts, buildings, and machinery, in the same way as the farmer pays more rent for the land, and farm house, and buildings, than he would for the land alone.

It is admitted, and it is too clear to admit of doubt or argument, that if the owner of coal would pay the rent of the land occupied by the colliery, and invest the capital required for sinking the shafts,
putting up the buildings, and erecting the machinery to work the coal, that the lessee of the coal would willingly pay an increased rent for the coal or the rent of the land, and also a rent for the use of the shafts, buildings, and machinery, or interest on the capital invested in the shafts, buildings, and machinery.

This is no imaginary or impracticable hypothesis, as it is the principle adopted in those rare cases where a tenant of a current-going colliery is found; this will be seen from the following extracts from the lease of the rents reserved under the lease of a current-going colliery.

"The parties hereto of the second part (the lessees) yielding and paying for all coals and cannel which shall be gotten or raised in, from, or out of all and every, or any of the mines hereby demised, three shillings and fourpence for every twenty shillings worth of coal * * * * * * * such quarterage to be calculated by and according to the selling price, for the time being of the coal and cannel at the pit's mouth also yielding and paying for, and in respect of the said pit called A pit, and the steam engines, engine houses, and workshops, and other buildings and conveniences, near to or adjacent to such pit, &c, the yearly rent or sum of three thousand pounds, payable quarterly."

Other cases in support of this principle could be added, but the

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author thinks no member of this Institution will contend (although it has often been contended before) that the royalty or rents paid for the coal or the mine rent alone can be taken as the criterion or measure of the annual value or the rent at which a current-going colliery might reasonably be expected to let from year to year.

This being admitted, the next point to consider is the practical application of the principle laid down, and in doing so it must be borne in mind that in assessing all property, it is the rent at which the hereditaments might reasonably be expected to let from year to year, and it is not to be an extravagant or exceptional rent, that is to be the measure of the annual value.

It must also be borne in mind that the "great point to be aimed at in every rate is equality. The first thing upon every rate, therefore, is to ascertain the true rateable value of every property upon which the rate is to be imposed." "In the case of land, the rateable value is the amount of the average annual profit or value of the land. It cannot be said where a farm is let, the year's profit on each particular crop is to be taken into consideration in fixing the rate, and the value cannot be ascertained by inquiring whether the property was more or less beneficial in a particular year."

Certainly no prudent tenant would bargain for the rent of land from year to year on an estimate of the crops of an exceptionally good year, nor would a prudent owner let his land at a rent leased upon an estimate of the crops of an exceptionally bad year, both parties would, no doubt, be influenced in the negotiations as to the rent to be asked or given by the latest evidence of antecedent value, not of a particular year, but over a fair average of years in order to arrive at the probable prospective annual value of the land from year to year.
And so it must be with coal mines, they must be valued like the land, on an estimate of the probable produce of the mines or the quantity of coal that may reasonably be expected to be worked at the time the valuation is made, and on a fair average annual value of the coal, and not with reference to the profits of a particular year; therefore, the recent exceptionally high prices of coals and great profits of the lessees must not be taken into consideration in determining the annual value of the coal except in so far as such high prices and great profits would influence the minds of the parties to a negotiation as to the rents to be asked or given for the coal.

That the recent high prices of coal and great profits of collieries have influenced the rents of coal, and improved the value of royalties,

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cannot be denied, and it is proved, not only by the large sums recently paid for the lessees' interest in coal held under old leases at low rents, and by the increased rents asked and given for coal recently let, but admitted by the lessees of coal.

Mr. J. Whitwell Pease, in his evidence before the select Committee of the House of Commons, in May last, said, in answer to questions 4,259, 4,260, and 4,473—

"And the tendency of rent with a high price of coal has been very much to increase."

"The royalties used to run at 4d. and 4½ d. a ton, and they cannot now be taken under a shilling a ton."

"I have just renewed one or two leases which are more than double, although the leases have years to run; not liking to run the risk of the price of the coal three or four years hence, I have paid more than double the present rents."

The royalty rents paid for coal under old leases cannot, therefore, be taken as the present annual values of the coal, and the rent or annual value must be estimated at the present value of the coal without reference to the rents paid or profits made in exceptional years.

The annual value of the surface land occupied by the colliery must be determined by the locality and value of the land taken, in arriving at which there can be little or no difficulty.

This leads to the consideration of the annual value or rent for the shaft, buildings, and machinery, which must, as before explained, be estimated on what would be adequate remuneration or fair interest on the capital invested.

It is important to observe here, that it has been held by the Superior Courts that the cost or the capital actually expended on works may be no criterion of value, as that which was valuable may have become valueless by subsequent changes, or the capital may have been injudiciously expended.

In the case of collieries, the rent of the coal is determined chiefly by the probable cost of sinking or winning it, and if the lessee of a coal mine bargained for the rent of the coal on a probable
expenditure of £50,000, and the coal was won for that sum, then the rents of the coal and land, and interest on the capital, would be the annual value; but the actual cost of sinking or winning coal may, from various unforeseen difficulties, far exceed the estimated cost, and in such cases the rents of the coal and land, and interest on the cost or capital expended, would not be the fair criterion of the annual value of the colliery; for, if the

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winning of the coal cost the lessee double what he estimated, or from unforeseen circumstances the lessee had to expend £100,000 instead of £50,000, then the rent agreed to be paid for the coal and the interest on the capital actually expended in winning it, would not represent the fair annual value of the colliery; for if the lessee had known that it would have cost £100,000 to win the coal, he would not have given, nor would the lessor have expected, to receive so much rent for the coal; consequently in such a case, if the interest on the capital invested in the shaft, buildings, and machinery, be calculated on the capital actually expended, then the rent of the coal must be reduced to the reasonable rent the lessee would have given for the coal if the cost of winning had been estimated at £100,000.

On the other hand, if the lessee agreed for the rent of the coal on an estimated cost of £50,000 for winning it, but from fortunate circumstances he succeeded in winning it for £30,000, then the rent agreed for the coal and interest upon £30,000 would not be the fair annual value of the colliery, inasmuch as, if the lessor and lessee had known that the coal could have been won for £30,000, the lessor would have asked, and the lessee would have been willing to give, a higher rent for the coal, and in such case the rent of the coal must be increased to the reasonable rent that would have been asked and given for it if the cost of winning had been estimated at £30,000.

In the author’s opinion, the best course to adopt to arrive at the rent at which a current-going colliery might reasonably be expected to let from year to year, is to estimate the rent of the coal at the rent it might reasonably be expected to let for, on a reasonable estimate of the probable expenditure for winning the coal, and to disregard the actual cost of shafts, buildings and machinery.

In valuing old collieries where several shafts have been sunk, and the buildings and machinery are in excess of the present requirements of the colliery, the capital invested should be limited to an estimate of the present value of the shafts, buildings and machinery, to a hypothetical tenant, taking into consideration the state and condition of the mine, and the probable produce of the mine at the time of making the valuation, and without any reference whatever to the actual expenditure on the shafts, buildings and machinery, much of which may really prove an encumbrance to the mine.

The next question to consider is, what would be adequate remuneration or fair interest on the capital invested, as the reasonable rent of shafts, buildings and machinery.

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It is contended that no contractor or capitalist would invest money in such hazardous undertakings as colliery shafts, buildings, and machinery, for less than ten per cent. per annum, and that the lessees of coal would be willing to pay as rent, ten per cent. per annum upon the capital so invested, but as it has been said by a learned judge, "the great point to aim at in every rate is equality," it is necessary, therefore, to consider how the rent of other property than mines is estimated, and what is considered adequate remuneration or fair interest on capital invested in other works than mines, where hypothetical tenancies are assumed.

1st.—Land and farm buildings are usually let at and rated on rents averaging about three per cent. per annum on the capital invested, from which is deducted about one-twelfth for repairs.

2nd.—Ordinary houses and shops are usually let at and rated on an estimate of about six per cent. per annum of the capital invested, from which about one-sixth is deducted for repairs and insurances, leaving about five per cent. as the rateable value.

3rd.—With regard to manufactories which are not usually let, and where hypothetical tenancies are assumed, the rents are estimated at from six per cent. to seven and a half per cent. upon the capital values; where six per cent. is estimated as the rent, one-sixth is deducted for repairs and insurance, but where seven and a half per cent. is estimated as the rent, the deductions for repairs and insurance vary from one-fourth to one-third, so that, practically, manufactories are rated on about five per cent. of their capital values.

It would, therefore, be manifestly unfair and unequal to tax or assess the lessees of collieries for their shafts, buildings, and machinery upon ten per cent. of the capital invested, whilst land is only taxed at less than three per cent., and houses and manufactories on about five per cent. of their respective capital values.

It is, however, immaterial what per centage be charged on the capital invested as the rent of the shafts, &c, if the deductions for repairs and insurance are only made in proportion to the risks; but the rents of colliery shafts, buildings and machinery ought not to be estimated at more than six and a half per cent. per annum upon the present capital values.

The reasonable rents of the coal and land occupied by the colliery, and the fair interest on the capital invested in the shafts, buildings and machinery being added together, will represent the gross estimated rental of a current-going colliery as a whole taken together, and from this amount must be deducted the probable average annual cost of repairs, insurance and other expenses, if any, necessary to maintain the colliery in a state to command such rent.

Here again, in order to secure "equality in the rate," it is necessary to enquire what deductions are usually made for repairs and insurance in assessing other property.

These deductions average about one-twelfth from the rent of land and farm buildings, and about one-sixth from the rent of ordinary shops, and from one-sixth to one-third from the estimated rent of manufactories as before described.
Taking into consideration these several deductions and the risk attending the working of coal mines, and assuming the rent of the shafts, buildings and machinery to be calculated at six and a half per cent. upon the capital values, the writer thinks at least one-fourth or 25 per cent. ought to be deducted from the gross estimated rental of the collieries for the probable average annual cost of repairs and insurance which the owner would undertake, but no deduction should be made for the repairs and insurance undertaken by the lessee.

The foregoing observations refer to the valuation of a current going colliery as a whole taken together, and if the colliery "lies in one parish or township the rate is on the whole," but if the colliery "lies in several parishes or townships the occupier is liable for the same amount of rateable value and no more," but the aggregate value of the coal mine, shafts, buildings and machinery, if situate in more than one township, must be apportioned between the townships from which the coal is worked, and the townships in which the surface lands, shafts, buildings, and machinery are situate.

There is one point connected with the working of a colliery, to which the author's attention has been specially directed, and which requires consideration, and that is, where, in working the coal, feeders of water have unexpectedly been met with, and large engine houses and engines have had to be erected, and pumps put down to draw off the water, in order that the mine might be worked.

Certainly such engine houses, engines and pumps, do not increase the value of the colliery, but on the contrary reduce it, although if the engine houses, engines and pumps, be situate in one township, and the coal is worked out of another, the engine houses, engines and pumps, must be rated in the township in which they are situate, on the same principle as other buildings and machinery, but the amount charged upon these engine houses, engines and pumps, must be subtracted from

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the rateable value of some other township, as the colliery must not be rated in the several townships in which it lies, beyond the amount at which it would be liable to be rated if the whole was in one township, as every addition to the rateable value assigned to one parish, must be a subtraction from the rateable value which might be given to some other parish, as the rateable value in the several parishes must not exceed the aggregate value of the whole taken together.

These observations relate exclusively to the valuation of coal mines, as other mines than coal are not rateable, except where the owners reserve their share of the produce of the mine in kind. The author believes, however, that the principles of valuation he has endeavoured to explain, are equally applicable to iron stone and iron ore mines, as to coal mines, as both iron stone and iron ore have now, like coal, well-ascertained local values either to sell, mortgage, or let.

Lead, tin, and copper mines, from the risk and uncertainty attending the working of them, have not local ascertained money values, and the mines are demised in consideration of the lessees giving the lessor or owner of the mine a proportion of the ore gotten or raised, but there would be no difficulty in reducing the lord's share to an annual value for the portion of assessment.
The lessees of these mines pay the rent of the surface land occupied by the shafts and buildings, and sink the shafts, put up the buildings and machinery to work the mine, but up to a very recent period, the surface lands, buildings and machinery, connected with lead, tin and copper mines were not rated, as they were deemed to be part of the mine, but in the year 1872, the Court of Queen's Bench decided, in Guest and East Dean, that the surface lands, buildings and machinery, connected with the iron mines in the Forest of Dean were rateable, and that the test of value was to be, what would the hypothetical tenant give for the surface land, buildings and machinery.

In estimating the value of the lands, buildings and machinery, connected with iron mines in the Forest of Dean, and the lands, buildings and machinery connected with the lead mines in Salop, the author applied the same principles as those he adopted in valuing the lands, buildings and machinery connected with the coal mines, and which he has endeavoured in this paper to explain. How far he may have succeeded in removing the supposed difficulties which exist in applying the statute in force and the decisions thereon to the valuation of mines is a question for the members to decide.

Mr. Hedley, in answer to a question by Mr. E. F. Boyd, stated that in his opinion pit cottages should be considered as a portion of the colliery, and should be rated in the same way as the machinery and general plant, but from the operation of the Assessment and Collection of Rates Act they had to be separately assessed, as every one was supposed to have the franchise conferred upon him who occupied a house. If the cottages were in a different township from the shafts and machinery, each portion of the property would have to be rated in the parishes in which they were locally situated. In further reply to Mr. Boyd, Mr. Hedley thought that it had been placed beyond doubt that until a mine was developed and worked it could not be rated, for it would be manifestly unfair to rate dead rents and then begin to rate the collieries on their workings afterwards, and that the rate must be upon the produce of the mine and the value of the produce at the time the rate was made.

In answer to a question by Mr. W. H. Hedley, he (Mr. Hedley) stated that, in his opinion, if the cottages were rated with the mine, as he before stated he considered they ought to be, they should follow the same law and be rated at six and a half per cent. upon the capital value with an allowance of 25 per cent. for repairs. Even if the cottages were let, and, from exceptional circumstances, obtained a rental of more than six and a half per cent. on the capital expended in their construction, he would consider it very unfair to rate the coal owner on the increased rent. He thought in all cases the rent should not exceed what the hypothetical tenant would give for the colliery including the cottages.

Mr. Bewick would ask how Mr. Hedley could make a difference between a miner's cottage and that of a farmer's, separated from each other perhaps by a simple wall? In the case of the farmer's cottage no deduction of 25 per cent. was made; how, then, could such a deduction be claimed for the pit cottage?

The Chairman stated that it must be remembered that as soon as the coal was extracted from the colliery the value of the cottage property was entirely destroyed. Especially so when these cottages
were built on moors or out of the way places where a single farmer's cottage here and there would be of value. He thought that these circumstances rendered the cases hardly similar.

Mr. T. F. Hedley perfectly agreed with the Chairman; there the cases were not similar. The farmer's cottage might always be beneficially occupied, but it was not the case with the pit cottage. Nor need they go to the top of a moor, for they would find at Ferryhill a great number of cottages built as appendages to the colliery which were all closed directly the colliery was shut up.

The Chairman asked Mr. Hedley if it would be considered that there would be a beneficial occupation should the colliery be laid in for a year or two?

Mr. T. F. Hedley considered that quite another matter. He thought he had stated in his paper that exceptional years ought not to be taken into consideration. It had been decided in the Court of Queen's Bench that during the time the dock gates were shut at Hull for the purpose of rebuilding the entrance, and when the yearly expenditure from this circumstance far exceeded the revenue, that still the docks were held to be rateable, and the judges said:—"We cannot allow exceptional expenditure occurring in particular years, as that would open the door to every species of fraud." If a colliery was laid off from badness of trade, he thought the decision in the Castleton case, where a cotton mill was off work, would rule. In that case it was held that the cotton mill was rateable, though not as a current-going cotton mill, but simply as a place for warehousing the machinery until trade revived, and that in this way it was beneficially occupied. Of course, if a colliery was laid in it could not be rated on the output of coal, but all the surface land, together with the buildings as warehouses for the machinery, would be liable to be rated until trade revived and the colliery was again at work. He upheld that principle in the case of the blast furnaces at Middlesbro', and very eminent counsel confirmed the correctness of the principle that although the machinery and furnaces could not be rated as a current-going concern, yet they were liable to be rated inasmuch as they were beneficially occupied in the manner before described.

The Chairman stated that it would seem hard that plant, under the circumstances last mentioned, should be rateable, since the plant so situated was actually a source of loss and not of profit.

Mr. Hedley, in reply, said, that the courts had often decided that the question of profits to the occupier was immaterial in a question of rating.

Mr. Southern moved a vote of thanks to Mr. Hedley for his able paper, and he thought the discussion had better be adjourned until the members had had an opportunity of reading it.

Mr. H. T. Morton seconded the motion, which was carried by acclamation.

Mr. W. H. Hedley suggested that Mr. Hedley should kindly give them an example of his mode of valuing a current-going colliery,
together with some remarks applicable to cottages, following out the discussion which had been raised. He thought this would add very much to the interest and value of the paper.

The Chairman stated that he had formed great expectations of the value of Mr. Hedley's remarks, which expectations he must say had been entirely fulfilled. The subject was one to which Mr. Hedley had devoted especial time and attention, and his impartial views upon the subject had caused him to be consulted by all who were interested either as assessors or assessed. At the discussion they would have a further opportunity of considering the subject, which, although not exactly a scientific question, was yet quite as important a branch of study, relating as it did to the commercial position of the colliery. In fact all their professional labours were to a certain extent of a commercial character, for unless they could as engineers make a colliery pay, that colliery must of course stop altogether. Therefore, any question which treats of the commercial interests of a colliery was one of very great interest to them. Almost every branch of engineering had been more or less considered in the Transactions of the Institute, and it must be a source of great gratification to the members that many subjects (and he would allude more particularly to the very important one of ventilation) had been for the first time treated of in their pages, and those contributions even now constituted the most reliable information published on the various matters touched upon, and he fully thought that Mr. Hedley's paper would prove an original and valuable addition to their proceedings, and would add another testimony to the great benefits the institution was conferring on the scientific public.

Mr. Hedley said he was exceedingly obliged to the meeting for this expression of satisfaction. In the preparation of his paper he had been influenced solely with a desire to remove all the difficulties and mystifications which were supposed to surround the question of rating collieries, and to make it as clear and as practicable as possible. The Chairman had referred to the satisfaction he had given, and he would only add that it had been a source of pleasure to him to find he had been able in most cases to satisfy both parties, and in nearly all the cases in which he had not been so successful he found that he had satisfied neither party: the one side thinking his assessment too high, and the other side considering it too low, so that he had been able to console himself with the reflection that he had hit upon a happy medium between the two extremes.

The meeting then terminated.
The Secretary read the minutes of the last meeting and reported the proceedings of the Council.

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

Members—

Mr. Theodore Borries, Quay, Newcastle-on-Tyne.
Mr. Matthew Heckels, Boldon Colliery, Durham.
Mr. Joseph Stokoe, Houghton-le-Spring, Fence Houses.
Mr. John Parkin, Rosedale Mines.
Mr. T. F. Walker, 58, Oxford Street, Birmingham.
Mr. Edward Ross, Tondu Coal Works, Bridgend, Glamorgan.
Mr. C. Holmes, Kilton Mines, Brotton, Saltburn-by-the-Sea.
Mr. Charles Swan, Low Walker, Newcastle-on-Tyne.
Mr. Charles Mitchell, Shipbuilder, Newcastle-on-Tyne.
Mr. John Dakers, Old Durham Colliery, Durham.
Mr. George Saint, Llangennech Collieries, Llanelly, South Wales.
Mr. C. A. Shute, Westoe, South Shields.
Mr. R. F. Martin, Colliery Office, Whitehaven.
Mr. J. L. Spours, Victoria Colliery, Howden, Darlington.

Students—

Mr. Charles F. Scott, Monk Bretton, near Barnsley.
Mr. Edwin F. Burnley, Briggs, Son, and Co.'s Colliery Offices, Whitwood.
Mr. G. H. Bulman, Haswell Colliery, Fence Houses.

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

Members—
Mr. Thomas Southworth, Hindley Green Collieries, near Wigan.

Mr. Harry Gill, Consulting Engineer, Newcastle-on-Tyne.

Mr. John Teasdale Bell, M.E., Wolsingham, via Darlington.

Mr. John Swallow, East Castle Collieries, Annfield Plain.

Mr. Wm. Jenkins, Manager, Consett Collieries, Lintz Green, Gateshead.

Students—

Mr. W. T. Hallimond, Etherley Colliery, Escomb, Bishop Auckland.

Mr. Wm. Thompson, Washington Colliery, County Durham.

Mr. Harrison J. Bulman, Killingworth Colliery.

Mr. W. Stanley Avery, Killingworth Colliery.

Mr. T. F. Hedley then read the following appendix to his paper "On the Valuation of Mines for the Purposes of Local Taxation:"—

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SUPPLEMENTARY PAPER ON THE VALUATION OF MINES FOR THE PURPOSES OF LOCAL TAXATION.

By THOMAS FENWICK HEDLEY.

The writer was asked to give an illustration of the valuation of a colliery on the principles laid down by him in the paper read before the last monthly meeting of the members of this Institution.

The following is a copy of a recent valuation of a colliery:—

THE VALUATION.

<table>
<thead>
<tr>
<th>Capital Values.</th>
<th>Annual Values.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>£60 0 0</td>
</tr>
<tr>
<td>Royalty</td>
<td>4,105 0 0</td>
</tr>
<tr>
<td>Estimated value of shafts, buildings and machinery</td>
<td>£94,000</td>
</tr>
</tbody>
</table>
Annual value of shafts, buildings, and machinery calculated

at 6½ per cent. on £94,000

203 houses (rents as per scale)

Gross estimated rental

Deduct for repairs, insurance, and risk

Rateable value

RATING COLLIERIES NOT WORKED.

A question was asked how a colliery should be rated when not worked. The writer answered, that would depend upon the particular circumstances of each case, and that if a colliery could not be worked from the "badness of trade," then the land, and the buildings as warehouses for the machinery alone would be rateable. But if a colliery could be worked and the lessee did not choose to work it, then the colliery would be rateable at the rent at which it might be expected to let to another to work it.

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But if a colliery is not worked for a few weeks on account of repairs, or an accident, or a strike, the colliery will be rateable on its full value as the allowance of 25 per cent. from the gross estimated rental is made to provide for such contingencies.

In the case of an accident to the shaft of Monkwearmouth Colliery, and during the strike at the same colliery, this question was raised, and the opinion of eminent counsel taken on the point, and counsel advised that allowances could not be made for such special expenses of repairs to the shaft or losses during a strike occurring in particular years, and the colliery continued to be rated on the full annual value during the repairs of the shaft and during the strike. In fact such contingencies are the only grounds on which a deduction can be made from the royalty rents for risk, as the coal requires no repairs.

RATING MINERS' HOUSES.

A question was asked how the writer would rate these houses. In Northumberland and Durham the practice, with one exception, is for the owners to find the miners' houses. In other parts of England and Wales, and in Scotland and Ireland, the miners find their own houses. No doubt the practice of finding the miners' houses in Northumberland and Durham originated from sinking pits in localities
where the workmen could not obtain houses for themselves, and this practice has been continued to the present day.

The lessees of coal in Northumberland and Durham of course take into their consideration the fact that they will, in addition to the capital invested in winning the coal, have to find houses for the workmen, but the amount of capital required to build miners' houses a few years ago was a comparatively small item to what is now required to build them.

From the usage or practice in Northumberland and Durham of finding the miners' houses, the houses actually form part and parcel of the colliery plant, and are appendages or adjuncts to the colliery in the same way as a station is an appendage to a railway; and in many places if the collieries ceased working, the houses would be unoccupied and could not be let, and would not be rateable.

The houses, therefore, ought to be rated as appendages to the colliery in the same manner as the stations of a railway are rated—that is, on the rent of the land and fair interest on the capital invested in the buildings.

But the capital invested must be limited to the fair value and not the actual cost of building at the present exceptionally high prices.

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The writer, for the purpose of simplifying the mode of rating miners' houses, prepared a scale of rents and deductions for the rating of the miners' houses in Houghton-le-Spring Union, and submitted that scale to the consideration of the Union Assessment Committee and to the lessees of the several collieries in that union, who unanimously agreed that it was a fair and reasonable scale for rating the miners' houses.

The same scale has recently been under the consideration of the Tynemouth Union Assessment Committee and some of the Lessees of the Steam Coal Collieries in Northumberland, and has been approved by them.

The following is the scale referred to:—

**ASSESSMENT OF COLLIERY HOUSES.**

**GROSS ESTIMATED RENTAL.**

* Old houses.

Subject to a deduction of one-fifth, or 20 per cent. for repairs, &c.

<table>
<thead>
<tr>
<th>Description</th>
<th>Rental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Cottage, 1 Room</td>
<td>£2 10 0</td>
</tr>
<tr>
<td>Double Cottage, 2 Rooms</td>
<td>3 10 0</td>
</tr>
<tr>
<td>Single House, 1 Room and Loft</td>
<td>3 0 0</td>
</tr>
<tr>
<td>Double House, 2 Rooms and Loft</td>
<td>4 0 0</td>
</tr>
</tbody>
</table>
Extra-sized Houses 30s. per Room.

<table>
<thead>
<tr>
<th>Description</th>
<th>Rooms</th>
<th>Rental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do. 3 Rooms</td>
<td>4</td>
<td>10 0</td>
</tr>
<tr>
<td>Do. 3 Rooms and Loft</td>
<td>5</td>
<td>0 0</td>
</tr>
</tbody>
</table>

Extra-sized Houses 40s. per Room.

GROSS ESTIMATED RENTAL.

New houses.

Subject to a deduction of one-sixth, or 16⅔ rds per cent. for repairs.

<table>
<thead>
<tr>
<th>House Type</th>
<th>Rooms</th>
<th>Rental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Cottage, 1 Room</td>
<td></td>
<td>£3 0 0</td>
</tr>
<tr>
<td>Double Cottage, 2 Rooms</td>
<td></td>
<td>4 0 0</td>
</tr>
<tr>
<td>Single House, 1 Room and Loft</td>
<td></td>
<td>3 10 0</td>
</tr>
<tr>
<td>Double House, 2 Rooms and Loft</td>
<td></td>
<td>4 15 0</td>
</tr>
<tr>
<td>Do. 3 Rooms</td>
<td></td>
<td>5 10 0</td>
</tr>
<tr>
<td>Do. 3 Rooms and Loft</td>
<td></td>
<td>6 0 0</td>
</tr>
</tbody>
</table>

The writer is satisfied that the adoption of this scale for rating miners' houses is fair as between the unions and parishes and the coal-owners, and the adoption of it will greatly facilitate and simplify the question of the miners' houses.

Mr. W. A. Potter moved a vote of thanks to Mr. Hedley for the paper he had read. He was absent from the last meeting, but he had

* These are the very old "Pit Cottages" built many years ago.

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heard the merits of the paper much and very favourably discussed. He was sure they were very much indebted to Mr. Hedley in this neighbourhood for the pains he had taken in collecting information and endeavouring to do justice between the owners of collieries and the public bodies for whom he acted; and although it was complained that he raised the rateable value of colliery property to an enormous extent, yet he believed it had been done on a consistent and equitable principle.

Mr. G. W. Southern had very much pleasure in seconding the motion. He was sure that Mr. Hedley's supplemental paper would form a very important paper to the original one.
The Chairman in putting the motion, which was unanimously carried, said that he hoped that Mr. Hedley would prepare himself against the next meeting to consider whether in estimating the rental, which should form the basis of the rating, he had taken sufficiently into account the fact that collieries were exhaustible, and that when the coal was worked out, the entire sum of money which had been expended upon plant was in a great measure lost.

Mr. Hedley said, he was very much obliged to them for the honour they had done him, and remarked that he had fully considered the point raised by the Chairman. It was one in which he had taken very great interest, and in fact he had taken steps to bring the matter under the consideration of the Legislature when it was dealing with the question of the rating of mines. The Court of Queen’s Bench has decided that the question of the exhaustion of the Corpus cannot be considered. He advised the Coal Trade to unite as a body, and endeavour to establish the justice of their views upon this important branch of the subject, when the local taxation scheme, which would no doubt be introduced either in the present or the next session, was discussed in Parliament, and secure a reasonable allowance from the royalty rents. He would illustrate his views of the matter by stating that he thought no prudent man, with an income of a thousand a-year from mineral property, would live up to it (for, if he did, when the royalty was exhausted he would have nothing more to live upon); he would lay aside sufficient to enable him when one royalty was exhausted to buy another.

With regard to the buildings and shafts being comparatively of little value when the coal was worked out, the assumed landlord would require more rent from the lessees, therefore the percentage for estimating the value of the shafts and buildings ought also to include a sum which a prudent landlord would expect the tenant to pay in order to form a redemption fund to recover his capital when the mine ceased working; but that would only affect the gross estimated rental, and not the rateable value. The rateable value was the question which affected the lessees who had the rates to pay. However, he was quite prepared, if any of these questions arose, to give them his best consideration. His only object was to make the matter as plain as possible, and to relieve all persons concerned from loss of money by litigation, for he was convinced that it required only a little common sense and reason to cause any difficulties entirely to vanish that might arise on this question.

[141]

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PROCEEDINGS.

GENERAL MEETING, SATURDAY, MAY 2nd, 1874, IN THE WOOD MEMORIAL HALL.
A. L. STEAVENSON, Esq., Vice-President, in the Chair.

The Secretary read the minutes of the last meeting, and reported the proceedings of the Council.

The following gentlemen were then elected:—

Members—
Mr. Thomas Southworth, Hindley Green Collieries, near Wigan.
Mr. Harry Gill, Consulting Engineer, Newcastle-on-Tyne.
Mr. J. T. Bell, Wolsingham, via Darlington.
Mr. John Swallow, East Castle Collieries, Annfield Plain, Lintz Green.
Mr. William Jenkins, Manager, Consett Iron Works.

Students—
Mr. W. T. Hallimond, Etherley Colliery, Escomb, Bishop Auckland.
Mr. Wm. Thompson, Washington Colliery, County Durham.
Mr. H. F. Bulman, Killingworth Colliery, Newcastle.
Mr. F. S. Avery, Killingworth Colliery, Newcastle.

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

Honorary Member—
Mr. Ralph Park Philipson, Newcastle-on-Tyne.

Members—
Mr. M. R. Waldo-Sibthorpe, Saltburn-by-the-Sea.
Mr. W. C. Eaton, Saltburn-by-the-Sea.

The Secretary said he had a telegram from Mr. T. F. Hedley, from the County Court, Durham, saying he was engaged there with the County Rate Court, and was sorry he could not reach Newcastle in
time for the meeting that day. He asked him to get the discussion adjourned. He had also a few notes sent to him by Mr. Greenwell, who asked him to read them to the meeting. He supposed that, as Mr. Hedley was not there, it would be as well to postpone both the discussion and the reading of the notes.

It was agreed that Mr. Greenwell’s notes, which follow, should be taken as read:—

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REMARKS ON MR. HEDLEY’S PAPER "ON THE VALUATION OF MINES FOR THE PURPOSE OF LOCAL TAXATION."

BY G. C. GREENWELL, F.G.S., M. Inst. C.E.

In this paper, which has, generally, been carefully got up, the writer begs to draw attention to what appears to him to be an important omission: it is that of the word "no," between "have" and "power," in the sixth line from the bottom of page 118. And he also thinks it is to be regretted that Mr. Hedley does not give the authorities for the extracts from the "statutes in force," and the "decisions thereon," which he gives in page 120. The writer would not make any further remarks on this paper until he arrives at Mr. Hedley’s "illustration," by comparison of "Farm" and "Coal Mine," in page 122, and afterwards; and to his illustration, to which he most decidedly objects.

Mr. Hedley says: "As it is with a farm, so it is with a current going colliery." Should "not" be interposed between the "is" and "with" of the middle of the sentence?

If the rent of the farm were to be paid in consideration of the tenant bodily removing a certain specified number of square acres of the land, Mr. Hedley’s illustration would be unexceptionable.

The writer entirely agrees with Mr. Hedley, that no one ought to be found to contend "that the royalty or rents paid for the coal, or the mine rent alone" can be taken as the rent at which a current going colliery might be reasonably expected to let at from year to year; and his reason for agreeing with him is that the writer cannot admit that the royalty (wrongly called rent) is rateable at all. The great mistake of calling royalty rent is the root of the difficulty which has surrounded the question. As in the case of the farm, quoted by Mr. Hedley in his "illustration," would the annual amount pay for the acres, bodily removed, be called rent? In addition to the land occupied by the colliery, it is the plant only, and not by any means the whole of that, which ought to be rated.

It may be that in many cases of valuable collieries, there would be very little to rate; but this has nothing to do with the question.

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It may be that in many cases of much less valuable collieries, there would be a great deal to rate; but neither has this anything to do with the question.
The coal, in the first instance, would simply be worth more royalty to the landlord than in the latter (other things very equal), but this is entirely apart from rateable value.

It is to be regretted, that the wise and common-sense decision, quoted in page 125, that "it cannot be said when a farm is let, the year’s profit on each particular crop is to be taken into consideration in fixing the rate, and the value cannot be ascertained by enquiring whether the property was more or less beneficial in a particular year," has not governed the practice of assessment committees, in the recent course of action which many of them had taken. It is difficult to see the consistency between the judgment, quoted in page 121, and the observations at the foot of page 122. A landlord does not raise his rents because his tenants have had an exceptionally good year of shopkeeping. If in addition to his letting shops he sells a raw material which can be manipulated, and from which the tenants can derive a larger profit than they could last year, he will probably (if he can) raise his price to his tenants; but that is not a rating question. It is a question of profits, not rateable. (Queen and Aylesford.)

The principal object in making the above remarks is, as far as possible, to promote such a ventilation of the subject as may assist in bringing about some satisfactory and equitable mode of settling this much vexed question before the impending legislation or local taxation takes place.

The above remarks on Mr. Hedley's paper will be read and discussed at the meeting of the Institute, in June.

The Chairman, at the last meeting, wished to ascertain if Mr. Hedley had taken sufficiently into account the exhaustibility of the coal when rating a colliery; if a sum of £10,000 was spent in putting up machinery, boilers, or furnaces, it continued for ever, or as long as they were kept in repair. But it was not so with a colliery. If £50,000 or £100,000 was put into a colliery, in the course of a few years the coal was gone and with it the capital; and he thought, therefore, that the rateability of the colliery should be considered in reference to this.

Mr. D. P. Steavenson said, that a mining engineer had come into his chambers that morning, and told him that at the last meeting the

question had been asked whether, in rating a coal mine, the fact that the coal mine was exhaustible ought to be taken into account in such rating? In consequence of what this gentleman said, he, having the books to his hand, looked up the cases, and he found two cases which were decided in 1847, the Queen v. Westbrook, and the Queen v. Everist, in which the question was, whether a brickfield was rateable. Now, it would appear to him, and he thought to the meeting, that a brickfield was more certainly a subject of exhaustion than a coal mine. A brickfield was generally a confined space of a few acres, and it was easy to tell from that how soon it would be exhausted. The layer of clay lay only perhaps a few feet from the surface downwards; and therefore, generally speaking, it could be absolutely calculated when that layer would be exhausted, and when no further rates could be levied upon it. Now, this case decided the question of exhaustion, for a
brickfield cannot be taken into account. But it went further: it said that if any tenant could be found who would give a larger rent than the rental the person in the occupation of the field was paying, taking into consideration the royalty as part of the rent, then that enhanced rental had to be the basis upon which the rating had to be taken. Now, he thought this went very far in deciding the question which the Chairman asked at the last meeting; because, supposing that a coal proprietor were paying a rental, say £300, for his coal mine, and supposing he were paying also a certain small royalty, if another tenant could be found, or if a practical valuer were to come and say, "I estimate that, if that coal mine were rented by a person who had to pay no royalty, he would pay a rent, not of £300 but of £900 or £1000," then the Quarter Sessions, to whom an appeal would lie, would at once decide that that coal proprietor was liable to be rated upon that enhanced value of £1000. That was not his own dictum, but it was a decision which, as he had already said, was come to by the Court of Queen's Bench in 1847. But beyond that decision, there had been a number of other decisions about chalk quarries, stone quarries, gravel pits, and others, which he did not remember, all of which were exhaustible. The bed of gravel could be seen, perhaps, as it was deposited in the ground; and yet it was always held that the rent which a tenant would pay for taking that gravel away, although the taking away might exhaust the pit in a short time, was the value upon which the property had to be rated. Now, he thought that this answered the president's question very fully as to exhaustion. Perhaps before he sat down he might say a word or two upon pit cottages, and he thought that what he did say would be more by way of

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warning to coal proprietors for the future than anything which had been decided. But the warning he would give would be from decided cases upon other matters, which were very similar to this. Pit cottages had been, and would still become, more and more the subject of discussion as to whether the pitmen could have a vote. Already they had votes for boroughs, on account of pit houses. Soon, he had no doubt, if any of these cottages could be brought up to the rental which entitled a person to a vote for the county, they would have their votes for the county; and therefore it was certain from the continual advance which the country is making, this question of "Can the pitmen vote for the county?" would be forced on; and an endeavour made, if possible, to bring up the rental of the houses, so as to give a vote for the county in which the houses are situated. Now, in comparing pit cottages with such a subject as a loop line of railway, and such a subject as a tramway, it led him to the opinion that a pit cottage was a very dangerous thing for a proprietor to hold; because there was a case decided in January last, where the London and North-Western Railway Company had a small cross line which they bought, perhaps to exclude two other companies from running into a certain place. It came before the courts as to how they were to be rated for that cross line. They gave the shareholders of the loop line their full share in the general stock; but they charged a very small percentage for the traffic indeed upon this cross line: that was for the purposes of opposition. Well, when the question of rating came before the Sessions, it was held that if any person, or if the two other companies could be found—and they could be found, they were at hand—to give a larger sum as the rental of this loop line, then the loop line was to be rated not as the London and North-Western Railway Company were rated, but according to the rent these other two companies would give. A tramway was another question: in the case of a Tramway Company, the question was raised of whether a tramway, which ran through the street, was to be rated to the poor. In that case the
Sessions held that a tramway, which seemed to be a very doubtful subject for rating, was rateable to the poor. Now, what he deduced from these cases with respect to pit cottages was this: suppose it should happen that a pit, say at Gateshead, or lying just without the boundary of Gateshead, had a large number of pit cottages; that twenty of these cottages were in Gateshead parish where the rents were high, and that some were in an adjoining parish where the rents were low;

then, if it should turn out, upon the valuation of such a mine by the learned gentleman who had read this paper, or by others, that the cottages in Gateshead were of greater value than the cottages in the neighbouring parish, he was afraid that the latter cottages would be rated at the larger rentals; and therefore the coalowners might find that those cottages were not rated as part of the plant of the colliery, but at the enhanced value in consequence of their being in a particular local situation. The meeting would easily draw the conclusion he had always drawn as to the value of pit cottages. The question would be forced upon the courts and the Legislature, that these cottages should each of them be rated as a separate house, as all other houses are; and then they might find that, unless the owners were careful not to let the pitmen rent the cottages but to keep them themselves as part of their plant, and as a convenience to the pit, they would have pit cottages going up in a short time to extraordinary rateable values, which would, he had no doubt, not please the owners of the pits in this district.

Mr. Willis said, there was one little question which Mr. Steavenson had mentioned about the rent of a mine being something like £300. He thought there was a little misconception on this point on the part of Mr. Steavenson; because, in addition to this £300, he mentioned royalty. He would like to ask Mr. Steavenson whether he meant £300 as certain rent, or rent of the land occupied by the pit; and the engine-houses, and so on?

Mr. Steavenson thought he could easily answer that by saying that the case he referred to was exactly this: the person who rented the brickfield rented it for £2; he also paid a royalty on every thousand bricks, of some 1s. 6d. a thousand. It was held on the valuation that a tenant without paying the royalty would give a rental of £10 a-year and it was held by the Court that the brickfield was rateable upon £10 a-year. Mr. Willis supposed he was restricted in the quantity of bricks he made?

Mr. Steavenson said there was no restriction. He was not quite sure of his figures, but he remembered the point; and he believed that the tenant had worked some three millions of bricks in one year; and the total of the last year was taken, he believed, as the average which could be worked with three brick-moulding stools in one year.

The Chairman said, the question which he raised was as to the capital put into the concern. In a chalk pit, no capital could be put at all; and it was the same with a brickfield.
Mr. Steavenson thought this was pretty well looked after in consideration of the profits they paid. It was hardly a matter of rating.

The Chairman—No; but it ought to be considered as a matter of value.

Mr. Bunning said, that Mr. Steavenson had just brought vividly before his imagination one question which had often before much exercised him—that was the great question of whether it was advisable for colliery owners to possess a large plant of cottages. In other districts they did not do so. In Wales, he understood, and in Staffordshire, and in fact in almost every district except Durham and Northumberland, the coalowners did not provide cottages for their pitmen. Of course professional gentlemen would be more able to form an idea of the peculiar requirements of the district; but it struck him, from what Mr. Steavenson had said, that this question really was an important one, and should be considered for many reasons. Although a pit population collected round certain localities where houses were difficult to get, might be advantageous to the working of the colliery, yet there were times, for instance during a strike, when the men live very quietly in the owners' houses, and burn their coals, without doing any work for them, and he thought such an arrangement was most undesirable. Now, the question of getting over that difficulty had sometimes passed through his mind, and it seemed to him it would not be a bad idea to get a limited joint-stock company to buy up all the pit houses in Northumberland and Durham and to let them to the colliers. Of course, the proprietors of the joint-stock company would most likely be in a large measure colliery owners; and the houses would of course be let for the purposes of the pit; but they would be a perfectly distinct plant from the pit, and would be dependent upon perfectly distinct sources for the payment of their dividends. He might say that he had consulted with several parties upon the subject—some legal gentlemen amongst others—and it was thought that such an arrangement would be beneficial, but that there would be, owing to the wording of colliery leases and other matters, certain difficulties in the way to surmount which would necessitate having a special Act of Parliament; but the subject was of such importance that getting an Act of Parliament would be a very minor consideration.

Mr. W. H. Hedley took the gist of Mr. Steavenson's remarks to be that he confirmed Mr. Hedley's statement, that the Court of Queen's Bench had decided that the question of the exhaustion of the corpus could not be considered; and that, on the other hand, he dissented from Mr. Hedley in his view with regard to pit cottages being taken as part of the whole establishment of the colliery, and credited with the same deductions for repairs and insurance that he credited the colliery buildings, such as the engines and the shops with. But he thought that what Mr. Steavenson said did not at all bear upon the chairman's question as to the sources of rent—and of the royalty rent, and of the coal, which was exhaustible.

Mr. Steavenson, with regard to the first point, might say that he differed from Mr. Hedley in this—that no doubt at the present time pit cottages were, he believed, considered in the rating as part of the plant of the colliery. But what he wished to point out was, that the tendency of the decisions of
late was to separate such houses from the colliery plant—not to make all the houses rated as one batch, but to separate each individual house, first as giving a distinct vote, and then, when it was separated with regard to that, it would be very soon found that the Poor-law officers would be only too anxious to separate it for their purposes; and if it had a greater value as distinct from the colliery, then he feared that, considering the two cases he had quoted, the London and North-Western Railway Company, and the Queen v. Guest, it would be held that it should be rated at the enhanced price, and not at the price as one cottage of the corpus of the colliery. With regard to the other question of the capital expended, he did not think that this question had ever been touched by any distinct case upon collieries. But he apprehended that if the question of the capital expended was taken into consideration in the same way in rating now, he did not think any alteration was likely to be made in that because of the exhaustion.

Mr. W. H. Hedley said, that in Mr. Hedley's example of rating he did not take at all the capital expended on fixed plant, as it might be called; the shafts, building, and machinery; he simply made an allowance for repairs, insurance, and risk, which did not include any allowance for redemption of capital; and he would ask Mr. Steavenson if he would hold that the word "corpus " included this, or simply the coal?

Mr. Steavenson said that the investment of capital was settled by another case, that of Guest and Dean. There it was held that the capital which had been spent upon buildings, cottages, machinery, and so on (although the mine itself—an iron mine—was not rateable) had improved the value of the land which was above the mine; he therefore took it that the capital expended became really the plant, and the rent which would be derived from that plant, so long as the mine was worked, would be a certain rateable sum of a certain value. When the mine ceased to be worked, then the plant would become valueless; and he thought that no reduction could be expected or had ever been made, for redemption of capital.

Mr. W. H. Hedley proposed that the discussion be adjourned to the next meeting.

Mr. Willis seconded the motion; and it was carried unanimously.

The meeting then terminated,

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PROCEEDINGS.

GENERAL MEETING, SATURDAY, JUNE 6th, 1874, IN THE WOOD MEMORIAL HALL.

E. F. BOYD, Esq., in the Chair.

The Secretary read the minutes of the last meeting, and reported the proceedings of the Council.
The following gentlemen were elected, having been previously nominated:—

Honorary Member—

Mr. Ralph Park Philipson, Newcastle-upon-Tyne.

Ordinary Members—

Mr. M. R. Waldo-Sibthorpe, Saltburn-by-the-Sea.

Mr. W. C. Eaton, Saltburn-by-the-Sea.

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

Members—

Mr. Vladimir Vondracek, Mahrisch Ostran, Moravia, Austria.

Mr. Franz Reska, Machinen Fabrik, Prague, Bohemia.

Mr. Josef Hybner, Mahrisch Ostran, Austria.

Mr. Josef Kasalousky, Florenz-strasse, Prague, Austria.

Mr. William Cuthbert, Beaufront Castle, Northumberland.

Mr. George Fletcher, Hamsteels Colliery, near Durham.

Mr. Henry Hornsby, Whitworth Colliery, Ferryhill.

Mr. Robert Wilson, Flimby Colliery, Maryport.

Student—

Mr. W. J. Southern, Tanfield Lea Colliery, by Lintz Green.

The Secretary said, he had received letters from Mr. Hedley and Mr. Hurd, stating that they would not be able to be present at the meeting.
The Chairman said, they would be very glad to hear remarks from any gentleman with regard to Mr. Hedley's paper on the rating of mines. He himself had one remark to make, and that was with regard to the observation which occurred in Mr. Hedley's paper in quoting evidence as to Royalty rent. He thought it only proper for him to draw the attention of the Institute to the observation which was there made. If it went forth to the world unchallenged, he thought the notion would be that their rentals for coals, one of the most important items to be considered in the circumstance of rating, were all charged 1s. per ton. He himself fancied that the coal trade of this country, and they themselves as largely representing it, would not wish such a representation to go forth as the usual rent for which coal was now being let. It was very well known that all the leases which were dated 20, 30, or 40 years ago, and had 50 or 60 years to run, were down to 18s. or 20s. a ten, which was not more than 4½ d. per ton; and if it went forth at all, that some of the coal in the county of Durham had actually been let for 1s. a ton, this explanation ought also to have accompanied the statement, viz.,—that the advance took place at a peculiar period arising from a peculiar condition of the coal trade, that trade having come to an abnormal state of prosperity. He did not doubt that the shilling might be fair in some cases, but it was well known that very recent lettings had been made at from 6d. to 9d. per ton, and it should not go forth to the world he thought, that the standard of their rents was always and universally a shilling.

Mr. Steavenson thought Mr. Boyd's argument showed clearly that the rent was hardly a proper basis, because those who were paying a high rent would be rated much higher than those who were paying a low rent, and those who were paying a high rent were so much less able to pay the rate than those who were paying a low rent.

The Chairman said there was a question whether coal, being an exhaustible material, should only be rated at the current value during the time of its working.

Mr. W. H. Hedley thought that on this point both Mr. Hedley and Mr. Steavenson stated very clearly that the law was such that the question of the exhaustion of the corpus could not be allowed for, and decisions of the Court of Queen's Bench had settled this very conclusively. But Mr. Hedley in his paper suggested that action should be taken by the coal trade to get Parliament to alter the law, that some percentage allowance should be made for the exhaustion of the corpus in assessing the rateable value.

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Mr. W. H. Hedley desired to make a few further observations, and would refer to the points in the order in which they occurred in the paper. One or two were in the shape of questions, not, it might be, of much importance, but which if the discussion were not closed to-day, Mr. Hedley would perhaps take opportunity of answering at another meeting.

At page 124, an instance is quoted of engines, shops, and other colliery buildings having been let at a rental of £3,000 per annum. Now in connection with a question previously raised as to the propriety of an allowance being made for redemption of the capital invested in plant, he would ask Mr. Hedley how he would treat this rental for rating purposes; merely remarking that in assessing the amount the lessor would doubtless take care that it should include, besides a fair interest, such an addition
as would serve to recoup his original capital outlay; and that, therefore, almost as fairly might the instalments which a man repays to a building society for a house built out of its funds be treated as rent, as that the full £3,000 should be made the basis of rating, subject to the ordinary deductions only.

At page 126, the evidence of Mr. J. W. Pease, M.P., is quoted on the question of royalty rents, and to the effect that "Royalties cannot now be taken under a shilling a ton." This being the only tonnage rate mentioned in the paper as now prevailing, it might, if allowed in this discussion to pass unchallenged, come to be accredited with the additional authority of this Institute. The chairman has already alluded to this matter, and it may, for obvious reasons, be desirable that there should be some expression of opinion from other members; and he would venture to state as his view, that in the past year or two royalty rents for new lettings in Durham and Northumberland had varied between 4½ d. and 1s. per ton, the bulk and the average rate being probably 8d. or 8½ d. per ton. In the same page (126) it is said, that "the rent of the coal is determined chiefly by the probable cost of sinking or winning it." In many instances this doubtless is so; but in others the distance from the shipping port or other market affects the matter even more largely, and in others again the quality of the seams enters materially into the question, differences on this account being not unfrequently made in the same royalty.

Page 129, the author refers to a class of outlay—"Pumping unexpected feeders"—which could not be allowed for in fixing the rent under the lease. He thought the author indicated (but will he kindly make it clear), that he would in dealing with such cases, rate the additional plant, but make an allowance or deduction for this in estimating the tonnage rent on which to rate the coal?

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In connection with the example valuation given at page 137, and with particular reference to the royalty rent of £4,105, would the author allow him to ask what has led him to abandon (apparently) the principle enunciated in a letter to the Hon. P. Wyndham, of date May 9, 1867, namely—in estimating royalty rent for rating, to capitalise the value of the coal, and then charge it with a like interest to the colliery buildings. For this system, it may be remarked, appears, if admissible, to afford means indirectly of compensating for the exhaustion of the "Corpus," namely, in the difference between the higher interest usually allowed to a purchaser of coal in estimating the capital value, and the lower interest which for equality of rating it might be reasonable to charge for rating purposes.

For the former, 10 years' purchase is suggested in the letter referred to; and as interest to determine rating, that now used in the paper for plant—6½ per cent.—might be fair to adopt. Applying these figures to the example case—

Rent, £4,105 x 10 years' purchase = £41,050

£41,050 rated at 6½ per cent. interest = £2,668

Allowance for insurance, risk, &c, ¼th = 667
As compared with £4,105, less ¼h in the paper

Being a difference in the nett result of

which amount of reduction would, it must be admitted, sufficiently allow for the exhaustion of the "Corpus."

The Chairman said, he had heard Mr. Simpson make a slight remark upon the difference in the cost of pumping in different collieries. If one pit happened to be at the dip of another, and got the water from his neighbour, and had all the pumping apparatus to put up, it does seem reasonable that he should be rated in the township where his place was, for doing his neighbour a good turn.

Mr. J. B. Simpson would put the case in this way: suppose two royalties adjoined each other, both having the same rent and apparently at the outset the same in every respect; but afterwards at one of them it was found that a pumping engine was necessary. According to his reading of Mr. Hedley's principle of rating, the lessee who had the extra capital to expend in pumping machinery, &c, together with probably an annual cost of £2,000 or £3,000, would be rated higher than the other who had not this expenditure to encounter. He (Mr. Simpson) did not think this was a fair basis, and some other system should be laid down so that an equitable rating of such circumstances should be arrived at. The same thing might be said with regard to a colliery waggon-way. Take a colliery situated close to a public line, and another three or four miles from it. On the present system of rating, the colliery which had the waggon-way would have to pay a greater rate than the one which had neither the capital nor the annual expense to provide against.

Mr. W. H. Hedley thought that, according to Mr. Hedley's own mode of stating the question, he would make allowance for collieries exceptionally burdened in assessing the royalty rent, or estimated tonnage rent for rating purposes.

Mr. Simpson thought Mr. Hedley's method was based too much on the profit principle, as he was now increasing all the rates in the parishes in consequence of the high price of coal. A farmer who has a lease of a farm pays a certain rental per annum, but if there is a particularly fine season to favour him he does not pay more rate on that account, for as a rule the rate is based on the rent. The same should hold good with a colliery, for it is subject to bad as well as good years, and it was very difficult to get the authorities to reduce rates in bad years. Putting the rate at 1s. a ton, as Mr. Hedley has it, was certainly too high for present purposes, for although in some instances this has recently been paid, yet it is very much above the average of present lettings.

Mr. Steavenson thought they would be very apt to get into fancy bases of rating, unless they took care, which would probably give rise to considerable irregularities. The question was, having a parish
which had to raise, say £1,000 a-year in poor rates, how could all classes of property, colliery property, house property, and farm property, be equitably rated so that they should each bear a share? It appeared to him that the question of what the colliery would let for annually was the most fair way of coming at it. What would the house let for? what would the farm let for? and what would the colliery let for? every attendant circumstance being taken into account.

Mr. Simpson thought Mr. Hedley's peculiar views were now increasing all the rates in the parishes in consequence of the high price of coal. Take a farmer, who took a lease of a farm for 10 or 12 years; he paid a certain rental per annum; if he had got a particularly fine year of sunshine to favour him, he did not pay more rent on that account. It was the same with a colliery: you might have good years and bad ones; but they would not get the parish authorities to reduce the rates when the colliery had a bad year; and he (Mr. S.) thought that to put the royalty at a shilling; a ton was far too high for present purposes, for he believed that in this district a shilling a ton was nothing like the average of those which were being let even in these very high times.

Mr. W. H. Hedley did not think Mr. Hedley had taken it at a shilling a ton on account of the enhanced profits; he did so because he supposed the royalty would let for a higher rental than before. Indeed, Mr. Hedley distinctly affirmed that he did not consider the question of profits had anything to do with the question of rating.

The Chairman—That is one of his remarks. Then as to the question of cottages, had any of them considered that point—as to the rate at which cottages belonging to an establishment ought to be rated in the poor-book? If they happened to be situated in two different townships; if one of them not in the township where the general plant of the colliery was situated, it came rather hard upon that colliery to pay in each township, according to where the cottages were placed.

Mr. Steavenson—Yes, but it might happen that a colliery adjoined a town, such as Gateshead, where plenty of houses could be obtained without building any; and therefore the colliery got free not only from the expense of building the cottages but also of being rated upon them afterwards.

Dr. Page then exhibited some specimens of artificial stones, whose beauty and delicacy of ornamentation attracted at once the attention and admiration of the members. These were Chance's Patent Stone, at one time manufactured near Birmingham, and Ransome's Patent Stone, now prepared on a large scale at East Greenwich. The former was produced by melting in reverberatory furnaces the basalt or "Rowley Rag" of the Rowley Hills, near Dudley, in South Staffordshire, and then casting the molten material in moulds of sand enclosed in iron boxes, which were raised to a red heat and allowed to cool slowly. The rate of cooling was an important part of the process, as rapid cooling produced a brittle glassy mass like obsidian, while slow cooling (according to its rate) produced a granular-crystalline stone of great hardness and durability. The work had been discontinued for some years, but the specimen exhibited (a chimney-head, with
delicate mouldings) showed well the character and capabilities of the substance. One geological advantage of Messrs. Chance's ingenious conception was the light it tended to throw on the nature and origin of the pyrogenous rocks.

Mr. Ransome's process, on the other hand, consisted in pressing sand

or other particles into moulds and cementing them by silicate of lime into a mass of stony hardness and consistency. A soluble silica being obtained from the treatment of flints in caustic soda—a boiling down, in fact, of flints and soda by highly-heated steam, this solution is incorporated with well-washed and sifted silicious sand, and moulded to any form. The silicate which binds the sand in this case is soluble, and the stone would not stand the action of water, but to render it insoluble it is saturated with a solution of chloride of calcium—the chemical results of which is an insoluble silicate of lime and a chloride of sodium or common salt. The silicate of lime now binds the particles of sand indissolubly together, and the salt is removed by copious washings. More recently, Mr. Ransome has succeeded without the use of the calcis-chloride and the subsequent washings which its use involves. This he has been enabled to do by the discovery of a silicious mineral near Farnham, in Surrey, which is readily soluble in caustic soda at a moderately low temperature. By this latter process he combines a portion of the Farnham stone, or soluble silica, with a solution of silicate of soda or potash, lime, sand, alumina, or other suitable materials, which, when intimately mixed, are moulded into the required form as heretofore, and allowed to harden gradually, as silicate of lime is formed by the combination of the ingredients present. The mass then becomes thoroughly indurated and converted into a compact stone, capable of sustaining extraordinary pressure, and increasing in hardness with age.

This stone, specimens of which were exhibited of great beauty of texture, and sharpness and cleanness of moulding, was suitable for all architectural and decorative purposes, and obtainable at a very moderate price. It was also formed into grindstones, whetstones, &c, and by substituting emery for sand, cutting wheels of unrivalled power and durability, were now produced at a cheap rate. Specimens of these wheels were also exhibited, the Professor remarking that so vast and varied were the capabilities of Mr. Ransome's Patent that he believed it could be brought to tub a shaft as well as to form a grindstone.

Mr. W. H. Hedley inquired whether the substance which Dr. Page had shown was of a porous character or impervious to the passage of water?

Dr. Page said, it could be made porous or impervious; and so porous that the finest filters of the present day were made of Ransome's patent material.

The Chairman asked if it was the pleasure of the members to render thanks to Dr. Page for the trouble he had taken to introduce this very
interesting question in applied geology to the meeting? He thought the Institute as well as the College of Physical Science was interested in it; and it might happen to be a very valuable application to some of their mining operations. He begged to propose a vote of thanks to Dr. Page.

Mr. J. B. Simpson begged to second the motion.

Dr. Page said, the Newcastle grindstone was supposed to be known all over the world; but he was not sure whether with Ransome’s sharp-cutting stones they would be able to maintain their place.

The motion was carried by acclamation.

The Chairman having asked if any one knew how the South of England Boring was going on.

Dr. Page said, he believed that the Sub-Wealden Boring Company had now passed through upwards of 200 feet of the Kimmeridge shale, showing that they had got into the deep-sea side of the oolite; and there they had an enormous thickness of shale, which does not appear in the midland counties. That rather went against the original idea of finding the palaeozoic ridge which was to have been met with at the depth of 500 or 600 feet. The entire boring was now well on to 800 feet.

Mr. Steavenson did not know whether it had yet been mentioned at the Institute, but at some of the shafts which occupied his attention at present they had come down upon the true basalt at 60 fathoms, 19 feet in thickness, lying quite horizontal, the rocks, as they approached it, were all altered by the heat; and after they had passed through it, the coal at a depth of several fathoms showed traces of heat, although the intervening rocks ceased to show it. In Scotland there were several cases where this basalt had been met with in a horizontal form, apparently broken away from whin-dykes in the neighbourhood.

The Chairman—What distance are the shafts alluded to from the whin-dyke?

Mr. Steavenson—They are a mile at least. They met the basalt in this horizontal condition, and of course for some time they were in considerable alarm; for they did not know how many fathoms there might be of it, and they might have to abandon a considerable winning. One shaft was at the Browney, about two miles from Durham, and he would be glad to allow any gentleman to examine it.

Dr. Page said that these beds of basalt in the coal-fields of Scotland were extremely capricious. In the parish of Ballingry the basalt

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appeared as a superficial overflow which had to be sunk through to reach the coal which lay undisturbed below. He had gone round it many times, and could discover no connection with any neck or dyke; so that great denudation must have taken place to sever it from the source from which it originally came.

The Chairman—As in Mr. Steavenson’s case.
Dr. Page—At Sunniside, however, it evidently came from a dyke—a dyke which had come up during the coal period, because, it must be observed, the dyke was covered by the other strata. This dyke had overflowed, and they had it for about a mile and a half, and then it thinned out, and they were no further troubled with it. Again, at Kirkcaldy, the basalt had flowed over the beds when they were sedimentary and horizontal; and after the beds were tilted up, the overflow of basalt had been tilted up at the same angle. There they had to sink through 130 feet of whin; and the only neck that they could trace it to was about two or two and a quarter miles to the west. Its abrupt edge came and cropped out exactly like the beds of sandstone and shale. He could give a dozen cases of these basalts that had had to be sunk through in the Scotch coal-field; and really they were the most capricious and puzzling things which the miner had to deal with.

The Chairman remembered one in Ayrshire.

Dr. Page—Yes; there were several.

The Chairman—A little to the south and east of Ayr, there were coal-measures overlaid by basalt in the same way, and which became almost the same as Welsh anthracite coal.

Dr. Page—Yes; and north of Dunfermline it had affected the coal materially; but in the instances he had mentioned the coal was good and pure, and not in the least affected by the overflow.

Mr. Steavenson said, the stone they went through at Browney was so hard that with eight men a shift and three shifts in the 24 hours they only got two inches per day for weeks; and it took four months to get only 19 feet sunk. They kept men drilling for six hours, and they could only drill a hole about a foot deep.

Dr. Page—Have mechanical means of boring been tried?

Mr. Steavenson—Yes; but they had hitherto not been able to compete with hand labour in point of cheapness.

The meeting then terminated.

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PROCEEDINGS.

GENERAL MEETING, SATURDAY, AUG. 1st, 1874, IN THE WOOD MEMORIAL HALL.

Mr. R. S. NEWALL, Vice-President, in the Chair.
Messrs. Wallace, Crone, Nelson, and Laws were appointed scrutineers of the voting papers.

The Secretary read the minutes of the last general meeting; and also the minutes of the Council meeting of July 25 and of that day.

The Secretary read the report of the Finance Committee.

The Vice-President thought that the report of the Finance Committee was extremely satisfactory; and he hoped that next year, instead of £1,730 they would have £1,875 as their income. They were going on adding to the number of their members. There was a large number to be balloted for that day; and their capital, instead of producing 4½ per cent. as it did with the Tyne Commissioners, would give 6 per cent. now it was invested in the Institute and Coal Trade Chambers Co. He thought the suggestion as to the change of investment was a most valuable one; because, by-and-bye, as their funds increased, they would be able to invest in further shares, and consequently obtain the whole building. The hall in which they then were seated being at present their property, and the adjoining building being only partially theirs, was an additional inducement for them to acquire the whole. They had to thank Mr. Bunning for the suggestion; and he thought it an exceedingly practical and useful one. He moved that the report be adopted.

Mr. A. L. Steavenson seconded the motion, and it was carried unanimously.

The Secretary read the report of the Council.

The Vice-President hoped that the report would meet with the approval of the meeting. It seemed that, on the whole, they were going on very satisfactorily. The report referred to the publication by the Institute of Mr. Watson's borings. It was expected that the book would be published within the next half-year. He moved that the report be adopted.

Mr. Cochrane had great pleasure in seconding the motion, which was carried unanimously.

The following new members were elected:—

Members—

Mr. Vladimir Vondracek, Mahrisch Ostran, Moravia, Austria.

Mr. Franz Reska, Machinen Fabrik, Prague, Bohemia.

Mr. Josef Hybner, Mahrisch Ostran, Moravia, Austria.

Mr. Josef Kasalousky, Florenz-strasse, Prague, Austria.

Mr. William Cuthbert, Beaufront Castle, Northumberland.

Mr. George Fletcher, Hamsteels Colliery, near Durham.

Mr. Henry Hornsby, Whitworth Colliery, Ferry hill.
Mr. Robert Wilson, Flimby Colliery, Maryport.

Student—

Mr. W. J. Southern, Tanfield Lea Colliery, by Lintz Green.

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

Members—

Mr. William Eltringham, Clavering Place, Annfield Plain, Lintz Green.

Mr. Charles J. Potter, Heaton Hall, Newcastle-upon-Tyne.

Mr. William Moor, Engineer, Hetton Colliery, Fence Houses.

Mr. James A. Thompson, Engineer, South Derwent Colliery, Annfield Plain, Lintz Green.

Mr. William Rutherford, Milkwell Burn, etc., Collieries, Lintz Green.

Mr. John D. Kendall, Roper Street, Whitehaven.

Mr. J. H. Straker, Willington, County of Durham.

Mr. H. F. Wild, Rhinebeck, New York.

Mr. Nathaniel Thoburn, Merthyr Dare Colliery, Merthyr Tydvil.

Mr. W. Dakers, Jun., Colliery Viewer, Birtley, County of Durham.

Student—

Mr. W. H. Telford, Cramlington Colliery, Northumberland.

The Secretary read a paper on "Morton's Ejector Condenser," by Mr. W. C. Wood.

[Plate XXXIV. Diagram of Morton's injector condenser]

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MORTON'S EJECTOR CONDENSER.
By W. C. WOOD.

Now that many high-pressure engines are being converted into condensing engines, it may interest the members of the Institute to have laid before them a description of "Morton's Ejector Condenser," which the writer applied two years ago to a large high-pressure pumping engine, which has since been regularly at work with most satisfactory practical results.

This condenser is of very simple construction, the use of an air-pump is dispensed with, and a steady vacuum of 24 to 25 inches is obtained. The apparatus is shown in Plate XXXIV.

The injection water, which is supplied under a head of six feet through the branch B, enters the condenser in the form of a central jet through the conoidal nozzle A, the orifice of which is regulated by the screw and hand-wheel H.

The exhaust steam enters at the branch D, passes through the space surrounding the central water jet, combines with it at the nozzle A, and the whole passes on through the conoidal nozzle F, and into the discharge tube G; this is trumpet-mouthed, increasing rapidly in diameter to the lower end, where it passes away.

The engine to which the condenser is applied is a beam engine of the usual construction. The cylinder is 66 inches in diameter, with a stroke of 10 feet, working at from 5 to 7 strokes per minute, with a steam pressure of from 25 to 30 lbs., and raising about 150 gallons per stroke from 600 feet.

The engine is not in very good condition, and therefore no reliable data as to the precise quantity of water required by the condenser can be given. At present for a vacuum of 25 inches, 400 gallons per minute are used, which leaves the condenser at a temperature of about 90°; the temperature of the injection water being 50° to 55°.

The saving in fuel is fully twenty-five per cent., and in this case amounts to 55 tons per week.

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The cost of condenser, including the necessary pipes and connections, was £180.

The cold water is passed direct from the pumps to the condenser, and although it contains a larger quantity of lime, no inconvenience has been experienced, nor has the apparatus cost anything for repairs since it was set to work.

The Vice-President said, that in the absence of Mr. Wood it was impossible to discuss that paper; because there were questions which they would like to put to the author, more especially with regard to the large quantity of water required. Mr. Wood said he could not give the precise quantity; and it would be well if the meeting would recommend the Secretary to apply to him for that information before the paper was printed and ready for discussion.
Mr. Stevenson—Yes; and whether it was substituted for any other condenser, and to what degree it was an improvement upon it.

The Secretary then read a paper "On the Coal Measures and Lower Carboniferous Strata of Western Newfoundland," by Mr. E. Gilpin.

NOTES ON THE COAL MEASURES AND LOWER CARBONIFEROUS STRATA OF WESTERN NEWFOUNDLAND.

By EDWIN GILPIN, M.A.F.G.S.,

Examiner in Chemistry and Geology, University of King’s College, Windsor, N.S.

During the summer of 1873, the writer was for some time occupied in examining the district on the south side of St. George’s Bay, believed to contain coal seams of economic value. The beautiful sections of the divisions of the lower carboniferous exhibited here, continually suggested comparisons with those of Nova Scotia and Cape Breton, and the following rough observations present some slight interest as descriptive of the still unknown eastern edge of the great Acadia Carboniferous region.

In a paper communicated to the Nova Scotia Institute of Natural Science last December, a general sketch of the district was given, and the localities of the more important mineral deposits named. The last report of the Geological Survey of the island, issued this spring, contains estimates of the value of the coal districts agreeing with this, and points to the ores of copper and lead as the most certain sources of revenue. Up to last year the district presented all the charm of an unexplored country, nothing being known beyond the report of Mr. Jukes, and the vague assertions of the fishermen who spoke confidently of coal-seams measured by the yard. The labours of Mr. Murray, the able director of the Government Survey, have given to the world a valuable topographical map of the shores of the bay and careful analyses of the various sections.

In order to understand clearly the connection between the carboniferous strata of Newfoundland, Nova Scotia, and New Brunswick, the student must go back to the time when the greater part of North America was a vast plain, with perhaps a few low hills showing above the shallow seas; the Appalachians were part of the coal-making region, and the marine limestones of the Rocky Mountains prove them to have been mainly under the sea. Near the course of the present St. Lawrence must have
been the drainage of that period, for the back country of New York and Canada contained azoic rocks of moderate elevation. The sombre and fathomless valley of the Saguenay may then have been the shallow bed of a palæozoic brook, while away to the south and east stretched the Silurian and Laurentian hills of Nova Scotia and Newfoundland.

The waters of this great eastern sea thundered against the ancient cliffs and gradually deposited immense beds of conglomerate. When emergence took place there spread from Maine to Newfoundland the marshes and quiet lakes of the coal-producing age. The action was continued till above the productive strata (6,000 feet thick in Pictou county), there came the barren upper measures, whose thickness is given by Dawson at 3,000 feet. The section of a bore-hole put down last summer 500 feet in these measures, gives little beyond gray sandstones, and bluish shales with fire-clay and bands of ironstone, two of which measured 1 foot 6 inches. The beds of this series crop again in Prince Edward’s Island, but no attempts have yet been made to penetrate to the underlying productive measures.

The sea has renewed its dominion over a great part of this region; but its former continuity is proved by the patches of carboniferous rocks along-Eastern and Northern Cape Breton, and the presence of marine limestones in the Magdalen Islands. Portions of the coal-producing measures are left like black patches on the rim of this wide basin, relics of a coal-field rivalling in extent that of the interior continental region, and even surpassing it in thickness and in the value of its coal seams.

For these reasons the carboniferous strata of Newfoundland are very interesting, as from it the conditions that governed the deposits on one side of the Acadia region are obtained, and another link is added to the connection of the coal-fields of Europe and America.

The lowest of the five divisions of the carboniferous rocks, adopted by Acadian geologists, frequently contains peculiar bituminous and calcareous shales, with fish remains and thin seams of coal, resting on beds of conglomerate and coarse sandstone. In some districts the bituminous shales disappear and conglomerates prevail. The formation is not invariably present; in the section given in page 170 it does not intervene between the marine limestones and the Silurian rocks. At Hillsboro’, in New Brunswick, the well-known Albertite vein is found in the bituminous shales of this horizon. In Pictou the bituminous Ganoid shales do not appear, and the conglomerates have undergone extensive metamorphism, so that the conditions of deposit can hardly be deciphered. Taking the various measures exposed on the middle Barrasois River, on the south side of St.

[Plate XXXV, Sketch of St. George's Bay, Newfoundland]
from two to three feet in diameter, are evidently from the range of Laurentian hills to the south, for the abundant rounded fragments of magnetite are indistinguishable in appearance from that found in situ on the flanks of these hills. Other boulders again contain silurian fossils, and mark a series of strata now probably buried under these measures.

The stern Laurentian hills, which have seen the dawn and aided the progress of so many periods in the stony history of the earth, still furnish material for new strata. The torrents which pour over these conglomerates sweep from the hills, boulders identical in appearance with those which ages ago were concreted into solid rock.

The fragments of magnetic ore are frequently visible in the conglomerates of the succeeding periods. The writer observed them scattered in the rocks of a district at least 50 miles square, and corresponding in extent to the range of hills to the south known to contain this mineral. This widespread distribution of the ore shows the gigantic scale on which the deposits were formed, and the amount of ore originally present, when the remains after the waste of ages are engaging the attention of capitalists.

These strata are much disturbed by faults which in some cases do not appear to affect the overlying beds of marl and limestone. The thickness of these conglomerates is calculated by the officers of the Geological Survey at 1,300 feet, probably an under estimate, but the faults and uniformity of the beds render accurate measurements very difficult.

LOWER CARBONIFEROUS MARINE LIMESTONES.

The measures of this group rest conformably on the conglomerates where exposed on the south shore of the bay, and are magnificently developed. The most striking feature in this horizon is the gypsum, nowhere in the Acadia district more prominent than at the Codroy Rivers. From Hillsboro', in New Brunswick, to Cape Breton, it forms a white rim round the coal measures; in some places it appears in lofty white cliffs, in other localities its course is marked by curious funnel-shaped pits. Its horizon is confined to the sedimentary limestones, from which it has evidently been derived.

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The following section, from measurements by Mr. R. Brown, gives a general idea of the strata usually associated with it:

<table>
<thead>
<tr>
<th></th>
<th>Feet.</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed Red and Brown Shales</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>(Frequently micaceous and sometimes argillaceous.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concretionary Limestone</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Soft Blue Clay</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Strong Slatey Limestone</td>
<td>47</td>
<td>0</td>
</tr>
</tbody>
</table>
Soft Blue Marl, with Gypsum near the bottom  32  0
Gypsum  8  0
Soft Green (or Bed) Marl (frequently concretionary)  3  0
Red Marl, with layers of Limestone  28  0
Coarse Limestone and layers of Red Shale  44  0

The shales are sometimes laminated and ripple-marked. The fossils of similar horizons in Cape Breton and Nova Scotia are also common here, embracing Conularia, several species of Spinifer, two of Rhynchonella, and several of Productus, with abundance of Crinoids.

The writer is not aware of similar beds of gypsum occurring in strata of the same age in England, and believes they are confined to the Acadia limestones. To account for these anomalous deposits, the theory has been advanced that during the formation of the sedimentary limestones springs of sulphuric acid were poured out from submarine volcanoes and formed huge beds of gypsum by expelling the carbon dioxide. The action must have been on the grandest scale, for the beds are frequently found over 100 feet in thickness, and at one place in North-Eastern Nova Scotia present a bold cliff seventy yards in height. The action was to great extent simultaneous, for they are found always about the middle series of the limestones, and the district affected by these disturbances extends from Hillsboro' to Cape Breton, and from the Magdalen Islands to St. George's Bay. As far as yet ascertained these outpourings do not appear to have been accompanied by any notable disturbance, for the higher beds follow in regular succession.

The impure earthy limestone of the Salina period in New York has in many places been converted to gypsum, and the action is still in progress. Sulphur springs abound there, one of which is described by Dr. Beck as over a mile long and 160 feet deep, showing the power of the agency concerned and the effects on the rocks below.

That the Acadia gypsum was produced under similar conditions is supported by several facts, among which may be mentioned the occurrence in the beds of bleached quartzile pebbles, as if the action of the acid had been spent on a mass of calcareous matter containing sand and gravel. The planes of stratification are also observed, but no signs of life beyond

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an occasional patch of black bituminous matter. The presence of masses of limestones and anhydrite imbedded in the gypsum is not easily accounted for, but as far as at present can be ascertained, does not suffice to disprove the usually accepted theory. Little, however, is yet known about these beautiful deposits, which are yearly becoming of increased economic value. Over 120,000 tons were exported last year, and sold in the States for about three dollars per ton.
Above the gypsum come calcareous sandstones, red and blue marls, beds of micaceous red shale, and impure limestone; in general characteristics resembling those of the southern border, with the exception of the red marls, which do not appear in beds of equal thickness.

The comparative absence of lamination (the mixture of calcareous matter with sand), and the paucity of vegetable remains, would show that these upper strata were mainly formed in still waters little affected by currents. Mr. Murray gives a thickness of 2,150 feet to the measures of this section. Sir W. Logan, in his section of the Foggins measures, gives the thickness of the carboniferous marine formation at 1,650 feet. He does not include the lower beds of limestone and shale, which would swell its dimensions to at least 2,500 feet. In Pictou it appears to attain a greater size, but no detailed examination has yet been made.

THE MILLSTONE GRIT.

These measures exhibit the conventional characteristics of this series, being little beyond a mass of coarse sandstones with every variety of texture. The remains of plants, with nests and seamlets of coal, are abundant in some of the beds about the middle of the series. Sometimes the carbonised fragments of plants have been replaced by copper pyrites. Generally the beds are of a brown colour, with occasional bands of bluish and red shales. In certain of the beds are layers of pebbles of limestone and quartzite, and fragments of magnetic iron ore similar to that described on page 169, as derived from the Laurentian hills. It is very possible that these pebbles may have come from the underlying carboniferous rocks. None of the limestones, however, showed any fossil remains. Some of the beds were uniform for thicknesses of 20 to 30 feet, frequently passing by imperceptible gradations into finer false-bedded sandstones.

The thickness is probably not far removed from that assigned by Sir W. Logan to the equivalent strata at the Foggins mines, where he measured nearly 6,000 feet of grit rocks underlying the coal measures. This enormous thickness is startling at first, but there can be no doubt in

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this case, for every bed can be measured as it stands exposed in the cliffs, cut and kept clean by the swift tides of the Bay of Fundy. Professor Dawson does not show any rocks of the millstone grit in his sections of the Pictou coal-field, but the researches of the Geological Survey of Canada have proved its presence on all sides of the productive measures, not, however, sufficiently exposed to furnish data for an estimate of its thickness.

It is largely developed in Cape Breton, and well exposed at the base of the productive measures. In crossing from the comparatively soft strata of the coal formation, we immediately find protruding everywhere the sharp, rough edges of the grit rocks, which cover the ground in angular masses, leaving scanty room for vegetation.

THE MIDDLE OR PRODUCTIVE COAL FORMATION.
The greater part of the writer's time and attention was devoted to these measures, but slow progress could be made. The ground was covered either by dense underwood or swamps, through which no prospecting pits could be sunk. The following is a summary of the information obtained.

The point of transition to the productive measures could not be clearly ascertained, owing to the presence of heavy beds of drift. The measures first met for about 150 feet of vertical thickness, consisting of light gray sandstones, with occasional bands of a darker colour, and light, arenaceous shales, holding ferns and casts of trees. About eight miles from the shore the first seam was met. Its thickness is 3 feet 10 inches, with layers of shale in the top. It was bright with mineral charcoal; the amount of ash, from the pieces burnt in the camp-fire, was very large. Where exposed in the bank of the river it appeared to be nipped out by a fault, and could not be traced. Above this came a series of coarse brown sandstones, with casts of calamites. These strata are much broken by faults, with a general course slightly to the north of east.

About 200 feet in ascending order above these sandstones is a 6 inch seam, overlaid by 6 feet of fine gray post containing ferns, and 2 feet of black shale. Above this the measures are concealed; but at about 50 feet, measured at right angles to the planes of deposit, is a seam of very bright coal, one foot six inches thick, resting on three inches of fire-clay, crowded with stigmaria rootlets.

For the next hundred yards the measures are disturbed by a heavy

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fault which is a downthrow going south. Close to the south side is a four feet seam pitching at a heavy angle with the following section:—

<table>
<thead>
<tr>
<th>Feet.</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray Sandstone</td>
<td>6 0</td>
</tr>
<tr>
<td>Brown sandstone (coarse)</td>
<td>2 0</td>
</tr>
<tr>
<td>Light Gray Sandstone</td>
<td>0 6</td>
</tr>
<tr>
<td>Good Coal</td>
<td>2 9</td>
</tr>
<tr>
<td>Ironstone</td>
<td>0 3</td>
</tr>
<tr>
<td>Coarse Coal, with thin, shaly Bands</td>
<td>1 0</td>
</tr>
<tr>
<td>Sandstone, with Ferns, &amp;c.</td>
<td></td>
</tr>
</tbody>
</table>

The measures now become flatter, and at a vertical distance of one hundred feet is a three feet seam of beautifully clean coal. The under-clay was four inches thick, resting on light gray sandstone, the same material forming the roof. On breaking the coal it was clean, and divided with a cubical fracture. No impurity was visible beyond a few thin films of calcium carbonate. An analysis gave—
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile Matter</td>
<td>33.4</td>
</tr>
<tr>
<td>Fixed Carbon</td>
<td>59.3</td>
</tr>
<tr>
<td>Ash</td>
<td>7.3</td>
</tr>
<tr>
<td></td>
<td>100.0</td>
</tr>
</tbody>
</table>

Still ascending the river no more exposures of consequence were found, till in about one and a half miles the millstone grit rocks crop again, and there is nothing to indicate coal beyond that point. At a distance of 16 miles from its mouth, the river is met rushing from the flanks of the great Laurentian plateau.

The section thus presents a narrow trough of coal measures about two miles wide, and of unknown length. A four feet seam crops on Robinson’s Brook four miles to the eastward, probably on the same horizon as one of the above-mentioned beds. Still further to the east the sub-productive measures were traced by the officers of the Survey from the shores of the bay to the mountains. The extent of the coal-field to the west is unknown; and here the most valuable discoveries may be made, for the measures appear less disturbed as they recede from the heavy fault which crosses the district obliquely. This trouble renders any estimate of the thickness of these strata unsatisfactory. There would be about 600 feet of measures exposed on the north side of it.

The difficulty of transport (there being no roads within a hundred miles), and the impenetrable nature of the country, have hitherto deterred investigators. The indications of coal, though encouraging, hardly warrant the expenditure of large sums of money when equally remunerative speculations can be undertaken at less risk.

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On the north shore of the bay are similar exposures of carboniferous rocks, and at one place a thin seam crops out in connection with coal strata. As yet, however, there has been no return for the labour of prospectors. Other thin seams are said to occur, but if any opinion can be formed from the measures exposed on the Barrasois rivers there is doubt if they prove of workable size.

The writer will now compare briefly the above description of the carboniferous rocks as they occur in St. George’s Bay with equivalent horizons in Nova Scotia, as, by this means, some light is thrown on the value of the coal formation of the former place.

After the formation of several beds of conglomerate at the base of the carboniferous, we find, in parts of New Brunswick, and near Windsor, in Nova Scotia, periods of slight submergence, allowing the formation of bituminous shales, with abundance of vegetable remains and thin beds of coal; whilst in Pictou, Cape Breton, and Newfoundland the whole series is occupied by conglomerates, to the almost total exclusion of such remains.

When the limestone period is reached, the conditions appear identical over the whole area of the Acadia region. The measures of North-Eastern Nova Scotia, Cape Breton, and Newfoundland, are precisely similar in fossils and structure. With slight variations in thickness and in composition of the
strata, owing to the nature of the underlying boundary rocks, the section of one district will answer for all. There is the formation of calcareous matter, and the simultaneous outbreak of volcanic acid springs converting masses of limestone into gypsum, and then a return to periods of quiet movement suitable for the deposition of the marl and shale.

During the millstone grit epoch the conditions in the Foggins district appear to resemble more those of St. George's Bay than of Pictou and Cape Breton. At the former place these strata are grouped under three sections by the eminent geologists who have explored them. The upper series of 2,000 feet consist of red shales and red and gray sandstones, containing no coal and few fossils. The middle group contains nine small coal-seams, and many thick, coarse sandstones of light colour. And the lower division consists principally of red shales, with sandstones and conglomerates. Its thickness is stated by Sir W. Logan at 650 feet. On comparison with the equivalent measures of Newfoundland, already described, we find a striking agreement in the presence of vegetable remains about the middle of the series. There are more shales at the Foggins and less evidence of the prevalence of strong shifting currents so

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marked on the eastern side of the region. In Pictou and Cape Breton, as far as is ascertained, the beds of this period present little beyond coarse sandstones and shales, usually of a dark colour.

When the productive or middle coal measures come under consideration, the conditions vary much within comparatively short distances. In New Brunswick there is a scanty section of these measures affording hardly any prospect of valuable seams. Mr. G. F. Matthew, in the last report of the Canadian Survey, gives the maximum thickness of the productive measures at 200 feet. On passing to the Foggins there are 1,269 feet of measures containing nothing beyond rudimentary and thin coal seams. Above this is a thickness of 3,404 feet, holding a large number of thin seams, several of which are workable. Continuing to the eastward, the beds of coal improve in thickness, and at Springhill, fifteen miles distant, there are eight seams, each varying in thickness from two feet eight inches to thirteen and a half feet, included in 1,200 feet of measures. Below this is a series of barren measures resembling those of the Foggins. There is, however, no evidence that these seams can be identified with any at present worked on the shore, and the probability is that local conditions favoured the accumulation of coal in certain places.

At Pictou, again, an equally great change is found. Here the lower coal measures are the most productive. The total thickness from the lowest to the highest seam is 4,321 feet. Below the Pictou main or great seam, there are 830 feet of strata, consisting of fine argillaceous sandstones and shales, holding 100 feet of coal, in seams of greater thickness than two feet eight inches. Above the main seam come 1,200 feet of black carbonaceous and arenaceous shales; and then the sandstones appear closing in as the courses of the currents were gradually diverted over the quiet nook so long covered with dense foliage. The upper beds contain seams from 3 to 8 feet thick, with much white post, and bear considerable resemblance to the Cape Breton measures. If the 1,800 feet of strata above the highest group of seams not yet proved to contain workable seams be added, there are 6,120 feet of measures included in the productive series.
At Cape Breton there are a series of seams from three to nine feet thick, apparently well disseminated through measures little under 5,000 feet in depth.

On comparing the coal measures of St. George's Bay, they are found to correspond more closely with the depauperated beds of the Foggins than with the other districts. The first seam met on the Barrasois measured three feet ten inches in thickness; but the writer is of opinion that its size was owing to the fault, and that its normal dimensions were much smaller. This would give a large extent of measures containing a few seams of small size, which is supported by the result of explorations on the north side of the bay.

The similarity of conditions between this district and the Foggins, the one being at the extreme east and the other on the west border of the Acadia region, is remarkable as far as the underlying millstone rocks and the band of comparatively barren measures are concerned.

The immediate increase in the thickness of the seams included in the measures south of the fault, and the fact of its being a downthrow, might show that higher strata were brought in of more consequence in an economic point of view. Should future research confirm this view, the field would be confined to the district between the fault and the first outcrop of the grit rocks, a width of one and a half miles, and gradually narrowing to the east as the fault kept bringing up lower measures to the north. This would allow, judging as carefully as possible from the angles of dip of the strata exposed, a thickness of about 2,000 feet.

Several of the English coal-fields furnish instances of similar deposits of unproductive strata beneath the coal measures. In Denbighshire they are 1,000 feet in thickness, and the Gannister beds of South Lancashire furnish a parallel case. These, and the facts noticed at the Foggins, hold out the hope that future researches will prove more encouraging than the prospects offered by the Geological Survey, or by the present trials.

The Vice-President said, the paper was a very interesting one, describing, as it did, a new country, so far at least as their information about the coal measures goes, and a cordial vote of thanks was given to the writer.

The scrutineers returned with the result of the elections.

On the motion of the Vice-President, seconded by Mr. Wm. Boyd, a vote of thanks was given to the scrutineers for the trouble they had taken in examining the voting papers; and the meeting was adjourned till Tuesday, the 4th of August, at Cardiff.
SPECIAL GENERAL MEETING, TUESDAY, AUGUST 4th, 1874, AT THE CARDIFF ARMS, CARDIFF.

Sir WILLIAM ARMSTRONG, C.B., LL.D., F.R.S., President, in the Chair.

The President— Gentlemen, the present meeting is not one that calls for a formal address, for it is not an annual meeting, but an extra meeting, held in a district which abounds with objects of great interest to the mining and mechanical engineer. With reference to the business now before the meeting, there are numbers of very valuable papers, which will, no doubt, elicit useful and solid discussion.

Mr. Bassett then read his paper on "The Diamond Drill."

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THE DIAMOND DRILL.

By A. BASSETT, M. Inst. C.E., and Past President of the South Wales Institute of Engineers.

In submitting the following remarks with reference to the success that has attended the application of the Diamond Drill in this district, it will be unnecessary for the author to enter into any description of the mechanical arrangements employed, as this was so fully and ably described in a paper read by Major Beaumont, R.E., M.P., before the meeting of the members of the Iron and Steel Institute, which was held on the 20th August, 1873, in Belgium. He will therefore at once proceed to state, as shortly as possible, the results that have taken place in this district.

When attention was first called to this subject, the writer was arranging, on the part of several Lessors, for letting some extensive deep mineral coal takings in this and the Somersetshire districts, ranging from 500 to 700 yards in depth; and as the minerals were overlaid by rocks of considerable thickness and hardness, the question of the time that would be occupied in sinking, coupled with the fact that a large capital is locked up for so long a period, was naturally urged with great force by the Lessees in carrying out their leasing arrangements. It is quite evident that if, by any means, the time occupied in sinking deep pits could be reduced, and the progress made to average about a yard per working day of twenty-four hours, an important problem would be solved in connection with mining operations, and which it is thought will be attained by the application of the Diamond Drill.
The writer was fully under the impression, when he promised to read this paper, that the Diamond Drill would have been fairly at work in this district at the deep pits Messrs. Harris are sinking, near Quaker's Yard, and that he should have had the opportunity and pleasure of placing before the members of this Institution some practical results that had been obtained. But, he regrets to say, that in this he was very greatly disappointed, as the

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Drill has not yet commenced its work. The delay has been caused from a variety of circumstances, consequent, to a great extent, upon the necessity of re-arranging the machinery required for executing this particular class of work, together with the non-completion of the arrangements at the colliery for its reception. Preliminary arrangements on behalf of the Diamond Drill Company have been made, for the Drill to be employed in some other deep sinkings; consequently, the results that will be obtained at these pits are being watched with great interest.

In letting the deep minerals at Harris' Navigation Colliery, it was calculated that much time would be economised by the application of the Diamond Drill, and which was fully recognised and admitted by the Company. From the reasons given the writer is unable to refer to the value of the Diamond Drill for shaft sinking, and fears that this paper will be sadly shorn of any interest it may have had on this subject, as he is now obliged to confine his remarks to the work performed by the Diamond Drill for prospecting purposes only.

On the table, are specimens of cores produced by the Prospecting Machine, together with crowns set in diamonds, ready for use. It may be here remarked that the crown makes from 250 to 300 revolutions per minute. The average value of a crown of 3½-inch diameter, properly set with twelve or fifteen diamonds, will be from £40 to £50; and one of 2½-inch diameter, with twelve diamonds, will be from £25 to £30.

The time occupied in this description of work, from the commencement to the finish, is influenced by a variety of circumstances, such as drawing and lowering the bore rods, which, as the hole increases in depth, naturally occupies more time, together with the many contingencies incident to work of this character; consequently, out of a day of nine hours, probably not more than from 2½ to 3½ hours would be actually employed in drilling.

In boring through the soft surface ground or gravel, it is found that by boring with a 5-inch crown, a sufficient quantity of ground, with the aid of the water supplied, is displaced to admit of lining tubes of 6 inches in diameter being put down. These lining tubes are made of iron, from one-eighth to three-sixteenths in thickness, but if it is found necessary to line any portion of a hole, lining tubes can be put down to any depth.

The core tube is 16 feet in length. The necessity for drawing the rods depends upon a variety of circumstances; in some cases, when the boring is in strong ground, the Drill may work to a depth of 14 or 15 feet, before the necessity arises for the rods being lifted; in other cases, it has been found necessary to lift the rods even before a depth of 6 inches has been reached. At a depth of 750 feet, the rods can be lifted up,
disconnected, a new crown put on, and lowered in less than two hours. At a depth of 1,000 feet, the
time occupied would be about three hours.

At present, the machinery is fixed immediately over the bore-hole, but an arrangement is now being
made by which the Prospecting Machine will be run back, thereby giving extra facilities for drawing
the rods, and economising time.

The five sections on the wall show the character of the strata pierced, and the depth bored each day
is represented by the black and white spaces.

The sections No. 1 and No. 2, Plates XXXVI. and XXXVII., represent the strata pierced at Risca, where
the application of the Diamond Drill was found to be of immense value in liberating the water from
the bottom of two large sinking pits, each of 17 feet 6 inches diameter, into the underground
workings. When these pits were sunk to a depth of 39 yards, the large quantity of water that was
met with so greatly impeded the progress of the sinking that not more than 2 feet per week was
sunk. The quantity of water lifted from each pit was about 96 gallons per minute. The owners were
advised to employ the Diamond Drill; consequently, one hole in each pit of 3 inches in diameter, was
put down to the Rock Vein Coal Workings, a depth of over 203 feet from the bottom of the new pits,
by which means the sinkers were relieved of the water. The hole from the bottom of the pit, shown
on No. 1 section, is 203 feet in depth, and was drilled in 99 hours (during a period of 18 days), being
the time actually occupied in drilling, lifting, and lowering the rods, giving an average of 18.5-11ths
feet per day of nine hours each, or 15.8-13ths per day over the whole time occupied. The greatest
depth bored in any one day was 26 feet 5 inches. The hole from the bottom of the pit shown on
section No. 2, was bored to a depth of 214 feet, and occupied 78 hours (during a period of eleven
days), or 24.9-13th feet per day of nine hours, or 19 feet 5 inches per day over the whole time
occupied. The maximum depth bored during any one day was 40 feet 5 inches through hard clift. The
two days before, 64 feet 3 inches was bored through hard rock, consequently 104 feet 8 inches was
pierced in three consecutive days, which is probably the highest duty ever performed by the
Diamond Drill. Since the water has been liberated, the rate of sinking has been more than doubled in
the same ground.

In order to prevent, during the course of sinking, the hole being filled up by rubbish, the top of the
hole should be protected by the insertion of a perforated pipe of from 10 to 12 feet in length.

Section No. 3, Plate XXXVIII., shows the strata passed through (1,007 feet 6 inches in depth), which
occupied 70 working days, showing

an average speed of upwards of 14 feet 4½ inches per day. The greatest speed attained in any one
day was over 32 feet. The cores brought up showed a complete section of the strata passed through,
and which was perfectly satisfactory to the proprietor, who has written a letter to the Company to
that effect.
Section No. 4, Plate XXXIX. In this case the bore hole reached a depth of 602 feet, the greatest depth bored in any one day being 30 feet 10 inches. The time occupied was 52 days, showing an average speed of 11 feet 7 inches per day.

Section No. 5, Plate XL. The depth of this bore hole was 604 feet, and occupied 45 days. The greatest depth bored in any one day was 29 feet 1 inch, showing an average speed of 13 feet 5 inches per day.

In these last three examples the author is unable to define the actual time occupied in drilling, lowering, and raising the rods, but the time stated includes delays arising from various causes.

Last week 51½ inches were bored in 23 minutes, at a depth of 248 feet from the surface, the revolutions made by the Drill being about 275 per minute, the rate of progress being equal to 2¾ inches per minute. Specimens of the cores are on the table. 234 feet of rods were unscrewed in 12 lengths of 19 feet 6 inches each, and were lifted in 21 minutes—in 10 minutes after the crown had been taken off and the core tube emptied. The rods are lowered in about two-thirds of the time occupied in lifting them. Although the present arrangements will only admit of rods of about 20 feet in length being unscrewed at a time, there is no reason why a light and high framework might not be constructed of steel, by which the rods might be lifted and unscrewed in lengths of at least 50 or more feet. Framework of this character might be made very portable and easy of transit, as the various parts can be fastened together with perfect security, and with very great facility.

From the five examples given, and which are taken from different parts of this district, the writer trusts he has conclusively proved the value of the Diamond Drill for expeditiously testing the character of strata.

Taking all the examples referred to, by which an aggregate depth of 2,630 feet has been bored in 191 days, it will be seen that, including all the contingencies, delays, &c, that have arisen during the progress of the work, the average speed has been rather over 18 inches per hour, taking six days of nine hours each, or 54 hours as the week's work.

As several important improvements will be made to guard against a variety of accidents and delays that have arisen in the work already executed, the writer is perfectly satisfied that he shall be able in future to attain a far greater daily average of duty than has hitherto been accomplished, by which the Diamond Drill will stand unrivalled in every respect as an instrument for boring and proving the strata, more particularly for mining purposes, where a perfect section of the strata is required. He has this morning been informed by Major Beaumont that a hole 5 inches in diameter has just been completed in the Somersetshire district, of 455 feet in depth, 360 feet of which was lined by 5 inch tubes. The whole of this work was satisfactorily executed in a month.

Since this paper was written, some trials have been made with the Drill at Messrs. Harris' Pit, of sufficient extent to prove that the working of the Drill has been most satisfactory, and of such a
nature as thoroughly to confirm the most sanguine expectations as regards the value of the Drill for pit sinking.

No doubt, much still remains to be accomplished in order to produce a machine that will be in every respect all that can be desired. The reduction of the weight of the machine, together with the further simplification of the several working parts, all demand serious thought and consideration. The employment of steel where iron is now used will materially assist in carrying out the improvements needed; and as every effort is now being made to carry out these practical improvements, it is anticipated very shortly the Company will have at work a machine of such a weight as will admit of its being put down the pit and fixed in its place with perfect facility, and in so short a space of time that practically the whole of the 24 hours may be occupied in drilling and removing the debris.

However, with the present arrangements, such a number of holes have been bored at the bottom of Messrs. Harris' Pit of 3 feet 6 inches in depth, in the space of five hours, as will enable the whole of the ground to that depth to be removed without difficulty, and which work ought to be accomplished in the remaining portion of the day of 24 hours. Consequently, there is no doubt that the average estimate of sinking one yard per working day of 24 hours throughout the year may be calculated upon with safety; and when pits of 600 and 800 yards in depth have to be sunk, it will be difficult to over-rate the great value of the application of the Diamond Drill for deep sinkings.

In conclusion, the writer begs to say that he shall have much pleasure in giving all the information in his power to any gentlemen who may wish to use the Drill, either for prospecting purposes or for shaft-sinking, and give every facility for inspecting the drills employed in this district.

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The Secretary then read the following communication from Mr. Wm. Topley upon "The Sub-Wealden Explorations," now going on in Sussex.

[Plates XXXVI to XL showing sections obtained with the Diamond Drill]

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THE SUB-WEALDEN EXPLORATION.


The boring now in progress in Sussex cannot fail to have attracted some attention from all who are interested in the mineral productions of our country. In one respect, however, it especially concerns those interested in the South Wales coal-field; and for this reason the writer ventures to lay a short account of the scheme before the members of this Institute at their Cardiff meeting.
Although Sussex is now a purely agricultural county, there was a time when it ranked high amongst the mineral-producing districts of England. For centuries it was the chief seat of the iron-trade; and, so long as charcoal only was used for fuel, Sussex maintained its supremacy. With the introduction of coke-fuel, however, the Sussex furnaces declined; but they lingered on into the present century, and it was only in the year 1828 that the last furnace, that at Ashburnham, ceased working.

Within three miles of the site of Ashburnham furnace, and perhaps within reach of the sound of its forge-hammer, is the site of the boring which is now in progress. The result of this boring may be to restore Sussex to its old position as a mineral-producing district, but such is not its main object; what that object is will be briefly explained.

The strata occurring in the district known as the Weald, of which the north and north-east of Sussex form part, are the Wealden and Purbeck Beds. These are mainly of fresh-water origin, and are about 2,000 feet in thickness. What underlies these beds has always been a question of great interest and scientific importance to geologists. The nearest outcrop of the oolitic rocks is so far away, and the changes which these rocks often undergo in short distances is so great, that it is impossible to estimate what the nature and thickness of the underlying secondary strata may be; it is a problem which can only be solved by actual boring.

Some years ago it would have been supposed that the thickness of the secondary rocks must be indefinitely great, and that any attempt to get through them by a bore-hole would be simply absurd. In 1855 Mr. Godwin-Austen read a memoir before the Geological Society of London, "On the Possible Extension of the Coal Measures beneath the South-Eastern part of England,"* in which he showed that the series of secondary strata in the south-east of England is incomplete, and that at a moderate depth from the surface there exists a band of older or palaeozoic rocks, with which it is possible that coal measures may be associated. Mr. Godwin-Austen based his argument upon known facts as to the easterly range of the South Wales and Bristol coal-basins, and the westerly range of the Belgian coal-basin. The Bristol coal-field on its eastern side is covered up by oolitic strata, through which pits are sunk. The Belgian coal-basins, in like manner, are covered up on their western range by cretaceous strata, through which also pits are sunk. Numerous experimental borings, carried as far west as Calais, prove that the palæozioic rocks occur under the cretaceous strata at depths rarely exceeding 1,000 feet; whilst near Marquise, and in some valleys cut through the chalk on the south-east of that town, the palæozoic rocks come to the surface.

Reasoning from these data, Mr. Godwin-Austen inferred that a band of palæozoic rocks stretches beneath the secondary strata of the south-east of England, connecting the rocks of South Wales with those of Boulogne and Belgium, and that with these rocks productive coal measures will probably occur. Mr. Godwin-Austen's reasonings were remarkably confirmed by a boring at Harwich, made for water; where, after passing through the cretaceous strata, palæozoic rocks were found at a depth of 1,030 feet. Some fragments of fossils brought up prove that these rocks are older than the coal measures. A boring at Kentish Town, done at about the same time, also, passed through the
cretaceous strata, and at a depth of 1,113 feet reached some reddish rocks, the age of which is doubtful, but which Professor Prestwich is inclined to consider as old red sandstone.

Although Mr. Godwin-Austen's reasonings were generally accepted by geologists, and had received such remarkable confirmation, nothing was done towards further testing the question. The Royal Coal Commission was appointed in 1866, and naturally devoted some attention to this subject. Much detailed information is given in the Minutes of Evidence by Sir R. Murchison, Mr. Godwin-Austen, Mr. Bristow, Prof. Phillips, and others; this is carefully analyzed, and the whole subject reported on by Prof. Prestwich in the first volume of the Commissioners' Report. The

* Quart. Journ. Geol, 8vo., vol. xii., p. 38, 1856.

great importance of making trial bore-holes to test this question was fully appreciated by the Commission, but no formal application was made to Government to help in the matter.

The question remained in this state until 1872. In that year the British Association met at Brighton, and Mr. Henry Willett resolved to test the question, and to commemorate the visit of the Association by boring in the Weald. A committee of engineers and geologists was formed in London, holding its meetings under the presidency of Prof. Ramsay, at the Geological Museum, Jermyn Street. The site ultimately chosen for the boring was one where the lower part of the Purbeck series is exposed by denudation at the surface, and where the beds are horizontal. Subscriptions were solicited and received, and in August, 1872, the boring was commenced.

A hole of 9 inches in diameter was first made; this was carried by Mr. Bosworth to a depth of 312 feet. At the end of 1873 the work was transferred to the Diamond Rock Boring Company, by whom the bore has been continued to a depth of 1,030 feet, at a diameter of 3 inches. It is essential in this undertaking to learn as much as possible of the nature of the rocks passed through, and from this point of view the Diamond system of boring is of great service. It not only does the work quickly, but it brings up solid cores of strata, in which the fossils are perfectly preserved; by these means the age of the beds traversed can be exactly ascertained.

The boring commenced in the Purbeck beds; it has traversed the Portland beds and the Kimeridge clay, and is now in the Oxford clay. Careful records of the fossils and strata have been kept, from which the beds may be classified as follows:—

<table>
<thead>
<tr>
<th>Strata</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purbeck Beds</td>
<td>180</td>
</tr>
<tr>
<td>Portland Beds</td>
<td>110</td>
</tr>
<tr>
<td>Kimeridge Clay</td>
<td>670</td>
</tr>
<tr>
<td>Oxford Clay</td>
<td>53</td>
</tr>
<tr>
<td>Total</td>
<td>1013</td>
</tr>
</tbody>
</table>
The lowest 17 feet of core (making a total of 1,030 feet) are still in the bore-hole, owing to an accident to the rods. This also is probably Oxford clay, but in the foregoing table only such cores are noticed as have been actually examined.

Two valuable beds of gypsum, 4 feet and 3½ feet thick, have been discovered in the Purbeck beds, at depths respectively of 184 and 142 feet. A shaft is now being sunk to work them.

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Many thousands of specimens of fossils have been obtained from the Kimeridge and Oxford clays, detailed lists of which have been published in the Quarterly Reports; other fossils have been discovered since.

Up to the present time £3,000 have been spent, the whole of which (with the exception of small grants from the Royal Society and the British Association) has been raised by private subscription. The Government has now promised £100 for every 100 feet bored below the 1,000 feet, but the actual cost will be nearly three times that amount. Having gone so far and obtained such important results, it is very desirable that the boring should not now be discontinued for want of funds.

Although public interest is excited in the boring chiefly by the hope of finding coal, yet it must be remembered that no subscriptions have been solicited with this object. The occurrence of coal measures at all in the south-east of England is as yet only a theoretical question, though one which is not devoid of good foundation; but, as the coal will probably occur in detached basins, along a line yet to be discovered, the chance of hitting upon coal in this boring is but small.

At the invitation of the President, Major Beaumont, M.P., said, that Mr. Bassett had presumed that the members of the Institute were acquainted with the substance of a paper read before the Iron and Steel Institute, at Leige, and as possibly some present have not read that paper, one or two remarks upon the Diamond Drill may be of interest. Now, the Diamond Drill differs essentially in its action from such a machine as the Worsop Drill, in that it makes the holes by abrasion, instead of by percussion. Until the use of the diamond was recognised for commercial purposes, the only way of dealing with rocks was by percussion, inasmuch as if it was attempted to scrape rock with steel, it was the steel that would give rather than the rock itself. Now, the secret of the Diamond Drill consists in the intense hardness of the diamond, as compared with any other known substance in nature. A piece of carbonate, of the size of a large pea, will cut a hole in sandstone, say, a mile deep, without any sensible abrasion of its surface; when it comes into rocks that are harder than sandstone, such as the conglomerate or hard whinstone, then the abrasion is something more; but, in any case, there is an enormous difference between the hardness of the diamond and that of the hardest known strata, and, taking the various kinds of rock that have to be dealt with, then it may be safely averred that thousands of feet may be cut by carbonate without

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any sensible wear. The way to use them is this:—They are fitted into a steel crown, and this crown is kept in rotation, and supplied with water in this way. They cut the hardest rock at rates varying from 2 inches up to 7 and 8 inches per minute, not that this is the speed at which it is possible to cut rock, but simply because the rates named are quite sufficient for all practical purposes. It is not necessary here to give the details of the machine by which this drill is worked, because the members will have an opportunity of seeing it at work, sinking at Harris’ Navigation Pit, on Saturday. In the machine in question, there are eight drills, each drill being complete in itself, and driven by compressed air. The engine is attached to the frame, and lowered down the shaft. The air to supply the drills is taken down to them in a suitable pipe, the final connection being made by a flexible hose. The water to supply the drills (because drills running at that speed, and with such a pressure behind, will rapidly get hot, if it were not for a supply of water which is necessary, not only for that purpose but also for the removal of the debris) is passed down in a pipe of smaller diameter than the drill itself, and is raised again by the ordinary means used for raising the water out of the pit. These eight drills would be capable of drilling twenty or thirty holes, three or four feet deep, as the case may be, in eight hours, and it is anticipated that these thirty holes can be blasted, and the debris removed, in another eight hours. The value that would attach to that when done can be fully appreciated by this meeting. But there are two ways in which it is proposed to use this machine; one is to put down ordinary blast holes, and the other to put down deep holes. Referring first to the ordinary holes for blasting, a great many attempts have been made to utilise boring machines, both for tunnel and shaft sinking, and so far without any material success; for, without speaking of experimental holes put down, it may be broadly stated that in the entire work of mine sinking up to the present time, there has been no great benefit from the use of machinery in drilling. The reason is possibly that the secret of success in the application of machinery for shaft sinking consists in having a sufficient amount of holing power. It is well known that a miner picks his places where he intends to put his holes down, so that each shot works to the best advantage, and he carefully inspects the shaft or heading he is working in, sees the result of the first shot, and then he places his next shot in such a position as to produce the greatest amount of effect, and so, no doubt, he gets the work done with the minimum amount of holing labour. But as soon as machinery is used it should be of sufficient power to put down 20 or 30 holes. In fact, to employ a machine successfully in

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troublesome to get out, from falling into the holes. The Diamond Drill is also used for sub-aqueous operations. The Diamond Boring Company have a contract for removing some rocks in Tees, and the practical advantage of the drill in this case is owing to the fact that there is no necessity of percussion to use it, and it is a matter of indifference how far the power employed is from the surface. It is well known with a percussion drill it is impossible to work it at any speed, if the drill is at the bottom of a hole 30 or 40 feet deep, or deeper. But the Diamond Drill being open abrasion, the depth is a matter of little importance. That being the case, it is possible to put the drill upon a barge to support it by legs on the top of the rock that has to be operated upon, and then by supplying the drills with power, by means of an engine from above, a series of holes are put down, and in a few minutes, without the use of divers, the drills are then withdrawn and the dynamite fired by electricity. Mr. Bassett's paper treats of the invention in reference to prospecting, and the details he gives you show the exceeding rapidity with which the drill does its work and gets down to the rocks specified. The reason that they could not put a hole 1,000 feet deep at the spot named, arose from the difficulty met with in manipulating the machinery. That is to say, soft ground was met with, which has to be lined, and then came fissures that let the water into the strata at the side. The time occupied in putting down those deep holes is due to imperfections, not in the Diamond Drill or in the cutting portion of its machinery, but in the lengthening and withdrawal of the drill, together with all those difficulties.

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common to this system of boring as well as to any other. There is one circumstance attached to this drill which gives it a great advantage over others. In going through soft strata, it is possible, by using a large crown to line the bore holes with thin, yet sufficiently stout, iron cylinders. To do this it is a matter of importance if a 5-inch bore could be made to grow into a 6-inch one at the bottom. To do this there is a tool attached to the apparatus; this tool is a crown that expands as soon as it has passed down a certain distance into the hole. At first this appears easy, but in reality it was not found so; in fact it was very difficult to get the drill to expand to a certain size at a particular depth and contract to its original diameter when withdrawn, and this more especially with reference to the heavy amount of work to be done; for, before anything can be done with a Diamond Drill, a pressure of a quarter of a ton must be put on. This difficulty has, however, been overcome, and if members will only spare time when they go out from here, they will see a heavy block of stone from the Pennant Rock, and a hole bored into it expanding from a 3-inch to a 4-inch. With reference to one of the latest results obtained at Chateau Wren, it is true that a much longer time was expended in putting down a bore hole there than ought to have been. The reason was that soft-running strata were encountered, and too small lining tubes were used. Within the last four months a large hole has been commenced; that hole, was begun 6 inches in diameter, and has gone to a depth of 360 feet. After getting down there a lining was required, and a 6-inch tube was put down and the boring continued with a 5-inch crown, with which a greater depth of 455 feet was obtained. The 6-inch hole, after the 6-inch tube had been inserted, was bored in about a month, which may be considered remarkable evidence of the speed with which the Diamond Drill can work.

Mr. Wright wished to know whether in any cases Major Beaumont had been able to bring up a perfect core of a coal seam?
Whenever the coal is sufficiently hard to enable it to be cut, then a perfect core is brought up, but never to the same extent as those cores which are obtained from rock, simply because the cut breaks by its own weight. In some cases pieces of core of considerable length have been brought up, at other times only a few inches; but never a core which represented the whole thickness of coal passed through. In the case of soft coal, the action of the drill grinds it up, and then no better results will be produced than will be got by the ordinary system. In fact, the boring would then be continued by a shell auger, and samples of the pounded material would be brought up; but, if the coal is sufficiently hard, a sample could be obtained such as could be raised by no other system. But, generally speaking, the cores of coal would be about 3 or 4 inches in length.

Mr. Wright stated that he had an opportunity of seeing in Cumberland a hole 1,400 feet deep, which passed through two seams of coal, one of which was reported from the action of the drill to be nearly 8 feet thick. All the coal actually brought up was a number of fragments which, as they lay in the core box, made up about 18 inches, there being no perfect core except one about an inch thick.

Now, in boring through carboniferous strata, the seam itself is the most important thing. Mr. Bassett states that at a depth of 750 feet it occupied two hours, and at a depth of 1,000 feet three hours, to withdraw the rods; at the hole in Cumberland, they were able to get them out more expeditiously than that. In a 1,400 feet hole they drew the rods in a little under two hours. The other point was the means used for securing the cores of stone while the rods were being withdrawn. He saw them draw an 8-feet core of stone which had to be cut in half, because there was not enough room in the quill to carry it up, and it struck him that there was very great danger of its falling down since the whole of the core depended upon the lip of the crown inside the core pipe, which had only about the eighth of an inch projection, and the foreman of the work assured him that the cores often fell from the top to the bottom.

Mr. Lewis would ask Major Beaumont whether it is possible, by his system of boring, to go through a seam of coal without knowing anything about it?

Major Beaumont—First, in answer to Mr. Wright. The reason he believed that only 18 inches of coal was brought up after the drill had travelled 8 feet of it, was that the coal was washed out of the core by the weight of water on the top of it. When a solid piece of rock is bored through, there is not much difficulty in withdrawing long cores; they catch on the lip, and if not removed are brought up next time. Besides that, they are self-acting clips which grip the core at the sides; and, besides, the action of the machine indicates the nature of the rock traversed. A man has no business to make a mistake; on an average only about one-tenth of the cores raised are kept, and consequently there is no great object in keeping them. In order to take the weight of water of the whole core, a valve is placed on the top of the core tubes, which valve relieves the core of the weight of the column of water above it. In some coal seams that have been passed through with the valve attached, good results have been obtained; besides, when coal is being proved the water...
is partly shut off, and only a moderate pressure applied, which ensures a most successful and satisfactory proof of the coal seam which is being gone through. With reference to the withdrawal of rods, that is purely a mechanical question, and any implements that are made by different companies working under the patent will be eventually adopted by all. Second, in answer to Mr. Lewis, with reference to passing a seam of coal without knowing it, he would state that with attentive workmen such a thing was totally impossible, for there are two ways, both of which may be allowed to be satisfactory for ascertaining the nature of the strata. The first is by utilizing the current of water which is always passing under the surface of the tool for the purpose of removing the debris and keeping the cutting part of the tool clean by examining the debris which is always brought up by the water to the surface. The second method is, when a machine passes through hard strata into coal, the operator can tell by the action of the machine itself the instant it has done so. The men then report to the master that the coal has been struck, and they proceed with caution until they have obtained satisfactory proof of the coal; then they again put the engine on at full speed, and bore right through the coal.

The President asked Major Beaumont how they managed when sinking by means of a number of deep holes to blast off only a certain depth at a time? Then, he would ask whether so considerable a demand for diamonds having sprung up, the supply is likely to be equal to the demand? and, also, whether any other material is known which could possibly take the place of the diamond—such as the mineral which forms the base of the ruby, for example, which could be supplied in greater abundance, being a commoner substance than the diamond? Then, again, as to injury by wear; for possibly those black diamonds, like everything else, do wear eventually. Is the wear in the nature of abrasion, or do the diamonds break away by a process of clipping? and can the duration of the tool be prolonged by any greater protections to the cutters against that liability?

Major Beaumont replied that for sinking by means of a number of holes put down some one or two hundred feet deep, exactly so much of the rock would be blasted out as the nature of the work admitted. Water, being absolutely incompressible, is an admirable tamping to support the dynamite in the hole, and also a sufficient tamping above the charge. The nature of the operation would be to put the dynamite charge when attached to the fuse down the hole, which is full of water, to such a depth as required. The action of the water below prevents it from blowing downwards, and the water above is sufficient tamping; so that the shot is fairly charged, just as if the holes were only of that depth: and this would be the obvious mode of proceeding, were it not that after the shots were fired the rubbish would fall into the holes, so that time would be lost in getting it out again. For that reason the holes are filled up with sand, and then, after each shot is fired, the sand is taken out to the depth required, which can be done with great ease. With reference to the supply of diamonds, that is an important question, and one which has always engaged the most serious attention. The diamonds used by the Company are supplied from the mines of Brazil, in the district of Bahia; and it is somewhat singular that up to this time there have been no diamonds of the same class or quality found in either of the other known diamond
fields, such as the Cape or India, but that the diamonds of Bahia are practically inexhaustible, so that up to this time no deficiency in the supply has been found. But, as the trade has by some means got into the hands of the diamond merchants, it is somewhat difficult at times to get a fresh supply. The cry is that no more diamonds are forthcoming, that the stock is becoming exhausted, and so on, with the view of enhancing the prices; and it is found advisable to keep a sufficient supply in hand, so as to be able to choose the time for going into the market. The stock now in hand is large enough to last a considerable time. It is a difficult thing to judge the proper quality of stone; and when the material is in its rough state, it looks like throwing away money to spend £1,000 on a lot of dirty stones that would not fill a tumbler glass. The stones are bought by the carat. Sometimes they will break, and sometimes they are very soft. All these things are difficult to judge. Large diamond fields have been opened at the Cape, and it was anticipated that carbonate would be found there; but, although many samples were sent home, none of them turned out to be the substance required. But why it is that diamonds which are of gem quality should not be associated with carbonate is unknown; but no carbonate is found in India. As yet, Brazil is the only place in which it is found. With reference to the use of corundum, Mr. Tennant, one of the chief mineralogists in London, and who had written a paper on stones, suggested corundum, and produced a table of the degrees of hardness of different stones—diamonds being placed at 100, corundum at 86, and ruby at 75. He could supply any amount of it at 8d. a carat; and, as carbonate was 20s. a carat, a piece was selected and put into a suitable frame, and then held against a grindstone, which is the best possible test that can be had. The result of the experiment with the corundum was, that whereas the grindstone was turned by the diamond, the grindstone in its turn turned the corundum. In point of hardness, therefore, the diamond stands probably at 100 and the other only at 5. I believe there can be no possible comparison between the two. But though there is no comparison between the diamond and corundum, there is a comparison between the corundum and ordinary rocks, so that for such a thing as boring holes in coal measure or shales, a very satisfactory result might be got from using it. But if carbonate is used, the wear is absolutely nil, whilst the other wears out and requires removing frequently, but still for soft rock corundum has a certain value. The diamond seems to be carbon in its finest state of crystallization; carbonate is the same material in an imperfect state of crystallization, and that is just what is wanted, because it prevents the diamond from breaking, and is as hard as the ordinary diamond. Boart, a sort of diamond, occurs in globules about the size of a pea, it is semi-transparent, and its hardness is about equal to the diamond, but not being useful for gems it has only half the value of ordinary diamonds; its disadvantage for boring is that it is too brittle. Diamonds, which have no value as gems, can be obtained at from 8s. to 12s. per carat. In point of hardness these would be all that is required, but the material is too brittle. With regard to the wear of the diamonds, nine-tenths of the loss is owing to breakage, and not to abrasion. If a good piece of carbonate is found, a natural stone water-worn on the surface—though whether it be so, and whether there can be such a lapse of time as must be necessary for the diamond to be abraded by water—the hardest thing in nature to be worn by the softest—is a theory for speculation, but still it is said to be so; and if a crown is set with such stones and they have nothing but rock to contend with, the loss on that crown would scarcely be five per cent, after drilling half a mile; but if diamonds are used the jarring will possibly break one, and that
causes more jarring which leads to the breakage of others, until perhaps three-fourths of the set are lost. To avoid this as much as possible, the projections are equalized and the stones carefully examined.

Mr. Smyth wished to know if Major Beaumont found any difficulty in dealing with dynamite.

Major Beaumont stated that it was an important question, and referred Mr. Smyth to the evidence which he gave before a Committee of the House of Commons on explosive substances. He entertained the highest opinion of dynamite, and believed, as an explosive, it will be found of great benefit to mining engineers, and especially when they use machine drills. He used nothing but dynamite, and its great advantage is that it

enabled him to blast a hole under circumstances where he could not get powder to act. If it is taken weight for weight, and the question of time put on one side, he was doubtful whether there was any advantage to be gained from it—that is to say, if fired in a heading or a railway tunnel, and there are plenty of men inclined to use powder in preference; in fact, as at Bristol, where a tunnel is being bored under the Downs, dynamite is used only in the advanced heading, and powder for general blasting. Under water nothing but dynamite is used, for the reason that water is the very best tamping for it. The only danger of dynamite is when it is not pure. Nitro-glycerine is a most dangerous material, and dynamite is nothing but that in combination with a silicious earth, and is perfectly safe if pure, but if from variations of temperature the oil exudes, it becomes highly dangerous, and as soon as it assumes that shape it is time that it was destroyed.

Mr. Forster Brown wished to know what is the usual quantity of water supplied to each drill, because in his district it might become a very important question that would have to be met, for if a number of drills are used in a shaft the quantity of water may be very considerable.

Major Beaumont, in reply, stated that the quantity of water will be important if it has to be taken from the surface, but the water might be pumped into a cistern and could there be used again.

The Secretary then read a paper by Mr. Thomas Forster Brown, "On the South Wales Coal-Field."

THE SOUTH WALES COAL-FIELD.

By THOMAS FORSTER BROWN.

It would be altogether beyond the scope of a single paper, to treat with anything like the degree of importance they deserve, the points which arise in writing upon a coal-field so extensive as this is,
and in which the physical and other conditions are so varied. The writer will therefore merely touch
upon such of the more general features as he hopes may be interesting to the gentlemen who have
paid the district the compliment of a visit, leaving it to them, as they have the occasion or the desire
to do so, to make their knowledge of the district more perfect by personal observation, and by
referring to the valuable published information which has been contributed from time to time.

HISTORY

There is no doubt that charcoal was used in very early times for smelting iron in this coal-field. The
first operations are said to have been conducted on the mountain tops in wind-furnaces, which later
were removed to the valleys, in order that water-power might be utilized.

It is stated in the Report of the Royal Coal Commission, "That in South Wales, iron making was
carried on as early as the 15th century." Although thickly wooded in earlier days, the country is said
to have become almost deforested about the middle of the 18th century. Pit coal is said to have
been used in copper works in the neighbourhood of Neath as early as the 16th century, and in the
year 1595, George Owen, of Henllys, describes the coal-field in his manuscript, "History of
Pembrokeshire," published two centuries later. After describing the mode of occurrence of the
"Vaynes of Limestone," he proceeds to notice the coals; of these he

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describes two varieties, which he calls "Stone Coal," and "Ring or Running Coal." The stone coal he
describes as "Hard coal which is burned in chimneyes and grates of iron, and delighteth to burn in dark
places," and that the "Running coal melteth and runneth as wax, and groweth into one clodd." He,
moreover, describes the rude manner of mining in his days; and as to Royalties, "The lords of the
land have eyther rent, or the third barrell, after all the charges of the works are deducted." The real
development of the coal-field, however, dates from the time when pit coal began to supersede
charcoal in the smelting of iron. The substitution of coal for charcoal was first successfully
accomplished by Mr. Darby, at Coalbrookdale, in 1735; and in 1755, Mr. Bacon obtained a 99 years
lease of a large mineral property in the neighbourhood of Merthyr, at a rent of £200 a year; later on
this property was sub-leased into the separate tracts upon which gradually began to be established
the very important and far-famed iron works of the Merthyr district. According to the Royal Coal
Commission, there were in the counties of Caermarthen, Glamorgan, and Monmouth, in the year
1788, seven charcoal furnaces, which produced 4,300 tons of pig iron, and six coke furnaces in
Glamorganshire which produced 6,600 tons. In 1790, an Act of Parliament was obtained for
constructing the Cardiff and Merthyr Canal; the works were commenced in 1791, and completed to
Cardiff in 1794. In 1796, a further Act was obtained to the sea, and in 1798, the first vessel entered
the sea lock. In 1804, Trevithick's high pressure tram-engine ran from Merthyr to Navigation,
carrying ten tons of iron and seventy persons.

There appears to be no reliable statistics of the early days of the coal trade, independent of the iron
trade, but the following statement of the quantity of coal brought into the port of London from the
South Wales coal-field in each of the following years, extracted from the Blue Book of the Royal Coal Commission, will be interesting:—

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[see in original text Table listing quantity of coal brought in from the South Wales coal-field for the years 1745 to 1765]

The steam coal trade of the Aberdare and Merthyr districts began to be developed in 1836, on the discovery of the very valuable properties of the carbonaceous coals of this coal-field. The West Bute Dock was opened in 1839. The Taff Yale Railway was completed to Merthyr and Aberdare in 1841, and the East Bute Dock was opened in 1859.

The following statistics, gathered from the Coal Commission and from Mr. Hunt's returns, will be interesting, as showing the rate of development of the iron trade:—

[200]

<table>
<thead>
<tr>
<th>Year</th>
<th>Tons of Pig Iron made in Monmouthshire and South Wales</th>
</tr>
</thead>
<tbody>
<tr>
<td>1823</td>
<td>182,325</td>
</tr>
<tr>
<td>1827</td>
<td>272,000 From 90 Furnaces</td>
</tr>
<tr>
<td>1830</td>
<td>277,043 From 72 Furnaces</td>
</tr>
<tr>
<td>1839</td>
<td>453,880 From 122 Furnaces</td>
</tr>
<tr>
<td>1840</td>
<td>505,000 Using 1,436,000 Tons of Coal</td>
</tr>
<tr>
<td>1854</td>
<td>750,000</td>
</tr>
<tr>
<td>1859</td>
<td>985,290</td>
</tr>
<tr>
<td>1867</td>
<td>886,234 From 115 Furnaces</td>
</tr>
<tr>
<td>1868</td>
<td>894,255 From 108 Furnaces</td>
</tr>
<tr>
<td>1869</td>
<td>800,972 From 112 Furnaces</td>
</tr>
<tr>
<td>1870</td>
<td>979,193 From 114 Furnaces</td>
</tr>
<tr>
<td>1871</td>
<td>1,045,916 From 112 Furnaces</td>
</tr>
<tr>
<td>1872</td>
<td>1,002,623 From 115 Furnaces</td>
</tr>
</tbody>
</table>

[see in original text Table of Shipment of coal from the South Wales coal-field]
EXPORTS FROM SOUTH WALES.—Continued.

1851  2,025,998 Tons
1852  2,110,390 "
1853  2,499,734 "

[201]
[see in original text Table of Quantities of coal raised in South Wales since 1860]

Total for 1870  13,664,132 tons
1871  14,035,525 tons
1872  15,047,250 tons

COLLIORIES AT WORK IN THE COAL-FIELD IN 1872.

<table>
<thead>
<tr>
<th></th>
<th>Tons.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monmouthshire</td>
<td>85</td>
</tr>
<tr>
<td>Edge of Glamorganshire</td>
<td>22</td>
</tr>
<tr>
<td>Glamorganshire</td>
<td>237</td>
</tr>
<tr>
<td>Pembrokeshire</td>
<td>9</td>
</tr>
<tr>
<td>Caermarthenshire</td>
<td>38</td>
</tr>
<tr>
<td>Total</td>
<td>391</td>
</tr>
</tbody>
</table>

N.B.—The above does not represent the number of single collieries. For instance, Dowlais is put down as one colliery, whereas there are several different and separate establishments at these works.

PATENT FUEL SENT COASTWISE TO OTHER PORTS OF THE UNITED KINGDOM.

Ports from which Shipped.  1870.  1871.  1872.
<table>
<thead>
<tr>
<th>Port</th>
<th>1870</th>
<th>1871</th>
<th>1872</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiff</td>
<td>4,396</td>
<td>12,323</td>
<td>3,802</td>
</tr>
<tr>
<td>Swansea</td>
<td>18,673</td>
<td>19,398</td>
<td>8,628</td>
</tr>
<tr>
<td>Liverpool</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Glasgow</td>
<td>-</td>
<td>250</td>
<td>6,631</td>
</tr>
<tr>
<td>Sunderland</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>23,073</td>
<td>31,971</td>
<td>19,061</td>
</tr>
</tbody>
</table>

PATENT FUEL SENT TO FOREIGN COUNTRIES.

<table>
<thead>
<tr>
<th>Ports from which Shipped</th>
<th>1870</th>
<th>1871</th>
<th>1872</th>
</tr>
</thead>
<tbody>
<tr>
<td>London</td>
<td>3,551</td>
<td>4,876</td>
<td>3,569</td>
</tr>
<tr>
<td>Newhaven</td>
<td>8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bristol</td>
<td>-</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Cardiff</td>
<td>52,762</td>
<td>57,127</td>
<td>58,260</td>
</tr>
<tr>
<td>Swansea</td>
<td>141,984</td>
<td>135,751</td>
<td>142,938</td>
</tr>
<tr>
<td>Newcastle</td>
<td>-</td>
<td>-</td>
<td>101</td>
</tr>
<tr>
<td>Sunderland</td>
<td>-</td>
<td>-</td>
<td>2,019</td>
</tr>
<tr>
<td>Liverpool</td>
<td>72</td>
<td>358</td>
<td>354</td>
</tr>
<tr>
<td>Total</td>
<td>198,377</td>
<td>198,115</td>
<td>207,241</td>
</tr>
</tbody>
</table>

[see in original text Table showing the coal shipped from South Wales for the year 1872]

Besides the above, a large quantity of coal is taken out of the district by rail to London and other places, probably upwards of 600,000 tons per annum; and a large quantity of patent fuel is manufactured in the district.
The following comparative table of shipments from Cardiff of coal and coke, foreign and coastwise, during the last ten years, may also be of interest:—

<table>
<thead>
<tr>
<th>Year</th>
<th>Foreign.</th>
<th>Coastwise.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1864</td>
<td>1,481,657</td>
<td>5,032</td>
</tr>
<tr>
<td>1865</td>
<td>1,450,941</td>
<td>10,291</td>
</tr>
<tr>
<td>1866</td>
<td>1,837,161</td>
<td>11,672</td>
</tr>
<tr>
<td>1867</td>
<td>1,966,079</td>
<td>12,429</td>
</tr>
<tr>
<td>1868</td>
<td>2,099,707</td>
<td>9,848</td>
</tr>
<tr>
<td>1869</td>
<td>2,192,586</td>
<td>5,318</td>
</tr>
<tr>
<td>1870</td>
<td>2,301,761</td>
<td>2,694</td>
</tr>
<tr>
<td>1871</td>
<td>2,060,138</td>
<td>9,949</td>
</tr>
<tr>
<td>1872</td>
<td>2,589,575</td>
<td>9,826</td>
</tr>
<tr>
<td>1873</td>
<td>2,629,030</td>
<td>12,828</td>
</tr>
</tbody>
</table>

The shipments of patent fuel to foreign ports were:—

- Tons.

- In 1873: 68,451
- As against in 1872: 63,244
- Showing an increase of: 5,207
- Or 8¼ per cent.

The shipments of iron to foreign ports were:—

- Tons.

- In 1873: 155,570
- As against in 1872: 250,221
Showing a decrease of 94,651
Or 38 per cent.

EXTENT OF COAL-FIELD.

The coal-field occupying the greater part of the County of Glamorgan extends into five counties—viz., Monmouthshire, Glamorganshire, Brecknockshire, Caermarthenshire, and Pembrokeshire. (See Plate XLI.) Its greatest length is from Abersychan on the east to St. Brides' Bay on the west, a distance of 89 miles; and its greatest breadth, which occurs in Glamorganshire, is 21 miles. From Abersychan, in Monmouthshire, to the

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Glyncorrwg fault, in Glamorgan, the length is 24 miles, and the average width 13 miles; from the Glyncorrwg fault, going west, to Neath (a distance of nine miles), the average breadth is 20 miles. At Aberafon, five miles due south of Neath, a portion of the coal-field runs beneath Swansea Bay for a distance of nine miles, and with an average breadth of 2½ miles, appearing again at Oystermouth. From the latter place to Kidwelly, a distance of 14 miles, it has an average breadth of 14 miles; a considerable portion of this tract, however (nine miles long by five miles broad), lies beneath the estuary of the Burry and Llwchwr rivers. At Kidwelly, the whole coal-field is lost beneath the waters of Caermarthen Bay, re-appearing at Amroth in Pembrokeshire, the portion beneath the sea being 15 miles in length, with an average width of six miles. From Amroth the field runs uninterruptedly to St. Brides' Bay (a distance of 20 miles), with an average breadth of only five miles. North of Walton, West, Pembrokeshire, at the westernmost extremity of the field, the coal measures take a sudden bend to the north for a distance of 5¼ miles, with an average width of 1¼ mile. (This portion is not taken into consideration in estimating the length of the coal-field.) The average width west of the Glyncorrwg fault is 9½ miles. The total extent of the field may be assumed to be approximately 1,000 square miles, distributed as follows:—

Square Miles.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Monmouthshire</td>
<td>104</td>
</tr>
<tr>
<td>Glamorganshire</td>
<td>518</td>
</tr>
<tr>
<td>Brecknockshire</td>
<td>74</td>
</tr>
<tr>
<td>Caermarthenshire</td>
<td>228</td>
</tr>
<tr>
<td>Pembrokeshire</td>
<td>76</td>
</tr>
</tbody>
</table>

1,000
Of the above about 846 square miles are exposed, about 153 square miles lie beneath the sea, and about one square mile is covered by newer formations.

OLDER FORMATIONS—MILLSTONE GRIT.

The coal-field reposes almost everywhere on the millstone grit, which generally rests on the mountain limestone. Beneath the mountain limestone lies the old red sandstone, and below that the silurian. The millstone grit is of the usual lithological character of these beds; it contains few fossils. At its base occurs a stratum of conglomerate about 20 feet in thickness. Its total thickness is about 220 feet. This formation is often confounded with the Farewell rock of the district, which is a true marine stratum lying above the millstone grit and in the true coal measures. Westward of Swansea Bay the millstone grit disappears, and the lower coal measures rest directly upon the mountain limestone, and still further west the coal measures lie immediately upon the lower silurian.

MOUNTAIN LIMESTONE

This formation, immediately underlying the millstone grit, and resting upon the old red sandstone, is generally seen to dip, where it is exposed, conformably with the coal measures. In a few places, as near Castelcoch, six miles north of Cardiff, south of the coal-field, it dips south, or away from the basin, and this fact suggests the interesting question as to whether the coal measures did not at one time extend in a series of anticlinal and synclinal folds over the whole district, from the south crop of this field to the Nailsea field near Bristol—a tract now occupied by old red sandstone, and the secondary rocks to be seen around Cardiff, and the waters of the Severn. The enormous denudation which Professor Ramsay indicates as having occurred in this field would at any rate afford a sufficient explanation for their absence. On the north of the coal-field the limestone ridge reaches a considerable altitude, over 1,200 feet above the sea, while on the south crop their usual height is 400 or 500 feet. They are divisible into two horizons: first, upper beds, consisting of alternating dark shales, with bands of limestones passing downwards into massive beds of the latter, the aggregate thickness being about 700 to 1,000 feet. A curious physical feature in these rocks on the north crop is the cave of Ystrad-yr-felte where a subterranean channel has been eroded by the River Nedd.

OLD RED SANDSTONE—UPPER DEVONIAN.

This formation occupies a large proportion of the district under consideration. It consists of conglomerates, red and brown sandstones, marls and calcareous cornstones, 8,000 to 10,000 feet in thickness. On the north of the field these beds form the highest ground in South Wales, rising to the height of 2,910 feet above the sea in the Fans of Brecknockshire, which Sir R. Murchison describes as "the grandest exhibition of the old red sandstone in England and Wales." They seem to have
undergone most of the convulsions which disturbed the other Palaeozoic strata resting upon them, for the great faults running through the coal measures, millstone grit and mountain limestone on the south crop, are to be likewise traced in the old red to the north-east of Cardiff.

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SILURIAN.

This formation consists of the upper Silurian (Ludlow and Wenlock series) in the east, and middle silurian (Llandovery rocks) and lower silurian (Llandeilo flags) in the west. Their thickness probably averages between 600 and 700 feet. They form tolerably high ground on the east of the coal-field between Pontypool and Usk. South of Llandegfydd, in Monmouthshire, they are lost beneath the old red sandstone; but that they run uninterruptedly beneath these rocks to Cardiff is proved by their cropping up around Llanfrechfa, three miles north of Newport, and again at Malpas, Penhos, Llanhennock, and Christchurch—all within a few miles from Newport. How far they extend eastwards is not known. On the west, after striking beneath the old red sandstone for some distance, they re-appear on the surface near St. Mellons, from whence they run uninterruptedly to Pen-y-lan and Rumney, near Cardiff. Almost the whole of these rocks are stained a deep red by protoxide of iron; though in places, as at Pen-y-lan, bands of cherty limestone occur, replete with bivalve shells.

In the west of the field, the lower silurian beds occupy a great portion of the counties of Caermarthen and Pembroke, by far the larger part of which is occupied by the Llandeilo flags, while the upper Llandovery rocks only occur on the southern border, between Langwm, Pembrokeshire, and St. Brides' Bay.

HYPOGENE.

A mass of igneous rock, greenstone, &c, five miles long by three-quarters of a mile broad, bounding the coal-field, occurs between Langwm, and Walwys Castle, in Pembrokeshire; a narrow strip of the same rock thence runs uninterruptedly along its southern border to its terminus in St. Brides' Bay.

SCENERY.

The coal measures of South Wales frequently form beautiful and varied scenery, consisting of bold hills intersected by numerous valleys, at the bottom of which run rapid streams. The sides of the valleys are frequently wooded for some distance up and above the bare and sterile mountains rise, covered only by coarse grass, heather, gorse, and bracken ferns, whilst the summits are capped by rugged cliffs and large masses of debris, chiefly of pennant sandstone. In other parts of the field the surface forms a rich undulating country. The average height of the hills is very considerable; and the highest ground in the coal-field is
Carn Fach, in Glamorgan, 1,971 feet above sea-level. The valleys are generally narrow and deep, running from north to south, and debouching upon the Bristol Channel, where all the ports are situated; and they afford great facilities for winning, and afterwards carrying away, the minerals along the railways and canals which are constructed up all the principal valleys, the rivers not being navigable far from their mouths. Everywhere throughout the field are indications of vast denudation having taken place, which probably happened simultaneously with the rising of the land, when, as each portion gradually rose above the sea, it was acted upon by marine currents. By these operations the upper portions of the valleys were most likely formed, while the lower parts, which alone show indications of alluvial deposits, were excavated afterwards by sub-aerial action, and by the streams which at present run through them. We have no positive traces here of abrasions by glacial action.

DESCRIPTION OF STRATA.

The coal measures of this field may be assumed to have a total thickness of upwards of 7,000 feet. They may be divided into three principal series, viz.:—

1. Upper Pennant,

2. Lower Pennant, and

3. White Ash Series.

See the General Vertical Section for division of these series (Plate XLII).

1.—THE UPPER PENNANT SERIES.

On the south rise, near Swansea, these strata are stated by Mr. Moses, in a book published in 1849, to be 3,000 feet in thickness, and in the south trough only 400 feet. In the eastern part of Glamorganshire, and in Monmouthshire, the writer estimates their thickness in the south trough at 500 feet, and in the north trough at 700 feet; but in the neighbourhood of Neath, between the Duffryn and Ridding faults, the thickness of this series is upwards of 1,200 feet; and at Loughor the thickness is very much greater, and there is a corresponding addition to the number of workable seams of coal in that part of the coal-field. The Broad Oak, Bryncoch, Primrose, Craigola, and Hughes’ free burning and bituminous seams of the Swansea and Neath districts, and the Mynyddfylwyn, Bedwas, Llantwit, and Bettws household coals of the eastern portion of the coal-field, and a vein of black band occur in this series. For average sections of the seams in this and the other series in the western part of the coal-field, the writer begs to refer to an extract from Mr. Vivian’s report to the Royal Coal Commission appended. The General Vertical Section, before referred to, gives the
average thickness of coal in the eastern portion of the field above 12 inches in thickness, as about 99 feet 10 inches in twenty-six seams; in the western part of the coal-field, a thickness of 182 feet of coal is locally observed, divided into eighty-two seams.

2.—LOWER PENNANT SERIES.

These strata probably average 1,100 to 1,500 feet in thickness between the Taff River and Llanelly, but in some parts of the coal-field, nearer the anticlinal, and in the southern basin, they attain a thickness of 3,000 feet. They may be assumed to include all the measures between the Craigola, Mynyddysllwyn or Llantwit seams of coal, and the Cockshute rock, a siliceous quartzose rock. This division contains fair steam coal seams in some districts, with valuable beds of black band, as in the Llwyni district; in other parts of the coal-field these seams produce good manufacturing and household coals, the small from which is converted into excellent coke, as in the Rhondda Valley. The black band has been for many years, and is now, extensively used for making iron at Maesteg, and the following are analyses of these ironstones:—[see in original text]

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Several of the principal seams of coal in this series are known by various names in the different localities of the coal-field. The series includes the Field, Wernddu, or Glyncorrwg (probably identical with the No. 2 Rhondda), Wern-pistill, Tormynydd, Jonah, white seam; in other parts of the coal-field: upper clay seam, No. 3 Rhondda, Havod seam (possibly the same as the Albert or the Victoria seams of Maesteg), Abergorchi, Caedefyd or Golden seam. The best known and most valuable are the Nos. 1, 2, and 3, Rhondda seams, Victoria and Abergorchi. The probable average thickness of workable coal in this series is about 25 feet; the average thickness of each seam will not exceed about 3 feet: the roofs are often rock, and with the floors are generally strong.

3.—WHITE ASH SERIES.

These strata contain by far the most valuable coal seams, and the great argillaceous ironstone deposits of the field. This division, like the others, varies considerably in thickness, thinning out towards the eastern edge of the coal-field to about 500 feet; but towards the centre of the coal-field the thickness of the strata of this series is about 1,000 feet. There are more seams, and of a greater aggregate thickness, on the south than on the north crop; the same may be said of the ironstones, which are also richer on the south crop.

It is to the coals of this series that South Wales owes its position as an iron-making and coal-exporting district. Within a comparatively small thickness of intervening strata, numerous seams of workable coal are found, varying from 3 feet to 9 feet and upwards each in thickness, and extending, with few exceptions, uninterruptedly, but of varying quality, throughout the coal-field.

The Farewell rock forms a portion of this series, and is the lowest stratum of the coal measures. It immediately underlies the bottom vein, or Pin-garu ironstone, and contains the Rosser veins of
ironstone and seams of coal. It is a true marine stratum, and contains numerous marine fossils, as mollusc and fish remains.

The probable average thickness of workable coal in this series is about 50 feet. Belonging to this series are the coal measures of Pembrokeshire, for the particulars of which the writer is indebted to Messrs. Daniel, mining engineers, of Swansea, who are much better acquainted with this part of the field than he is.

Pembrokeshire contains an area of upwards of seventy square miles, under which seams of coal are found to exist, and which are no doubt a continuation of the South Wales coal-field beyond Caermarthen Bay. The minerals have been but partially developed, but sufficient information has been obtained to indicate the geological horizon and the existence of large faults and contorted strata.

In no other part of the South Wales coal-field is the strata found to be so contorted as in Pembrokeshire. This is probably due to the large faults known to exist, the chief ones being—first, that which may be observed about 800 yards north of Saundersfoot, extending in a westwardly direction to St. Brides' Bay; and, second, the fault extending about 400 yards south of Saundersfoot to Langwm, where the greenstone appears close to the coal formation. The last-named fault is possibly a continuation of the main anticlinal.

The limestone lying under the coal measures on the north and south, in Pembrokeshire, is similar to the same formation in the other parts of the coal-field. A peculiarity of this part of the field, however, is the fact that there is but one general dip or inclination of the coal strata to be found, viz.—to the south. This is probably caused by the disturbances before mentioned. The veins of coal exist at a moderate depth, the maximum being about 1,500 feet.

The highest workable vein known to exist is the "timber rock vein," about 3 feet 4 inches thick; next in descending order, at a depth of 76 feet, is the "timber low vein," 1 foot 6 inches thick; the next, at a depth of 160 feet, is the "timber vein," 6 feet 6 inches; following, is the "stinkard vein," 1 foot 6 inches thick, at a depth of 365 feet; below the stinkard vein, at a depth of 490 feet, is the "rock vein", 1 foot 6 inches thick; below the rock vein, at a depth of 695 feet, is the "lower level vein," 1 foot 8 inches thick; below this latter seam, at a depth of 980 feet, is the "Kilgetty vein," about 1 foot 9 inches thick; below which there are several small veins of coal too thin probably to be profitably worked at the present time. Total depth from the "timber vein" to "Kilgetty vein," 980 feet.

All the coal in Pembrokeshire is anthracite; and, from the report recently made to the Royal Coal Commission, there yet remains in this county 215,695,910 tons of workable coal.

With the exception of the Kilgetty vein the coals are considered to be somewhat tender.

The entire thickness of the coal measures varies greatly in different parts of the coal-field. On the south rise they are stated by some authorities to be 11,000 feet thick; on the north, 7,000 feet; between Briton Ferry on the west and the River Taff on the east their thickness is about 4,800
feet on the south crop; and to the east of the Taff they still further thin out as they approach the eastern limits of the coal-field.

IRONSTONES.

In the upper and lower Pennant series there are two beds of workable ironstone, viz.—the Llancaich black band, and another black band occurring over the No. 2. or charcoal vein coal, besides the black bands already referred to in the Maesteg district.

The following is an analysis of the bed over the charcoal vein as worked at Abercarn, by W. Ratcliffe.

Description.—Colour, brownish grey; compact, containing thin seams of coal, and films of pyrites in some of the joints.

ANALYSIS.

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protoxide of iron</td>
<td>43.37</td>
</tr>
<tr>
<td>Sesquioxide of iron</td>
<td>4.10</td>
</tr>
<tr>
<td>Oxide of manganese</td>
<td>1.50</td>
</tr>
<tr>
<td>Alumina</td>
<td>6.05</td>
</tr>
<tr>
<td>Lime</td>
<td>8.00</td>
</tr>
<tr>
<td>Magnesia</td>
<td>0.25</td>
</tr>
<tr>
<td>Silica</td>
<td>2.80</td>
</tr>
<tr>
<td>Potash</td>
<td>0.32</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>30.50</td>
</tr>
<tr>
<td>Sulphuric acid (from pyrites)</td>
<td>1.56</td>
</tr>
<tr>
<td>Organic matter</td>
<td>6.25</td>
</tr>
<tr>
<td>Phosphoric acid</td>
<td>traces</td>
</tr>
<tr>
<td>Hygroscopic water</td>
<td>0.27</td>
</tr>
<tr>
<td>Combined water</td>
<td>0.31</td>
</tr>
</tbody>
</table>

100.28
Iron (total amount) 36.49

3.—THE IRONSTONES OF THE WHITE ASH SERIES.

This series contains an aggregate thickness of over 8 feet of ironstone, exclusive of the Rosser veins. The separate veins are not persistent over the whole field, often thinning out altogether; but their stratigraphical horizon can generally be known by the peculiar fossils by which each vein is often distinguished.

Analyses of ironstones of the white ash series, as worked at Dowlais, by A. Dick, Esq.:—

[212]

PIN-GARW ANALYSIS.

(Soluble in hydrochloric acid.)

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>0.14</td>
</tr>
<tr>
<td>Protoxide of iron</td>
<td>44.29</td>
</tr>
<tr>
<td>Alumina</td>
<td>0.45</td>
</tr>
<tr>
<td>Protoxide of manganese</td>
<td>1.13</td>
</tr>
<tr>
<td>Lime</td>
<td>3.06</td>
</tr>
<tr>
<td>Magnesia</td>
<td>3.73</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>32.48</td>
</tr>
<tr>
<td>Moisture</td>
<td>0.42</td>
</tr>
<tr>
<td>Combined water</td>
<td>1.03</td>
</tr>
<tr>
<td>Phosphoric acid</td>
<td>0.42</td>
</tr>
</tbody>
</table>

87.15

(Insoluble in acid.)

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>7.77</td>
</tr>
<tr>
<td>Alumina</td>
<td>3.75</td>
</tr>
<tr>
<td>Peroxide of iron</td>
<td>0.41</td>
</tr>
<tr>
<td>Lime</td>
<td>0.12</td>
</tr>
<tr>
<td>Magnesia</td>
<td>0.19</td>
</tr>
</tbody>
</table>
Potash
Organic matter
Sulphur

13.36

+ 87.15

= 100.51

Metallic iron per cent. 34.72

Traces of copper found in each 500 grains of ore.

In the Farewell rock are found the Rosser veins of ironstone. The following is an analysis of them, as worked at Dowlais, by A. Dick, Esq:—

ROSSER VEINS ANALYSIS.

(Soluble in acids.)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>0.27</td>
</tr>
<tr>
<td>Protoxide of iron</td>
<td>41.03</td>
</tr>
<tr>
<td>Alumina</td>
<td>0.23</td>
</tr>
<tr>
<td>Protoxide of manganese</td>
<td>0.55</td>
</tr>
<tr>
<td>Lime</td>
<td>2.83</td>
</tr>
<tr>
<td>Magnesia</td>
<td>3.11</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>28.49</td>
</tr>
<tr>
<td>Moisture</td>
<td>0.57</td>
</tr>
<tr>
<td>Combined water</td>
<td>1.36</td>
</tr>
<tr>
<td>Phosphoric acid</td>
<td>0.70</td>
</tr>
<tr>
<td>Organic matter</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>79.21</td>
</tr>
</tbody>
</table>

[213]

(Insoluble in acids.)
Hematite iron ore occurs in the mountain limestone, at Pentyrch, at the mouth of the Taff valley. Iron ore occurs here in nearly vertical fissures in the limestone. A bed of ironstone is also situated in the lower limestone shales, and is made up of encrinital remains cemented together by protoxide of iron, but it has not as yet been worked to any considerable extent.

The following is an analysis of this hematite iron ore from Whitechurch, near Cardiff, taken from the Memoirs of the Geological Survey.

Description.—Compact, soft, lustre, greasy, so dull; colour, dark red on outside, on the fracture blackish red; streak, bright red; soils the fingers and makes a red streak on paper; structure, oolitic, and sometimes pisolitic.

ANALYSIS.

<table>
<thead>
<tr>
<th>Material</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sesquioxide of iron</td>
<td>66.554</td>
</tr>
<tr>
<td>Protoxide of iron</td>
<td>1.131</td>
</tr>
<tr>
<td>Oxide of manganese</td>
<td>1.127</td>
</tr>
<tr>
<td>Alumina</td>
<td>1.753</td>
</tr>
<tr>
<td>Lime</td>
<td>8.547</td>
</tr>
<tr>
<td>Magnesia</td>
<td>1.116</td>
</tr>
<tr>
<td>Silica</td>
<td>0.312</td>
</tr>
<tr>
<td>Potash</td>
<td>0.190</td>
</tr>
</tbody>
</table>

\[\text{Silica} \quad 13.08 \\
\text{Alumina} \quad 5.56 \\
\text{Protoxide of iron} \quad 0.41 \\
\text{Lime} \quad 0.17 \\
\text{Magnesia} \quad 0.25 \\
\text{Potash} \quad 0.86 \\
\]

\[\text{Silica} + 20.33 = 79.54 \\
\text{Potash} = 99.54 \\
\text{Metallic iron} \quad 32.18\]
Soda 0.068
Carbonic acid 6.733
Sulphuric acid 1.309
Phosphoric acid 1.017
Organic matter 0.376
Water (total) 2.118
Ignited insoluble residue 10.356

101.707

[214]
(Ignited insoluble residue.)
Silica 8.589
Alumina (with a little iron) 1.042
Lime 0.850
Magnesia 0.272
Potash 0.235
Soda 0.076

11.064
Iron (total amount, soluble) 47.468

No metal precipitable by sulphuretted hydrogen, from the hydrochloric acid solution of 300 grains of ore was detected.

Besides the preceding, other beds are met with in the Permian rocks. These belong to the lower Permian, and are worked at Mwyndy, near Llantrissant, where the ore passes down into fissures in the mountain limestone. A similar deposit is also met with, covering an area west of Llantrissant; and again at Quay-Coch, two miles north of Porth Cawl, where it lies immediately over the mountain limestone, and contains a large proportion of manganese. Its thickness here is five feet.

The following is an analysis of this ore as worked at Mwyndy, also extracted from the Memoirs:—
Description— Compact red hematite, easily scratched by a file; lustre, earthy; colour, deep red yellow; streak, brown red; fracture, uneven, showing numerous cavities lined with crystals of quartz; the ore contains minute particles of quartz visibly diffused through it.

Sesquioxide of iron 70.572  
Oxide of manganese 0.522  
Silica 18.362  
Alumina 1.572  
Lime 3.562  
Magnesia 1.311  
Potash 0.317  
Sulphuric acid 0.451  
Phosphoric acid 0.132  
Carbonic acid 1.716  
Water (total) 0.660  

99.177  
Iron (total amount) 48.932

There has been a gradual but certain increase in the cost of producing the native argillaceous ironstone of the district as the workings from

[215] which it is obtained increase in depth, and the iron masters have consequently given special attention to the importation of hematite ores from other districts; the hematite deposits of the Forest of Dean, Northamptonshire, Cumberland, and North Lancashire, Somersetshire, Cornwall, and Foreign ores, all now contribute to the supply of the Welsh iron works, but the great resources of the future are probably the inexhaustible deposits of Spain; the further development of these deposits will have a very material influence upon the iron and steel industries of South Wales, this coal-field is so favourably and exceptionally situated for importations from Spain, Portugal, and the Mediterranean; and having regard to the increase in the importation of iron ore from oversea, we may expect to observe in the future iron works established at the South Wales ports in preference to the northern outcrop of the coal-field, where the existing works are chiefly situate, the conditions
which prevailed when the works were first established, namely, the supply of cheap native ironstone
and coal, as regards the ironstone, exist no longer.

FIRE-CLAY.

Almost every coal seam in this field rests upon a bed of fire-clay composed in great part of stigmaria;
the fire-clay underlying several of the white ash series of coal seams is of good quality, and the
manufacture of fire bricks from it in the district will ultimately become an important local industry.

BUILDING STONE.

The Pennant sandstones afford an inexhaustible supply of fine and cheaply-worked building and
paving stones.

FAULTS.

The basin is traversed by the ordinary slip faults, many of which are of great size. The main faults,
with one or two important exceptions, range generally north-west and south-east, and are, in most
cases, nearly parallel; the Box Bar, Garden, Duffryn, Riddings, Gnoll, Grlyncorrwg, Moelgilau, Bwlifa,
Dinas, Gadlys, Werfa, Merthyr Church, Llanvabon, and Risca, may be quoted as a few of the best-
known faults of the coal-field, but there are no whin dykes.

In some of the faults the displacement increases as they pass south, and in others the reverse is the
case.

The lateral separation is inconsiderable, seldom above 8 or 12 yards. The coal in the immediate
neighbourhood of the faults is generally

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affected for a few yards, and in the immediate districts where the general character of the coal is
undergoing a change the difference in quality becomes, in some cases, more marked at the faults.

SLIPS.

In the coal seams cleavages, called "slips," occur in parallel divisions, usually from 9 to 18 inches
apart, having generally a direction of north 30° west true meridian, or the same polarity of direction
as the main faults, with an underlie west of three-fourths the height of the coal. Two exceptions to
this usual direction of the slips are, however, occasionally met with; first, when they underlie
eastward, when they are called "backs;" the other exception is found often in the Rhondda Valley,
where there are disturbances parallel with the anticlinal line; the slips here lie in a diagonal course
between north 30° west, and the bearing of these lines of local disturbance north 80° west; the "slips" having the same diagonal relation to the main faults. Various theories have been proposed from time to time to account for these "slips," but the most eminent geologists believe them to be the result of pressure.

ANTICLINAL.

The coal-field practically forms two coal fields, being divided into two elongated troughs by an anticlinal ridge running east and west in a somewhat sinuous course from Meddart, Monmouthshire; crossing the Ebbw, the Sirhowy, by Velin-fach, Newbridge, Ton-y-refail across the lesser Ogmore, by Nantyrus, and the Maesteg Iron Works, through Baglan, and beneath Swansea Bay and Gower, and is continued through the older rocks in Pembrokeshire.

The basin is thus divided into a northern and southern portion; the cross sections illustrate the influence which this important elevation has upon the coal measures. The line of elevation is nearer to the southern edge of the basin where the natural dip of the coal seams is greatest, so that it has the effect of bringing near to the surface seams which would otherwise lie at a great depth, and elevates the deepest seams to within a workable depth.

CHANGE OF QUALITY.

A striking feature in the nature of the coal of this field is the change in different localities from bituminous to anthracite, and vice-versa. This change is generally gradual, although occasionally very remarkable exceptions are to be found to this rule. The intermediate qualities are known

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as semi-bituminous, smokeless and bastard anthracite; the change in quality operates both vertically and horizontally. In those portions of the coal-field where the change in a vertical direction may be observed, the upper seams are most bituminous in quality, the loss of bitumen as a rule increasing in a downward direction; and in many cases, therefore, the upper seams of the lower Pennant series are found to be of bituminous quality, and the white ash seam immediately below carbonaceous. Generally it may be assumed that all the coals of that portion of the coal-field west of Carmarthen Bay are of pure anthracite quality; eastwards of that bay the coals of the peninsula of Gower, the upper seams of the Llanelly district, and approximately the coals of the white ash series, south and east of a line drawn from Gower Road to Neath, Cymmer, Ystrad, Ferndale, Navigation, and Merthyr, are more or less bituminous, the same seams north and west of that line being carbonaceous in the Aberdare and Rhondda districts, changing gradually to anthracite west of the vale of Neath.

Approximately the area of bituminous coal-field may be assumed to be about 410 square miles; of anthracite, 410 square miles; and of coals, of a quality ranging between bituminous and anthracite, 180 square miles.
THEORIES FOR CHANGE OF QUALITY.

Several theories attempting to account for this change in quality have been suggested. Friction caused by pressure, resulting either from the weight of superincumbent strata or from lateral forces or resistance; or from internal disturbances; or by combinations of some, or of the whole, have been held to be an explanation. The phenomena have been attributed by others to the various forms of electrical disturbance; whilst others again seek for the explanation in the thinning out of the old red sandstone to the west, thereby bringing the coal measures in that direction nearer to the influence of possible volcanic disturbances.

It has also been suggested that an explanation of the phenomena may possibly be arrived at by analyzing the ash of the different coals which may show the loss of bitumen to be due to the chemical changes which have taken place in the coal seams owing to the variation in their component parts.

Mr. G. C. Greenwell, in a paper read before the Manchester Geological Society, also refers to this subject in the following terms:

"It has usually been considered that the anthracite condition of coal is due to the action of heat, but I think that by a certain process of reasoning we may arrive at the conclusion that this agency is not necessary; and if we can find ourselves justified in arriving at such a conclusion, we shall, I think, have cleared up many difficulties which have beset us when endeavouring to account for the varied conditions in which we find the same seam of coal to exist in different localities. In considering the origin of peat it is at any rate acknowledged that it is in a comparatively slight degree removed from existing vegetable matter. And what do we find to have taken place in the process of change? We find that, in mass for mass, as compared with wood, peat contains a greater proportion of carbon, a little less hydrogen, and considerably less oxygen; and we also know that the vegetable matter has become peat from, to a certain extent, the conversion having been formed under water, and where it was, consequently, unexposed to the action of the atmosphere. If, then, a certain process of fermentation or chemical action has the effect of converting what was originally vegetable matter, pure and simple, into peat, a continuation of the same process would, a fortiori, convert it into a mass with a greater relative proportion of carbon, a little less hydrogen, and considerably less oxygen than those contained in the peat before it was subjected to this further process; and, by the same train of reasoning, we can ultimately arrive at the formation of anthracite. All that is necessary to account for the production of a varied condition in the result from the same origin is that, in the progress from vegetation, or rather vegetable matter to anthracite, the progress of the change should be arrested by the superposition of such deposits of sand or shale as would completely check the action which has been referred to. And I think it quite consistent with reason that as the superincumbent masses increased and exercised greater pressure, we should have such development of the latent heat of
the compressed vegetable mass as fully to account for such phenomena as we have hitherto attributed to heat developed by other and external causes."

At some of the faults a somewhat sudden change in quality has been observed, but in most cases the change is very gradual and is uninfluenced by faults.

**STATISTICS.**

**QUANTITIES OF COAL WROUGHT AND UNWROUGHT IN THE FIELD.**

The following figures are obtained by an analysis of the Report of the Royal Coal Commission upon this field:—

Workable coal at a less depth than 4,000 feet, after deducting for faults, pillars, barriers, small left behind, &c 33,285,541,245

Worked 828,375,598

To be worked at a less depth than 4,000 feet 32,457,165,647

Coal at a greater depth than 4,000 feet 4,108,996,750

Total quantity of unworked coal in the coal field 36,566,162,397

Present rate of working about 15 million tons or $\frac{1}{24.37}$th part per annum.

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**WINNING.**

The primitive method of mining by open patchwork at the outcrop of the seams is still practised under circumstances favourable for its adoption, especially in getting argillaceous ironstone. A fine example of this system of working may still be observed at the great patch in operation on the anticlinal at the Maesteg works.

Where the seams crop out along the hill sides, water levels are generally driven in upon them to work the coal above the level of the valleys; below that, pits become necessary. The practice of these several systems in succession from the north outcrop is pretty well the history of mining in most of the important valleys. On the south outcrop, where the inclination is steeper, slopes driven down with the seams, or water levels driven across the measures to intersect the different seams, are generally adopted. Pits also are sunk where deeper ranges are required than can be obtained by levels across the measures.

The following is a list of some of the deepest working pits in the field:—
Name of Valley. | Name of Pit. | Owners. | Depth, yards
---|---|---|---
Ebbw | Abercarne | Ebbw Vale Co. | 304
Rhymney | New Tredegar | Powell Duffryn Co | 418
Rhymney, Bargoed | Vochrhiw | Dowlais Iron Co | 435
Merthyr | Castle | Robert Crawshay, Esq. | 332
Aberdare | Navigation | Messrs. Nixon and Co. | 365
Rhondda | Dinas | Messrs. Coffin and Co. | 403
Rhondda | Llwynypia | Glamorgan Coal Co | 382
Rhondda | Blaenhondda | Messrs. Marychurch and Co. | 402

MODE OF WORKING.

From the main or water levels leading to the pit bottom, or to slope drifts, or to the surface, as the case may be, headings are driven to the rise and to the deep, the rise headings being generally called cross headings, and from the headings the stall roads are driven. The amount of dip working will depend upon the quantity of water; and the distance between the headings will depend upon the length it is found most prudent to drive the stall roads before cutting them off; this question, as well as the distance between the stall roads, depending chiefly upon the nature of the floor or roof, or both combined; the conditions varying with almost every seam, and with the same seam in different localities.

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There are three principal systems of getting the coal, namely:—first, single road stall; second, double road stall; and, third, long-wall.

The following general sketches will explain the different systems, and the mode of ventilating in each case. The seams of the upper and lower Pennant series, and the 9 feet seam of the white ash series, are generally worked by the first or second systems, or a modification, and the seams of the white ash series are chiefly worked upon the long-wall system.

The last named system was generally substituted a few years ago for No. 1 system in working the steam coals of the Rhondda and Aberdare Valleys, and the result has been to increase the produce of large coal, simplify the ventilation, and reduce the labour of the workmen.

SINGLE AND DOUBLE ROAD STALLS.

Single road stalls are generally turned narrow for a short distance off the heading, after which they widen out to their proper width. (Plates XLIII. and XLIV.) The width of single and double road stalls
will depend principally upon the quantity of rubbish to be stowed away, and the rate at which the seam dips. The size of the pillars between the stalls, and between the stalls and the heading, will depend for the most part upon the nature of the roof and floor. The stall pillars are worked when the stalls have gone their full length, and the heading pillars when there is no longer any use for the headings, and the operation is called "pulling back the stall," or "pulling back the heading," as the case may be.

LONG-WALL.

This system is adopted when the roof is sufficiently strong to remain up with only the aid of a few props; but more generally when it is sufficiently friable to settle down permanently behind the working face. (Plate XLV.) On account of the friable roofs and the great pressure, it would be almost impracticable to work some of the steam coal seams in the deeper pits otherwise than by long-wall; and so pernicious an effect have stumps or pillars upon the roof, that it has become the general practice to work the whole of the coal away with the exception of the large pillars at the shaft bottom. It is important in this system that the working face should be kept moving on, so as not to give the roof time to break at the face; regard, too, must often be had to the quantity of rubbish available for packing. The ventilation is simpler in this system than in stall and pillar working, and the percentage of large coal is higher. It is the usual custom in South Wales to take the horse and tram to the face of

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the workings; and when the seam is not thick enough, either the top or the bottom has to be cut in the horse roads to give the necessary height. In some instances, when both top and bottom are very hard, the coal is put along the stall either in small carts or in sledges, and loaded into the trams at short sidings, often called "spout holes," off the headings.

The following is a sketch of a system of working generally adopted on the south outcrop where the measures are steep (Plate XLVI.):—

The collier in South Wales has to cut the coal and fill it into the trams; he has to gob the rubbish, make and keep the working place safe and in order; he has to keep his stall road in travelling order, and do all the timbering necessary in his working place.

The mode of hewing the coal depends upon the section of the seam, and in what degree it sticks to the top or bottom. When the seam is in one block, the holing or kirving is done either at the top or at the bottom; and when the seam is divided into different beds, the holing might be done in one of the smooth partings, or in any intervening band of clod that may be suitable for the purpose. When the slips, referred to in a former part of this paper, are frequent, and long-wall working adopted, the operation of cutting or securing the coal is a comparatively easy operation.

The bituminous seams are cut "through and through," but in the steam coal seams the large coal only is sent out.
The coal is screened at the surface, over screens with longitudinal bars, on the average 1½ inches apart, and 13 feet long by 7 feet wide, angle about 20°. The small out of each tram is weighed, and, if it exceeds a given weight, a deduction is made from the hewer. The machine, by means of which the weight of the small coal which passes through the screens is ascertained, was named, many years ago, by the colliers of the district, "Billy Fairplay;" and it is astonishing what an unpopular individual this fellow has become, and, as years go on, his unpopularity, instead of passing away, if anything, increases. The coal after being screened at the colliery, is known as "colliery screened large," but, in many cases, it is again screened at the port of shipment, and is known as single screened at time of shipment, or double screened at time of shipment as one or both of the two screens in the shipping shoot are open. The proportion of steam coal small left underground is about 15 per cent.; the small taken out by screening at the colliery averages about 14 per cent.; and double screening, at the port of shipment, from 7 to 10 per cent.

Coal cutting by machinery has not been adopted to any material extent in this district, but Firth's and Baird's and other machines are on trial at one or two collieries, and are said to be giving good results. A greater percentage of large coal is undoubtedly obtained by the use of these mechanical cutters.

In portions of a colliery where strong blowers of gas make it dangerous to blast with powder, Chubb's hydraulic hand machine for wedging out the coal has given good results, and a hand machine for kirving has lately been introduced at the Yniscyon Colliery.

Argillaceous ironstone is worked generally by the long-wall system, but in some cases by pillar and stall; the black band is universally worked by the long-wall system, and the ironstone is carted along the stall roads to the main headings, where it is loaded into the large trams.

VENTILATION

The mode of coursing the air along the working faces has been shown in the sketches explaining the different systems of getting the coal. Gas is seldom to be found in collieries upon seams which crop out to the surface and worked by levels. The most fiery collieries are those upon the lower or steam coal seams, and, probably, no seam in any coal field gives off more gas than the Aberdare four feet seam, especially in new districts where the gas has not had any previous opportunity of draining off. The whole of these lower seams are very subject to strong blowers, generally in the roof, upon which, of course, they have a very bad effect, independent of the danger involved in the presence of the gas itself. The ventilating power usually adopted is the furnace, but mechanical ventilators are now at work at several of the collieries. The first great stride in the direction of mechanical ventilators was Mr. Struve's air pump; several of these machines have been erected in South Wales, but the Guibal and the Waddle fans have latterly come into more general use. These machines are all so well known that it is unnecessary to describe them in this paper, but the following list of fans at work will be interesting as indicating the progress in the application of mechanical ventilation in the district:—
And the following is a list of the Waddle fans in operation in the district:—

<table>
<thead>
<tr>
<th>Name of the Colliery.</th>
<th>Feet in Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonvilles Court Colliery</td>
<td>Pembrokeshire 16</td>
</tr>
<tr>
<td>Bryndu &quot;</td>
<td>Glamorganshire 19</td>
</tr>
<tr>
<td>Llansamlet Do.</td>
<td>12</td>
</tr>
<tr>
<td>Eesolven Do.</td>
<td>14</td>
</tr>
<tr>
<td>Llynvi &quot; Do.</td>
<td>22</td>
</tr>
<tr>
<td>Mynydd-Nowydd Do.</td>
<td>25</td>
</tr>
<tr>
<td>Morfa &quot; Do.</td>
<td>40</td>
</tr>
<tr>
<td>Gorwydd Do.</td>
<td>20</td>
</tr>
<tr>
<td>Glasbrook's Do.</td>
<td>20</td>
</tr>
<tr>
<td>Gadlys &quot; Do.</td>
<td>40</td>
</tr>
<tr>
<td>Aberaman Do.</td>
<td>40</td>
</tr>
<tr>
<td>Nevill and Co.'s Carmarthenshire</td>
<td>25</td>
</tr>
<tr>
<td>Aber &quot; Glamorganshire</td>
<td>20</td>
</tr>
<tr>
<td>Maesteg Do.</td>
<td>40</td>
</tr>
<tr>
<td>Davis Maesteg Merthyr Do.</td>
<td>—</td>
</tr>
<tr>
<td>Abercwmboy Do.</td>
<td>40</td>
</tr>
<tr>
<td>New Tredegar Monmouthshire</td>
<td>40</td>
</tr>
</tbody>
</table>
Rhondda-Merthyr Colliery, Glamorganshire 40
Cwm-Avon Do. 25
Pentre " Do. 40
Nixon and Bell Do. 20
Lletty-Shenkin " Do. 40
Fowlers' Pontypridd " Do. 25
Dinas " Do. 40

UNDERGROUND HAULAGE.

At most of the important collieries where the lead has become considerable, the underground haulage is done by machinery. In the levels the main and tail-rope system is adopted, worked generally by a pair of horizontal cylinders. On the roads to the deep, the empty trams take the rope after them, the drum riding loose on the shaft, and the engine hauls the full trams up the bank. When the rise headings become cut off by new or upper levels, the most convenient of the old headings are often converted into self-acting inclined planes. Arrangements are frequently effected for hauling along the dip and rise headings by spare ropes in connection with the main and tail ropes of the principal levels. Within the last few years, compressed air has come very much into use as a motive power for underground engines, and although there is a loss of power at the outset in compressing the air, this objection is more than counterbalanced by the extreme facility with which the power may be applied, and that, too, under such very variable circumstances. Examples of successful applications of compressed air for hauling purposes may be observed at several of the Powell's Duffryn Company's collieries. Steel ropes are found in the long run to be the most economical. Electric signals are often used on the main engine roads. The trams are brought from the face of the work to the different stations by horses driven by men called hauliers. The main engine roads are laid with comparatively heavy double-headed rails chaired to the sleepers; but on the horse roads a lighter and flat-bottomed rail is used, fastened to the sleepers by nails. In working bituminous seams where the small coal is brought out, closed sheet iron or wooden trams are used; but when the small made in cutting the coal is gobbled, and the large coal only sent out, trams made of flat bar iron, with spaces between the bars, are used. The trams vary in capacity. In some of the bituminous collieries a tram carrying as much as 80 cwt. of coal is used. The question of large trams, as compared with the smaller tubs used in other districts, has been very fully discussed from time to time. Small tubs are used at

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some of the collieries, but the Welsh people as a rule are more in favour of the large tram. There is no doubt that certain seams can be worked more economically with small tubs, whilst the particular conditions of other seams would suggest the adoption of the large tram. In working the best steam
coals, where a cubical fracture does not prevail, and when it is important to procure the coal as large as possible, a tram of large capacity becomes a commercial necessity. The tram in pretty general use at the largest steam coal collieries is made of flat bar iron, with spaces between the bars; the tare is from 7 to 8 cwt., but the weight is often reduced by using steel instead of iron in their construction. The load of coal is from 18 to 20 cwt. At some of the best collieries, where the roads are kept in first-rate order, trams with fixed wheels are used.

The following are the particulars of the underground haulage arrangements at the New Tredegar Colliery:—Air-compressing engines at the surface. A pair of steam and air-compressing cylinders, 21 in. diameter and 5 ft. stroke; speed, 35 revolutions per minute; pressure of air, 22 lbs., supplying the following engines underground:—

Two single engines, 12 in. cylinder and 12 in. stroke.
One single do. 4 in. do. and 18 in. do.
Two pairs of engines, 14 in. do. and 18 in. do.

but as the underground engines are not all working regularly at the same time, the average speed of the air-compressing engines is 25 revolutions per minute, and average pressure of air 35 lbs. per square inch.

DIVISION OF LABOUR.

The following are the different persons employed in and about the collieries of South Wales and their several duties:—

1. The manager, who is personally responsible to the owners for the proper carrying on of the works, both as to the underground and surface operations.

2. The overman, and in the larger collieries the underviewer, who is responsible to the manager for the carrying out of all instructions given by him, and for the safety of the men, and the proper working of the mine.

3. The fireman, who makes a thorough inspection of the working faces before the hewers enter them; to see that there is no accumulation of gas; if the places are all safe, he puts the date on the roof or face; if it should happen that there is gas in the heading or stall, cross timbers are placed some distance back in the heading, and the word "fire" written upon them.

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4. The furnace-man, who attends to the furnace.
5. Hauliers or horse drivers, who are supposed to attend to and clean down their horses after the day's work, and to commence at seven o'clock in the morning.

6. Door-boys or trappers.

7. Timbermen, to put up the timber necessary to keep the roads and airways, &c, in proper working order. Commence work between six and seven.

8. Roadmen, to keep the horse-roads in repair.

9. Hewers or colliers, who cut and fell the coal and drive all headings, air-ways, &c, necessary for the proper opening out of the mines, and set all timber required in the working faces. The hewers commence work about seven o'clock in the morning, and only one shift per day is worked.

10. Lampman (underground) to examine all safety lamps, and lock them as the men pass the lamp station.

11. Hitchers or onsetters.

12. Enginemen or brakesmen.

13. Landers or banksmen, to change the trams at the top of the pits.

14. Girls, who in some cases assist banksmen in taking trams to tippers and running trams of rubbish to tips.

15. Tippers, tipping coal out of trams into trucks over screens.

16. Trimmers or screeners.

17. Weighman.

18. Lampman (surface), to attend to the giving out of the lamps in the morning and receiving the same in the evening, trimming, mending, and locking the same.

Payments are made at some of the collieries once a month, with a draw on account every fortnight. At other collieries once a fortnight, and a draw once a week. From the pays are deducted the amount paid on account, the doctor, schools, house rent, coal, tools, fines, &c.

The colliers are paid so much per ton for cutting the coal, and a rate per yard for driving, headings, air-ways, cutting bottom, ripping top, allowance for soft coal, water, driving through faults, &c.

All other workmen are paid per day.

The following statement of workmen employed at two of the important steam coal collieries of the district, producing on the average about 500 tons each per day, will convey a correct idea of the present divisions of labour in the Welsh steam coal collieries, with the explanation that the proportion of hewers to other labour has been much reduced within the last two to three years, and before that time each of these collieries
produced 700 tons per day, with a less staff of underground off-hand labour than is now required for 500 tons per day:—

<table>
<thead>
<tr>
<th></th>
<th>No. 1 Colliery.</th>
<th>No. 2 Co</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colliers cutting coal</td>
<td>225</td>
<td>200</td>
</tr>
<tr>
<td>Hauliers for coal, rubbish, and water</td>
<td>58</td>
<td>37</td>
</tr>
<tr>
<td>Door boys</td>
<td>26</td>
<td>21</td>
</tr>
<tr>
<td>Roadmen, shacklers, &amp; boys oiling sheaves</td>
<td>17</td>
<td>22</td>
</tr>
<tr>
<td>Wastemen and shifters</td>
<td>164</td>
<td>46</td>
</tr>
<tr>
<td>Ostlers and hitchers, or onsetters</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Timbermen and cutting for arching</td>
<td>23</td>
<td>15</td>
</tr>
<tr>
<td>Men ripping tops</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Fluemen, ventilation enginemen, &amp; stokers</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Masons</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Enginemen underground</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Hard heading men (stone drifts)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Men drawing pit wood</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Overmen and firemen</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>--- 229</td>
<td>--- 174</td>
</tr>
<tr>
<td>Total underground labour</td>
<td>----454</td>
<td>----374</td>
</tr>
</tbody>
</table>

Surface.

<table>
<thead>
<tr>
<th></th>
<th>No. 1 Colliery.</th>
<th>No. 2 Co</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankers, tippers, screeners, croppers, hauliers, and screen boys</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Lampman and boys assisting</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Weighers</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Rubbish tippers</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Winding enginemen</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
### WINDING ENGINES AND PIT FITTING.

The class of winding engine mostly in vogue at the comparatively shallow pits consist of one large, or a pair of smaller, horizontal direct acting cylinders, with slide valve, but latterly double-beat valves are preferred. Flat and round ropes are used. Conical drums are used at a few of the collieries.

The following are particulars of winding engines at some of the principal collieries:

[228]
[see in original text Table of dimensions of winding engines at 8 pits]

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The weights to be lifted in the deep pits in South Wales are exceptionally heavy, and the increased depth of several of the new winnings in progress in the district raise the question as to how far the best known types of winding engines are applicable to the deeper pits of South Wales, and the subject of winding engines for some of these deepest winnings is now under consideration.

The pulley frames are sometimes made of wrought iron. At some of the largest collieries two trams are lifted at a time, either together on one deck, or one above the other in a double-deck cage.

The cages are frequently made of steel.

The guides in the shaft are either made of wood or of wrought iron.

Bound ropes, weighted heavily at the bottom, are frequently used for this purpose.

### PUMPING APPLIANCES.

Although the lower or steam coal measures are tolerably free from water, the upper series, especially the Pennants, are often heavily watered. Workings that have extended continuously from the outcrop are also generally heavily watered at the deepest point. As in other mining districts,
almost all sorts of pumping appliances—more or less perfect, or rather imperfect—may be seen in South Wales; but on the other hand, where real work has to be done in the way of raising water, first-class pumping engines, generally in accordance with the best Cornish practice, are to be found.

The following are particulars of some of the largest pumping engines in the district:—

[230]
[see in original text Table of dimensions of pumpings at 11 pits]

[231]

BOILERS.

A great improvement has been gradually effected in the construction of the boilers used in South Wales. The old-fashioned egg end or flash flue boilers have been to a great extent either tubed or altogether replaced by new tubular boilers. The double-tubed boiler is the class most in vogue, but there are several excellent examples of single-tube or Cornish boilers. Greater care is also observed in clothing the boilers and steam pipes, and in firing.

COKE OVENS.

Although the Bee-hive ovens, similar to those used in the county of Durham, are about to be tested at several of the works, the form of oven in general use in South Wales is almost rectangular, and of about the following internal dimensions:—

<table>
<thead>
<tr>
<th></th>
<th>Ft.</th>
<th>In.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width at front</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Width at back</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Length</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Height inside, to crown of arch</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

They are generally built back to back, with chimney between, and several have side and bottom flues.

This oven is charged sometimes at the door and sometimes from the top. The usual charge is 4½ tons for first three days in the week, and for the remaining four days (including Sunday) 5 tons. Seventy-two hours are generally allowed for the coking of the smaller charge, and ninety-six hours for the larger charge. The charge, which consolidates upon a wrought-iron bar laid along the length, and another transversely to it at the back of the oven, is drawn by means of a windlass.
The watering is sometimes done in the oven and sometimes after the coke is drawn. At some works, the small coal is washed before being coked, and the result is a denser and more valuable description of coke.

Thirty Coppée ovens have lately been erected at the Ebbw Vale Iron Works, and an additional thirty are now in course of building. The ovens already erected are said to give satisfactory results, but sufficient time has not yet elapsed to test them effectually.

DEVELOPMENT OF COAL-FIELD.

The great development which has taken place in the South Wales coal-field has been chiefly confined to the eastern portion of the county of Glamorgan and the county of Monmouth; nearly two-thirds, probably, of

the whole of the coal raised in the coal-field is worked eastward of Maesteg. From the Merthyr, Taff, Aberdare, and Rhondda Valleys, the great bulk of the steam coal worked from the white ash series is at present obtained; and on the northern outcrop, from Hirwain on the west to Blaenavon on the east, the bulk of the coal required for iron-making is raised, and the manufacture of iron at several of the works within the limits named is supplemented by a steam coal trade during depressed periods in the iron trade.

Towards the central parts of the eastern portion of the field, the upper and lower Pennant series of coals are worked for colliery, household, and general manufacturing purposes. At Maesteg, iron works have been established in the neighbourhood of the anticlinal, where the white ash series exist at a comparatively shallow depth, and again at Cwmavon in the valley next beyond to the west. Westward of Cwmavon, the principal workings are mostly confined to the white ash series, near to the northern, southern, and western edges of the basin, and to the upper Pennant series in the inner portions of the coal-field.

With the exception of a comparatively small quantity of mining coal, and a small proportion of anthracite shipped and sent by rail to the inland counties, the bulk of the coal produced west of the Maesteg district is raised for local consumption at the iron, steel, tin, copper, silver, and other works, which have, owing to the comparatively cheap cost of fuel in times past, attained a very large industrial development in the western portion of the coal-field.

OUTPUT OF SINGLE COLLIERIES.

In this respect the district does not compare very favourably with some of the other coal-fields; the average of the best laid-out collieries does not exceed probably 600 tons of large coal per day from one shaft; but there are some special features which, more or less, affect the capacity for output in the district. The surface is extremely undulating, and the coal-field is divided by a series of deep valleys with mountainous hills intervening, hence it practically becomes a necessity to establish the winnings in the valleys in connection with the railways, the result in many cases being that the pits
are situate on one side of the coal-field to be worked. Again, the workmen require an excessive width of face to work in, and they will only work one shift. Any circumstances such as those described, therefore, which limit the area of pit room immediately affects the quantity, and with every natural advantage the area of pit room would be greater to produce, say 500 tons per day in South Wales, than in a

Northumberland colliery producing double that quantity. As a set-off to this the steam coal when produced is of a comparatively high value.

The following information, extracted from Mr. Wales' (the Government Inspector) Report for 1873, may be of interest, with the explanation that Mr. Wales' district is bounded on the east by the Rhymney Valley, and it does not include that valley, or any part of the county of Monmouth:

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of male persons employed</td>
<td>45,474</td>
</tr>
<tr>
<td>Quantity of coal raised in tons</td>
<td>11,473,152</td>
</tr>
<tr>
<td>Separate fatal accidents</td>
<td>109</td>
</tr>
<tr>
<td>Lives lost by accidents</td>
<td>116</td>
</tr>
<tr>
<td>Persons employed, per separate fatal accident</td>
<td>417</td>
</tr>
<tr>
<td>Persons employed, per life lost</td>
<td>392</td>
</tr>
<tr>
<td>Tons of coal raised, per separate fatal accident</td>
<td>105,258</td>
</tr>
<tr>
<td>Tons of coal raised, per life lost</td>
<td>98,906</td>
</tr>
</tbody>
</table>

NEW WINNINGS.

The exceptional conditions which prevailed in the coal trade during last year and part of 1872, have had a material influence in expediting the development of the coal-field, and the coal in the more approved districts within comparatively shallow depths has been taken up; the more important new undertakings comprise large areas which involve deep sinkings. The following are a few of the more important new winnings either in progress or projected:—[see in original text]

NEW APPLIANCES FOR SINKING.

These deep winnings, for a considerable portion of the upper part of their depth, pass through the hard rock stratification of the lower Pennant series, and the rate of progress in sinking by hand labour is excessively slow. For this reason the Burleigh and other drilling machines have been
experimented upon with varying success; and an experiment is now being made at Harris' Navigation Colliery, with which the writer is professionally connected, to apply the Diamond Boring Machine to expedite the rate of progress, with what degree of success our visitors will have an opportunity, probably, of forming their own opinion from a personal inspection before leaving the district.

Dynamite has very generally superseded gunpowder for sinking purposes in the district.

CHARACTER, &c, OF THE MEN.

A general description, such as the writer has endeavoured to give of the coal-field, may be held to be incomplete without some reference, however slight and imperfect, to the race of people by whom, and among whom, the various industries are carried on. The Welsh are a brave, hard-working, and athletic race of people; warm-hearted and generous, and capable of high intellectual attainments. Their numerous and highly disciplined choirs, and the laurels won by them in the great competitions of the kingdom, prove how passionately fond the Welsh are of music; whilst their Eisteddfodds show the love they have for their old bardic poetry, and how proud they are of their ancient nationality. Not interesting themselves much in politics, they are eminently possessed with religious ideas; and a stranger is invariably struck with the number of their chapels, towards which they liberally and cheerfully subscribe.

The national church has failed to keep pace with the spiritual requirements of the district, although of late years she has made gigantic efforts to recover the lost ground; and it is to the credit of the people that they have taken the question of religion into their own hands. At the present day nearly the whole of our iron-workers and miners have become members of the two great unions of the country. The working people are not exempt from the faults which their class are liable to, but a favourable comparison can nevertheless be drawn with other manufacturing and mining districts, whilst the far better class of houses and improved sanitary arrangements which are being provided, with the increased facilities for education, cannot fail to bear fruit in a national improvement in the moral and physical condition of the next generation.

FITTING.

A large proportion of the steam coal raised in this district is consumed on the various lines of English and Continental mail steamers, the contracts for which are almost invariably made directly between the coal-owners and steam companies. The general export trade is carried on by means of sales, also made direct between the producers and buyers abroad, and to some considerable extent through the agency of merchants or "middlemen."

TURNS.
The old system of regular "turns" for loading has in this district become quite obsolete, having given place to the introduction of nearly all forms of contract on a scale of lay days varying according to the size of the ship. About eight days (Sundays excepted) being the basis for ships of four hundred tons, extended at the rate of one day for each hundred tons of cargo in excess. Special conditions are of course made applicable to steamers ranging (for a carrying capacity of a thousand tons) from twenty-four to fifty hours. In all cases protecting clauses are inserted providing against delays from strikes, accidents, and other unavoidable causes. The writer has not been able to obtain very reliable information as to the proportion which steamers bear to sailing vessels in the mercantile fleet of the world at the present time; but the proportion probably may be assumed to be about one-fourth steamers. The progress in the rate of substitution of steamers for sailing vessels is extraordinarily rapid; and the question will arise at some future time whether the increasing ratio of demand for steam coal will be maintained when the substitution of one description of motive power for the other has been practically effected.

PORTS.

The ports of this district are Newport, Cardiff, Porthcawl, Port Talbot, Briton Ferry, Neath, Swansea, Llanelly, Pembrey, Kidwelly, Saundersfoot, and Milford. Of the above Cardiff, Swansea, and Newport, are the principal.

Newport.—This is an old town, its castle having been built in 1135, but it was not until 1798, when the Monmouthshire Canal was opened, that the town possessed any degree of importance, although Caerleon, a once great Roman station, is within three miles. Newport is situate on the river Usk, and connected with the Great Western, Eastern Valleys, Western Valleys, and Newport and Brecon Railways. The town contained 31,247 inhabitants in 1871. The basin and lock of the present dock were opened in 1842, and the dock itself in 1858. The following are its principal dimensions:—Length, 220 feet; breadth, 61 feet; depth of water (average high spring tides), 32 feet 3 inches; floating area, 11½; and five hydraulic coal staiths.

In 1865, the Act for the Alexandria Dock was obtained, and the works are now rapidly approaching completion. The following are its principal particulars:—(Outer lock) length, 350 feet; width, 65 feet; depth of water over cill at spring tides, 35 feet; ditto at neap tides, 25 feet; width of basin opposite entrance, 800 feet. (Dock) length, 2,500 feet; width, 500 feet; depth of water, 30 feet; area, 28¼ acres; and seven hydraulic coal hoists.

Besides the existing dock and the Alexandria Dock, Newport possesses a magnificent water frontage on the river Usk, by means of which an extensive trade is carried on.

The following is a statement of the Imports at the port, taken from the Custom Bills of Entry in the years 1871, 1872, and 1873:—[see in original text]
Cardiff.—The history of this town has been touched upon in a previous part of this paper. It is situate on the river Taff, and connected with all parts of the kingdom by means of the Great Western, Taff Vale, and Rhymney Railways. Its population at the last census was, including Roath and Canton, about 57,000. This port possesses a splendid roadstead, and the fine docks, all of which, with the exception of the Penarth Dock and Tidal Harbour, and the Glamorganshire Canal Docks, have been constructed by the Trustees of the Marquess of Bute, and are of the following dimensions:—[see in original text]

Besides the existing dock accommodation, the Trustees of Lord Bute have obtained Parliamentary powers this session to make a dock on the east side of the existing East Dock, in connection with the new basin, with a water area of 55 acres.

The following is a statement of the Exports and Imports at Cardiff and Penarth for several years past:—[see in original text for Penarth Dock and tidal harbour, statement showing the total quantities of the following articles shipped and imported from the year 1865 to 1873]

[see in original text Statement of the trade at the Bute Docks, Cardiff, from the opening of the docks in Oct. 1839 to 31st Dec. 1873]

[see in original text Statement of traffic conveyed on the Taff Vale Railway]

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The progress of the coal trade of Cardiff will be understood by reference to the foregoing statement of traffic conveyed over the Taff Vale Railway, which is the principal mineral feeder to the port.

Swansea.—Situate on the Swansea Bay, at the mouth of the River Tawe, and connected with all the important mineral districts of South Wales, and with other parts of the kingdom, by the Great Western, Swansea Vale, Llanelly, Dunvant Valley, and Vale of Neath Railways. The development of this port has been rapid; it only possessed in 1791 a few small wharfs near the mouth of the river. The present piers were completed in 1800. The eastern pier is 1,340 feet in length, and the western 580 feet. In 1827 a small harbour was established on the eastern side of the space within the piers, called Fabian's Bay. The new cut was finished in 1844. The north dock was commenced in 1849; the lock and float were completed in 1851, and the half-tide basin and locks at the upper end of the float
in 1861. The south docks were completed in 1859. The population is about 51,000. Patent fuel is manufactured on a large scale in the neighbourhood of Swansea, and exported from that port.

The following are the particulars of the dock accommodation at this port:—

**North Docks—**
- Entrance to half-tide basin: 60 feet wide.
- Depth of water over cill at ordinary spring tides: 25 ft. 6 in.
- Lock entrance to dock: 160 ft. by 56 ft.
- Depth of water over lock cill at ordinary spring tides: 22 ft. 6 in.
- Area of lock and half-tide basin: 13¾ acres.

**South Docks—**
- Entrance basin area: 3 acres
- Half-tide or outer dock entrance: 70 feet wide.
- Depth of water over cill at ordinary spring tides: 24 feet.
- Outer dock area: 4 acres
- Depth of water at ordinary spring tides: 25 ft. 6 in.
- Entrance lock: 300 ft. by 60 ft.
- Depth of water over inner cill at ordinary spring tides: 22 ft. 6 in.
- Dock area: 13 acres.

There is provision at this dock for shipping coal from iron boxes, four of which, with false bottoms, are placed upon one truck, each holding about 2½ tons, as well as from the ordinarily-used tipping wagons.

The writer has not been able to obtain reliable particulars of the annual exports and imports at this port.

**Porthcawl.**—This port is situate on the Bristol Channel, and is
connected with the railway systems of South Wales by the Porthcawl branch of the Llynvi and Ogmore Railway. The trade of this port is chiefly supplied by the Llynvi and Ogmore Railway; and the following is a statement of imports and exports during the last seven years:— [see in original text]

The following is the dock accommodation:—

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width of entrance to half-tide basin</td>
<td>62 feet</td>
</tr>
<tr>
<td>Do. do. to new dock</td>
<td>55 &quot;</td>
</tr>
<tr>
<td>Depth of water on cill of half-tide basin—neap tides</td>
<td>16 &quot;</td>
</tr>
<tr>
<td>Do. do. —spring tides</td>
<td>27 &quot;</td>
</tr>
<tr>
<td>Depth of water in half-tide basin when gates are closed</td>
<td>16 &quot;</td>
</tr>
<tr>
<td>Depth of water on cill of new dock—neap tides</td>
<td>18 &quot;</td>
</tr>
<tr>
<td>Do. do. —spring tides</td>
<td>29 &quot;</td>
</tr>
</tbody>
</table>

There are four coal tips, capable of tipping 2,200 tons per day; and three cranes, capable of lifting 500 tons per day.

WATER AREA.

<table>
<thead>
<tr>
<th>Component</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dock</td>
<td>7½</td>
</tr>
<tr>
<td>Basin</td>
<td>1½</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
</tr>
</tbody>
</table>

Briton Ferry, situate on the river Nedd, in Swansea Bay. It is in connection with the Great Western and South Wales Mineral Railways, and is chiefly supplied with minerals from the district, served by the last named railway. Foreign iron ore is also rather largely imported. The population is under 5,000.

Port Talbot is situate in Swansea Bay, at the mouth of the river Afon, and is in connection with the Great Western Railway. A short line also connects the port with the copper and tin works at Cwmavon. Besides the iron ore consumed at the local copper, iron, and tin works, it is the port of export for the collieries in its immediate neighbourhood.
The population of the Parliamentary borough of Aberavon, which includes Port Talbot, is about 12,000.

Neath, situate on the river Nedd, about three miles from its mouth, is in connection with the Great Western, Vale of Neath, and Neath and Brecon Railways, and although having no dock, has a considerable length of river frontage, which is used by the local collieries for the shipment of coal. The population in 1871 was 10,060.

Llanelly—with docks—is situated on the estuary of the Burry and Llwchwr rivers, on the east of Caermarthen Bay, and connected with the Great Western and the Llanelly Railways. The principal coal shipped at this port is anthracite. There are extensive copper and tin works in the neighbourhood. The population is about 22,000.

Burry Port and Kidwelly.—Very small ports, situate a few miles west of Llanelly. The Great Western Railway runs through these ports, and the Gwendraeth Valley has its termini. The principal trade is in anthracite coal. The population of Kidwelly and Pembrey is about 7,000.

Saundersfoot.—A very small port, situate on the western extremity of Caermarthen Bay, and connected with the Great Western Railway by the Pembroke and Tenby Line. Anthracite coal is also shipped at this port.

Milford and Pembroke.—This used to be one of the largest ports of South Wales until the trade moved eastward, and is still of considerable importance. It is situate on the mouth of the Dauleddau River, which here flows into an inlet of the Atlantic, which constitutes one of the finest harbours in the world. It is here that the South Wales section of the Great Western Railway terminates. There is a large Irish traffic at this port, and it is also an important naval station. The population in 1871 was 3,252, and of Pembroke 11,530.

IRONWORKS.

Reference has been made, in an earlier part of this paper, to the large ironworks of the district; an idea of the magnitude and importance of this industry may be conveyed from the following statistics extracted from Mr. Robert Hunt’s Returns for 1872:—

Furnaces using anthracite in Glamorganshire (Ystalyfera, Swansea, and Ystalyfera Iron Co.), 11 furnaces built, 6 in blast; Brecknockshire (Ynисcedwyn and Ynисcedwyn Iron Co.), 2 furnaces built, 2 in blast; total, 13 furnaces built, 8 in blast; pig iron made, 25,678 tons; total coal returned as used in the manufacture of pig iron in furnaces using anthracite, 72,392 tons.

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[see in original text Table of Furnaces using coal containing bitumen]

TOTAL COAL USED IN THE MANUFACTURE OF PIG IRON.
Tons.

Glamorganshire 1,172,453
Brecknockshire 88,519
Monmouthshire 1,117,626

Total for South Wales and Monmouthshire 2,450,990

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Probably Mr. Hunt's estimate of the number of furnaces in blast is too high for the whole year.

[see in original text Table of mills and forges]

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STEEL WORKS.

The following are some particulars of the principal steel works:—

Dowlais.—The Bessemer works started in June, 1865. They consist of six five-ton converters, with the usual blowing and hydraulic machinery. Besides the Bessemer works there are four Siemens Martin furnaces at work, and two more are being built. The works are capable of producing 1,500 tons of steel per week. The trade consists chiefly of railway bars and railway fastenings.

Ebbw Vale.—The works were erected in 1866, and comprise seven five-ton Bessemer converters; six Ireland cupolas for supplying the molten pig to the converters; six ordinary cupolas for smelting speigelisen; one 30-inch train of rolls driven by a pair of 50-inch vertical engines of 4 feet stroke, gear 2 to 1; six large Siemens' gas heating furnaces for ingots and blooms, twenty-four gas producers. When in full operation the works can produce 1,000 tons of ingots per week, and 800 tons of finished rails have been rolled at the one mill in the week. Through the exertions of the engineers, Mr. W. Richards, and Mr. John Parry, the chemist, Ebbw Vale was the first place in this country to manufacture speigeleisen.

Llandore Siemens Steel Works, situated at Llandore, near Swansea, covering about 100 acres of land on both sides of the navigable river Tawe; the Great Western and Swansea Vale (Midland) Railways run through the Company's land, and a system of railways connects both with all parts of the works. The works at present comprise:—Two blast furnaces with Cowper's patent stoves, turning out about 600 tons a week of pig iron when in work; twenty-four Siemens' regenerative steel melting furnaces, with the requisite gas producers, etc., each furnace making an average about 65 tons of steel per week; six steam hammers of eight tons each, one four tons, and one two tons, for making blooms for rails, tyres, etc., and for forgings; two rail mills complete with saws, straightening and other machines, capable of making about 1,300 tons per week of finished rails—the highest out-turn they have made in one week is 1,460 tons of finished rails from Monday till Saturday inclusive; tyre mill complete, Webb's patent; bar mill, for steel bars of all kinds; wire mill, for rolling wire rods; thirty-three Siemens' gas heating furnaces, for heating ingots and blooms, for hammer and mills, with
producers for making the necessary gas; one hundred coke ovens, for supplying coke to blast furnaces; brick works, for making special bricks for the melting and other furnaces. The number of steam engines of all sizes at work in the steel works is sixty-four, besides five

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locomotives, pattern shops, foundries for casting, both in steel and iron, and fitting shops, where all machinery is repaired and new parts made as required. The Company have purchased several coal properties in the immediate neighbourhood of the works, comprising steam coal, coking coal, and anthracite, ensuring an unlimited supply of fuel. When in full work the steel works employ over two thousand men, independent of collieries, etc.

OTHER INDUSTRIES OF THE DISTRICT.

Next to the coal, iron, and steel trades, perhaps the most important local industries are the copper and tin plate trades, to which may be added the smelting of silver, zinc, lead, and sulphur ores, chemical and other general manufacturing works. The principal development in copper smelting is in the neighbourhood of Swansea, Neath, and Llanelly, and, lately, by the establishing of the Tharsis Copper Works, Cardiff is becoming a copper smelting district.

The following are the particulars of copper ores purchased by the Copper Companies from June 30, 1873, to June 30, 1874:—[see in original text]

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MANUFACTURE OF TIN PLATES.

Tin and zinc plate works are spread over the whole district. About four-fifths of the tin and zinc plates manufactured in Great Britain are manufactured in South Wales and Monmouthshire, and exported chiefly to America and the Australian colonies, either direct by the line of Transatlantic steamers which have commenced lately to sail from Cardiff to New York, or by way of Liverpool, London, Bristol, &c.

The total capabilities of the various works for the manufacture of tin plates are estimated to be as follows:—

<table>
<thead>
<tr>
<th></th>
<th>Tin Plates.</th>
<th>Boxes per Week.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scotland</td>
<td>2,000</td>
<td></td>
</tr>
<tr>
<td>Cumberland</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>Worcestershire and Staffordshire</td>
<td>8,000</td>
<td></td>
</tr>
</tbody>
</table>
Gloucestershire 3,700
Monmouthshire 10,000
Glamorganshire (east of Bridgend) 6,500
Do. (west of Do.) 30,000
Caermarthenshire 16,000

76,900

Equal to four million boxes per annum; but the actual production of 1873 probably did not exceed three million boxes, which were disposed of as follows:

Exported from Boxes.
Liverpool 1,585,012
London 251,806
Southampton 117,010
Swansea 73,077
Hull 12,560
Glasgow 8,059
Newcastle 613
Bristol 63,392
Cardiff 41,948
Home consumption, estimated 846,523
Total 3,000,000

LEAD SMELTING.

The following are the returns of lead ore imported for smelting in the year 1872:

<table>
<thead>
<tr>
<th>Tons.</th>
<th>Value.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Llanelly Port 6,006</td>
<td>£87,405</td>
</tr>
<tr>
<td>Swansea 1,622</td>
<td>23,734</td>
</tr>
<tr>
<td>Total 7,628</td>
<td>£111,139</td>
</tr>
</tbody>
</table>
Gold, Silver, and Zinc Ores Imported into Swansea in the Year 1872, and Smelted in the District.

<table>
<thead>
<tr>
<th></th>
<th>Tons</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>54</td>
<td>£1,060</td>
</tr>
<tr>
<td>Silver</td>
<td>2,239</td>
<td>219,085</td>
</tr>
<tr>
<td>Zinc</td>
<td>26,838</td>
<td>118,068</td>
</tr>
</tbody>
</table>

Iron Pyrites and Sulphur Ore imports in 1872.

<table>
<thead>
<tr>
<th></th>
<th>Tons</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiff</td>
<td>7,996</td>
<td>£17,053</td>
</tr>
<tr>
<td>Swansea</td>
<td>10,645</td>
<td>28,825</td>
</tr>
</tbody>
</table>

FUTURE PROSPECTS.

The future of South Wales is, of course, intimately associated with the future industrial position of England as the manufacturing emporium of the world. If this country maintains its position, the development of South Wales must be rapid. The coal-field possesses large and valuable resources, is situate parallel and near to a broad and deep estuary of the sea, upon which several first-class ports are established, communicating, by means of numerous railways, with the coal-field. The geographical situation of the district is also exceptionally favourable for communicating with Spain, America, and all our important colonies. Several important industries, besides the production of coal and manufacture of iron and steel, have already attained very rapidly an important development; and with all these advantages, it is reasonable to assume that this district will progress in a rapidly increasing ratio for very many years to come, and it is not unreasonable to suppose that, within the next fifty years, the Port of Cardiff will attain the importance at present attached to Liverpool as a port of importation.

NEWER FORMATIONS.

The following formations, more recent than the coal measures, are found occupying the comparatively low grounds on the south as far west as Swansea Bay; but, beyond that, they are nowhere to be met with. In one or two localities small tracts of the coal measures are overlaid by one of these formations (dolomitic-conglomerate):—

A.—Palaeozoic.
1.—Permian.
   a.—Magnesian limestone and conglomerate.

B.—Mesozoic.
   1.—Trias.
      a.—Dolomitic-conglomerate.
      b.—Keiiper.
      c.—Rhaetic beds.

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2.—Lias.
   a.—Lower lias.

C.—Cainozoic.
   1.—Quaternary.
      a.—Gravels and alluvium.

Permian.—The magnesian limestone and conglomerates, and the lower Permian deposits of haematites in the neighbourhood of Llantrissant, represent this formation in this district. Their thickness is inconsiderable.

Trias.—Dolomitic-conglomerate.—This formation is well developed around Cardiff, and immediately underlies the Keiiper. At Radyr it is extensively quarried, and produces a rich warm red-looking stone, much admired for building purposes. In the neighbourhood of Llantrissant a small portion overlies the coal measures unconformably. It is made up entirely of angular fragments of a pre-existing rock, cemented together by dolomite and oxide of iron. No fossils have hitherto been found in these beds in this district.

Keiiper.—This formation consists of red marls and greenish bands, with veins of alabaster and of gypsum intermixed. It is extensively developed on the south and west of Cardiff, a particularly fine section being seen along the coast between Penarth and Lavernock; near which latter place they dip beneath the Bristol Channel, and are continued, together with the Rhaetic beds lying immediately above them, on the opposite coast at Watchet. No fossils have been detected in the keiiper in this neighbourhood.

Rhaetic Beds.—This formation is better developed in this district than in any other part of Great Britain. The finest section is to be seen at Penarth Headland, where these beds are about 90 feet thick, and pass down into the Keiiper and up into the lower lias.
Lower Lias.—This formation is extensively exposed to the west and south of Cardiff. It consists of alternating bands of limestone and shale, and is replete with characteristic fossils.

Gravels and Alluvium.—The Went Loog Levels or Plain, extending from Cardiff to Newport, and the East and West Moors of Cardiff, are a mass of alluvial mud, many feet in thickness. These accumulations are in most part pure argillaceous matter, horizontally bedded with zones of recent shells, and several species of extinct and other mammalian remains, together with trees and leaves.

In the ancient gravel bed of the River Taff, remains of cervus-elaphos have been met with a few feet beneath the surface. On the high table lands of the Hill district large accumulations of peat occur, and large trees are often met with embedded in them.

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FOSSILS.

The following is a list of the more important fossils of the South Wales coal-field, belonging to the Museum of the Cardiff Naturalists' Society:—

A.—Palaeozoic.

1.—Silurian.

Mollusca.


Articulata.

Trilobites, sp. Phacops, Stokeii.

Radiata.

Petraia, sp.

2.—Devonian.

a.—Old red sandstone.

Pisces.


3.—Carboniferous.

a.—Mountain limestone.
Pisces.
Psammodus-porosus.

Mollusca.

B.—Millstone Grit.

Plantae.
Sigillaria, sp.
c.—Coal measures.
Pisces.

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Mollusca.

Articulata.

Plantae.

4.—Permian.—Nil.

B.—Mesozoic.

1.—Triassic.
a.—Dolomitic-conglomerate.—Nil.
b.—Keiiper.—Nil.
c.—Rhaetic beds.

Sauria.
Ichthyosaurus-platyodon.

Pisces.

Mollusca.

Triassic.—Lower Lias.

Sauria.
Ichthyosaurus, sp. Plesiosaurus, sp.

Mollusca.

Cainozoic.—Quaternary.

Mammalia.

Mollusca.

Plantae.

APPENDIX.

[see in original text Table of Particulars of coal seams in the western division of the coal-field (Upper Pennant Series - Extracted from the Report of the Royal Coal Commission.)]
PROCEEDINGS

SPECIAL GENERAL MEETING, WEDNESDAY, AUGUST 5th, 1874, AT THE CARDIFF ARMS, CARDIFF.

W. COCHRANE, Esq., Vice-President, in the Chair.

The proceedings of to-day comprised the reading of papers by Mr. Wallace on "The Warsop Rock Drill;" Mr. J. B. Simpson on "The Coal-fields of Russia;" Messrs. Daglish and Howse on "The North Lincolnshire Ironstone Field;" and Mr. Walker on "A New Hook for preventing Overwinding;" and the discussions thereon. After which, the Secretary completed the reading of Mr. Brown's paper on "The South Wales Coal-field," which, for the convenience of printing, has been published altogether in yesterday's proceedings.

It has been found that the time required to print the very valuable map, which Mr. Brown prepared to illustrate his paper, rendered it impossible to publish it at the same time as the volume. In fact, to print it in colours, in a manner worthy of the extreme care with which it has been compiled, will take other two months. The large mass of work in this plate has also interfered with the production of the plates illustrating Mr. Simpson's paper, which are to be printed in colours, and it has been thought desirable to close Vol. XXIII. with Mr. Wallace's paper, and reserve the remainder of the papers for Vol. XXIV.

THE WARSOP ROCK DRILL.

By JOHN WALLACE.
In the present condition of mining operations it would be needless to dwell on the desirability of introducing steam power wherever it is possible in order to meet the increasing cost of labour; it is one of the most important facts of the age, and it shows plainly that future generations must look to their fuel supplies for the force which is to execute the bulk of the labour of their industries, and to man principally for the skill to direct it.

The value of a foot-pound was never appreciated as it is now, although it may safely be said that it is far from having that universal estimation which is its just due. The enormous demand for mining machinery of all kinds shows how thoroughly in earnest mine owners and engineers are to put their experience into practice. At present the two most prominent novelties are, without doubt, the Coal Cutter and the Rock Drill, of which the latter instrument forms the subject of the present paper.

The numerous inventions which have been applied with more or less success to rock boring by steam power directly, or through the medium of compressed air, may be taken as a fair estimate of the value attributed to that system as compared with hand-boring, and every encouragement has been given to inventive ingenuity in that direction; for, it seems certain that as soon as a machine is produced which shall be sufficiently cheap, simple, and trustworthy, it will at once find a wide field of usefulness.

A new Rock Drill which lays claim to many valuable improvements is shown—Plate XLVII. Its chief distinctive peculiarity is that it strikes the boring-chisel with a hammer, the chisel remaining in the hole as in the manual process, instead of working backward and forward in it to deliver the blow in the manner common to most other power drills. The hammer follows the progress of the chisel or drill. It is equally suited to work with compressed air or steam, and may be driven at the rate of 1,000 blows per minute.

The machine resembles a small steam-hammer with a heavy piston-rod of steel, the end of which is hardened. The cylinder forms part of a frame having at its lower extremity a hardened socket called the anvil, which receives the back end of the chisel.

The force of the blow is estimated and adjusted so as to correspond, as nearly as possible, with the quality and durability of the cutting edge of the tool, and the weight of the cylinder and frame is made sufficient to take the recoil of the blow which would tend to throw it off the anvil.

In this manner the hammer frame, although not attached to the chisel but simply resting upon it, is made to follow the progress of boring at a natural rate, varying continually with the hardness of the material to be penetrated, never forcing the tool beyond its capacity, nor feeding too slow when the quality of the stone allows quicker progress.

After a series of careful experiments the automatic rotating gear has been abandoned, and the chisel is turned by hand in the following manner:—A circle of teeth is cut around the bottom of the anvil, which are locked in one direction by a pawl fixed to the bottom of the cylinder frame. Opposite the pawl is a small pinion geared into the teeth on the anvil, and attached to a rod passing
inside the frame to a handle on the top, by which the operator can turn the boring chisel at whatever rate circumstances may require.

The valve gear for regulating the movement of the position is of the simplest possible kind.

The cylinder has a loose lining, having ports cut in it corresponding to those in the cylinder. This lining is closed at the top end, and has attached within at the centre a square steel bar with a slight twist upon it. The bar works through a steel die in the piston into the piston rod which is bored out, and the amount of twist is such that the lining turns in the cylinder with every movement of the piston, opening and closing the ports and giving the admission cut off and release with the same precision as an ordinary steam engine. Even if the anvil were removed, the piston might be driven at its highest velocity without once striking the cylinder covers.

The cut-off being made so close to the inside of the cylinder, there is no loss due to the contents of the ports or passages leading into the cylinder.

There are two kinds of drills or chisels employed according to the nature

of the stone to be bored. Both have the cutting edge in the form of a cross, but one is made of rolled steel of a cross section, and twisted something like a twist drill, so that when at work and rotating slowly it brings out the cuttings and avoids clogging when used on soft stone.

It has been found that when the cutting edge of the tool is always against the stone when the blow is struck it does not blunt so soon as it would if made to work like a pick; and, in addition to this, the resistance due to friction when the chisel is made to work up and down in a hole half-full of sand and gravel may very soon amount to more than the power requisite to perform the boring.

Moreover, if by chance the frame carrying this kind of drill should be shaken or jarred from its original position, the friction on the side of the hole becomes enormous, and if not soon attended to, will soon stop the work.

All these difficulties are to be avoided by letting the chisel remain in the hole and striking it as in the manual process.

It is not by cutting out large pieces that a small hole is to be made in stone. The process more resembles disintegration, and is best effected by a rapid succession of light blows, each one delivered home on the stone; and a much smaller cylinder is sufficient than where provision has to be made for chance obstructions in the way of the cutting tool.

In fact, a drill working with a reciprocating motion can only strike a blow of the proper force by chance; for, as the cylinder has an excess of power, a certain amount of obstruction is counted on to modify the blow, and this obstruction is never uniform for any length of time.

Plate XLVII. represents the hammer and frame resting in a sleeve tube or guide, supported by a tripod stand to which it is attached by a universal joint, so that the direction of the drill may be
varied at pleasure. The legs of the tripod are telescopic, allowing of considerable elongation for convenience of working, and each leg may be set and fixed at any required angle.

This kind of supporting frame is well suited for sinking pit shafts and drilling in quarries when the holes are principally vertical, but for general mining purposes a pillar, with or without a carriage on wheels, is usually preferred to carry the drilling tool.

The details of the frame or support best suited to the above purpose form a matter of diverse opinion among mining engineers, and will doubtless depend much on the style of working and the mineral sought. It will also depend to a considerable extent upon the construction and principle of the rock drill to be used upon it. It may safely be assumed in any case that the drill which must be held accurately in any position will need a much heavier supporting frame than another requiring less care; and its attendant expenses will be greater than those of its simpler rival—other things being equal.

Plates XLVIII. and XLIX. represent a simple form of heading frame designed to be used with the Warsop Drill. The upright pillar is of 3-inch wrought iron tube, with a hinged claw at one end, and an elongating screw at the other. The pillar carries an adjusting arm which supports on a universal joint the sleeve tube of the Rock Drill. A short line is attached below the cylinder A and passes over a grooved pulley B to suspend the weight C, which counterbalances the weight of the drill frame sliding in the sleeve tube D. This apparatus weighs only 95 lbs., is easily fixed, and is sufficiently rigid for its purpose.

The leading points to be observed in the construction of a drill of the class in question may be stated as follows:—After having ascertained by experiment the power of resistance and durability of the cutting edge of the tool to be used under a rapid succession of blows, it will appear that a blow of medium force delivered rapidly is best suited to ensure progress. A light blow only loses time, and one which is too heavy either splits the cutting edge from behind or breaks off the corners. Having decided on the blow to be given, the machine must be constructed and proportioned so as to strike as rapidly and uniformly as possible. No additional work should be put upon the percussion apparatus that can possibly offer a varying resistance, else the speed and force of the blows must certainly suffer.

The amount of power necessary to turn a chisel at the bottom of a hole 18 inches deep is almost always greater than that requisite at the beginning of boring. If the chisel works backward and forward in the hole, there are imminent risks of sudden and irregular resistances which all tend to rob the cutting point of the tool of its proper force and impede the progress of boring. This can only be provided against by enlarging the piston or increasing the pressure upon it—two things equally undesirable in the economy of rock drilling. A larger cylinder involves additional weight and waste of motive power; and increased pressure (especially when air is employed) involves waste of fuel at boiler, as well as waste of power at drill. The Warsop Drill will do its work with a pressure of 20 lbs. per square inch, and this, when air is used, secures a large economy, as the amount of heat lost from air during compression increases rapidly with increased pressure. Again, a small cylinder allows the
instrument to be lighter, and consequently more easily handled—a most desirable property for a
tool which has to be manipulated among loose stones and in confined

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places. A machine to drill 1½ inch holes weighs only 65 lbs. without the tripod, which weighs 60 lbs.

The absence of external gearing and the general fewness of parts go far to insure against those small
accidents and aggravating stoppages to which a complicated machine is liable, as well as to promise
increased durability even in the hands of men who have had no mechanical training. Such an
apparatus as has just been described must, comparatively speaking, be cheap—a matter by itself of
small importance, but which, if combined with the advantages set forth above, should assist in
bringing mechanical rock-boring into more general use.

A light, strong, and at the same time cheap and serviceable tool should be eminently useful in
mining and engineering operations abroad where skilled labour is rare and expensive. The boiler
supplying steam might be a portable one on wheels, carrying a compressing engine to supply air for
working in tunnels and confined places.

For drilling under water it is only necessary to make the chisel long enough, and place the hammer
on the top. At the commencement the chisel would need to be supported until it entered a few
inches, after which it would remain upright and only require turning or rotating by hand. This would
make the apparatus independent of support from a boat which might at the time be too unsteady to
allow of fixing any drilling tackle to it.

When a deep hole is required there is considerable advantage in having the chisel detached from the
piston rod. Every foot in length adds so many pounds of resistance to the lifting of the piston,
causing the machine to work proportionately slower as the depth increases, even supposing there
were no friction on the sides of the holes from the rubbing of the chisel. When, on the contrary the
chisel remains in the hole and is struck by the hammer, the speed and force of the blow can be
maintained always constant, and a more rapid rate of progress ensured.

The use of such a hammer as is embodied in the Warsop Drill is not confined to drilling in stone; it
has been tried on a larger scale as a pile driver, with complete success as far as the experiments
went—the hammer being simply placed on the top of the pile and connected by means of a flexible
tube to a steam boiler.

It is also to be applied as a riveting machine on ships, bridges, tanks, and such work as does not
come within the scope of the stationary riveting machine. The hammer will only need to be
suspended by a rope over a pulley and brought up to the rivet which has been put through the
plates and held behind in the usual way. Running at the rate of 1,000 blows per minute the riveter is
expected to do the work of several men.

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Experiments are also in preparation to apply the hammer to machines for stone-dressing at quarries, making light forgings, planishing metals, and in fact to any process requiring a rapid and regular succession of blows.

The Chairman felt that all would agree with him as to the importance of the paper just read, and the thanks of the meeting should be given to the author for preparing it. The peculiarity of the machine appeared to be in the detaching of the drill from the piston, which was something quite new in his experience. Perhaps Mr. Wallace would inform the meeting why the automatic rotation was given up. It seemed to him that in this case it would have been specially applicable, and ought to have been a success. He could quite understand that a blow could be given to the chisel when drilling into soft sandstone which would so far jam it into the hole that it could not be withdrawn, if there was no provision made in the machine itself for doing so.

Mr. Wallace stated that the reason why automatic rotation was abandoned in favour of hand rotation was, that the resistance is not constant in any particular stone, but varied according as flaws, cracks, or boulders occurred, consequently a regular and unvarying system of turning did not appear to be so well suited for working as a rate of rotation which could be altered by the workmen. It is not a matter requiring much labour, but simply attention, and some skill. Again, wherever mechanical complications can be reduced, the chances of derangement are reduced as well. Mr. Wallace said, in answer to Mr. Bewick and Mr. M'Murtrie, that the machine was entirely new, and that there were no statistics as to the cost of work done by it.

Note.—The remainder of Wednesday's proceedings will be found in the next volume.

[Plates XLVII to XLVIII illustrating the Warsop rock drill]

APPENDIX No. I.

BAROMETER AND THERMOMETER READINGS FOR 1873.

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 0.150 of an inch to each reading, and both readings are reduced to 32° 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.

Owing to the difficulty of obtaining complete accounts of the nonfatal explosions they have not been recorded.

At the request of the Council the exact readings at both Kew and Glasgow have been published in figures.

The writer makes no attempt to offer any remarks, but hopes his efforts will be acceptable, and form a data on which to build more effectual arrangements for the safety of life.

[2]
[see in original text Table of Barometer readings for Kew and Glasgow in January and February 1873]

[3]
[see in original text Table of Barometer readings for Kew and Glasgow in March and April 1873]

[4]
[see in original text Table of Barometer readings for Kew and Glasgow in May and June 1873]

[5]
[see in original text Table of Barometer readings for Kew and Glasgow in July and August 1873]

[6]
[see in original text Table of Barometer readings for Kew and Glasgow in September and October 1873]

[7]
[see in original text Table of Barometer readings for Kew and Glasgow in November and December 1873]

[8]
[see in original text Diagrams shewing the height of the barometer, the maxima and minima temperatures and the direction of the wind at the observatory of Kew and Glasgow together with the explosions of firedamp in England and Scotland for the year 1873]

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APPENDIX No. II.

A DESCRIPTION OF PATENTS CONNECTED WITH MINING OPERATIONS,
TAKEN OUT BETWEEN JANUARY 1, 1873, AND DECEMBER 31, 1873.

BEING A CONTINUATION OF APPENDIX TO VOL. XXII.

By the SECRETARY.

The descriptions have been mostly given in the words of the patentee, all matter being excluded except that which is actually necessary to give some idea of the general principle involved. The exact details, if required, can readily be obtained from the Specifications. The patents are classified as before, viz.:—

1.—Lifting and winding, including safety-hooks.
2.—Mining, boring, and sinking.
3.—Pumping and modes of raising water.
4.—Ventilation.
5.—Safety-lamps and lighting mines,
6.—Coal cutting, getting, and breaking down.
7.—Explosive compounds.
8.—Miscellaneous.

FIRST DIVISION.

LIFTING AND WINDING, INCLUDING SAFETY-HOOKS.

1873. No. 428. BARNARD.

For preventing the falling of cages in shafts. This relates to cross timbers or bars working upon a common centre or on separate centres, and with the four legs extending outwards, the lower ones being shaped to engage into teeth or detents in or on the side walls of the shaft or uptake when acted upon by springs.

1873. No. 508. Siddons.

For preventing the overwinding of skips in the shafts of mines. This invention consists in the construction of an improved self-acting apparatus connected to
and worked by the engine employed for raising skips in the shafts of mines, whereby when the skip reaches the point to which it is to be raised, steam is automatically shut off from the engine and the brake applied, thus preventing the overwinding of the skip.


This invention consists in arranging the two drums, round which the winding ropes used in collieries and mines and for other purposes are coiled, upon separate axles connected together by toothed wheels, so that both ropes are coiled round the drums in the same direction as that in which they pass over the pithead pulleys.


A lever on each side of cage, one end by a bar connected to the rope: if the latter breaks, the outer ends of the levers shoot into racks fixed to sides of shaft and stop the cage. The suspending hooks are made to open and thus drop the cage on coming in contact with a projection on the head gear.

1873. No. 1482. Underhill and Snow.

The prevention of accidents through overwinding or breakage of the winding rope. We attach two diagonal suspension chains to the winding rope, and from these we suspend the cage. The catches to which the said chains are attached are not secured to the cage or other receptacle employed, but are held vertically in position at each side of the cage by means of latches turning upon horizontal pins, each latch having a handle or tail end projecting horizontally when in ordinary use. The guides between which the cage travels terminate at a suitable height above the mouth of the pit, and are furnished with strong bolts, which project in such manner as to catch and depress the tail ends or handles of the aforesaid latches, should the said cage be overwound or raised too high. The catches are thereby set free from the cage, and pass away with the winding rope. In adapting our invention to prevent accidents from the breakage of the winding rope, we make each of the aforesaid supporting catches in two pieces, the upper piece being hinged to the lower piece. The upper piece has an external hook or catch at its upper end, which, when the rope breaks, is forced by a spring into gear with ratchet-shaped teeth formed upon the inner face of each guide bar, but as long as the rope or chain is unbroken, and the cage hangs therefrom, the tension of the diagonal suspension chains counteracts the force of the spring, and holds the upper catches out of action.


Improvements in hydraulic hoisting apparatus, including an improved friction clutch, an improved safety device for elevator cages, and an improved governor or brake for regulating the descent of the cage. This invention relates to that class of hoisting apparatus in which the pressure of water upon a piston in a cylinder is used for elevating a cage from one level to another, and first, to a vertical arrangement of cylinders; secondly, to a horizontal arrangement, either of which can be employed.
1873. No. 2059. Johnson.

Improvements in moving and raising coal and other granular material, and in the machinery or apparatus employed therein, and to save the tedious and costly

labour demanded in the moving and raising them by the aid of shovels and wheel-barrows and the usual hoisting apparatus.

1873. No. 2376. Scott.

Instead of the wire rope hitherto used for colliery winding and other purposes, a belt or band is made composed of two or more layers of flat steel, charcoal iron, or other suitable metal, and of a thickness or breadth according to the purpose required. When practicable, the strips, layers, or plates forming the belt or band are each made of one piece, but when required to be of excessive length, two or more strips of metal are joined together according to the desired length by brazing, welding, or rivetting. It will not be always necessary to fasten the strips, layers, or plates together, but when desired they may be secured by clips, rivets, or any other suitable means.

1873. No. 2382. Urquhart.

Improvements in preventing accidents in the shafts of mines, and in the machinery or apparatus employed therefor.


Improvements in apparatus to stop the motion of cages or loads down mines and other places, and on inclines. This apparatus consists of claws or clutches of a forked form with a central point, all the interior surfaces of which are toothed, said teeth being inclined in such a way as to penetrate by their own action more and more deeply into the guides from the moment when they first come in contact with them.

1873. No. 3506. Owen.

Improvements in winding engines and apparatus for raising coal, stone, minerals, and other heavy bodies. This invention relates to the use of compressed air as a counterbalance or power accumulator applicable to winding engines for raising coal, stone, minerals, or other heavy bodies.
SECOND DIVISION.
MINING, BORING, AND SINKING.


The novelty of this invention consists, as to the first part thereof, in a new mechanical arrangement of standard to carry mechanism for perforating rock, &c, so made that it can be fixed rigidly in position to the face of the rock to be perforated or other material upon which the standard rests, and take the thrust of the perforating mechanism while the process of boring is being effected; and, secondly, in a new mechanical arrangement of standard, also to carry mechanism for perforating rock and other mineral substances, so contrived that the same standard can be adjusted and fixed rigidly in position between rock and other bearing surfaces varying in the heights or distances between the same, thus obviating the necessity for using standards of different heights.

1873. No. 879. Rigby.

Improvements in drill heads for rock boring and tunnelling. This invention consists in a method of driving the boring bar and nut in drill heads of diamond borers or others of similar character.


The objects of this invention are to simplify and make cheaper and more durable the automatic feeding gear of rock boring engines.

1873. No. 1455. Cranston.

Improvements in machinery for drilling or boring rock, and cutting coal. This machine, like other machines of this character in use, consists of a cylinder, piston, and slide valve, worked by either steam or compressed air, and is mounted on a carriage when used in drifts or headings, in mines or tunnels.

1873. No. 1638. Ball.

This invention consists in making drills for cutting rocks, tubular in their cutting parts, and having teeth formed upon their cutting edges.


Improved means of obtaining reciprocatory motion in percussive engines for boring rocks. Piston so constructed as to open and close necessary distributing passages in the cylinder during the stroke.
Improvements in rock drilling apparatus. According to this invention a number of rock drills operating by percussive action, are all worked by one single slide valve detached therefrom, and connected to the ports of all the drill cylinders by flexible or jointed pressure pipes, so that by the motion of the slide valve the air or gas under pressure is admitted simultaneously to and exhausted simultaneously from all the drill cylinders. The rock drills are by preference mounted on the uprights of a framing constructed as described in the Specifications to Patents No. 1,682 of 1868, and No. 392 of 1872. The partial rotation of the drills at each stroke is effected by a small air cylinder, supplied from the pressure pipes, actuating a ratchet in gear with a ratchet wheel on a rod from the drill piston passing through the back end of the drill cylinder. The forward motion of the drill cylinder, as the boring proceeds, is effected by a curved incline or cone on the said rod from the piston, actuating a ratchet in gear with a ratchet wheel, carried by a bracket from the drill cylinder, and fitting with a female screw on a fixed screw spindle. This screw spindle is provided with a hand wheel by which it can be rotated for drawing back the drill cylinder after the boring has been completed.

Improvements in machinery for drilling rock, consisting of a tappet, the head of which forms the valve of a steam boring apparatus, and which is actuated directly from within the steam chest, thereby dispensing with external valve rods, stuffing boxes, and other parts; of a peculiar mode of rotating the tool at each back or return stroke; of a clamp by which the machine is instantly secured at any suitable angle.

A simple and efficient boring machine, which can be readily fixed in position and transported from place to place, and will have great scope of action—that is to say, will be capable of working either in a horizontal, vertical, or diagonal direction, at the pleasure of the miner.

Improvements in machinery for drilling rocks, consisting of a stand for supporting the machine, and which is capable of adjustment to permit the drill to penetrate the rock in any direction; the means for attaching the cylinder thereto, so that it may be firmly sustained thereon; mechanism for turning the drill upon its axis during the operation of the machine.
1873. No. 2506. Imray.

Apparatus for drilling blast holes, and consists of a drill attached to a spindle mounted free to rotate and move longitudinally in bearings on a frame jointed so that the drill can be directed at any required angle. A wheel mounted on the framing has cam-shaped ratchet teeth which act on a pawl-lever. This pawl-lever bears against one edge of a clamp-ring encircling the drill spindle, and a volute helical spring bears against the opposite edge of the ring. The ring when pressed backwards by the pawl-lever is canted so as to nip the drill spindle and to draw it back and twist it a little round. When the pawl escapes a tooth, the spring drives the spindle forward, and thus the successive teeth, as the wheel is made to revolve, cause the drill to make a succession of blows which have the effect of drilling a hole, the drill being at the same time turned and advanced a little, as in hand boring.

1873. No. 3396. Patterson.

Machinery for boring rocks, and consists in applying the machinery for hammering for which Letters Patent were granted to Alfred Vincent Newton on the 24th day of March, 1866, No. 872, to impart the requisite motion to the drills of boring machines, whereby the rocks or other hard substances are bored more expeditiously and perfectly than heretofore. The drills are attached to the springs with flexible connections described in the said Patent, and motion is communicated to the driving shaft of the boring machine by means of a small water engine ram or wheel, driven by the water so abundant in mines and cuttings; or the arrangements may be modified so as to allow the application of compressed air or steam or other motive power, as circumstances may require.

1873. No. 3901. Lake.

Machinery for boring rocks, and relates to improvements in those machines whereby drilling rocks is effected by the action of the drill carried and operated by a reciprocating piston, which is driven more or less rapidly to and fro within a cylinder by the force of steam, compressed air, or other elastic fluid, admitted alternately to opposite ends of the said cylinder by a distributing valve.

1873. No. 4283. Carr and Urwin.

The invention relates to an improved machine or apparatus for boring fire clay, coal, or other hard substances, either on the surface of the ground, or underground in coal pits, or other mines or quarries.

THIRD DIVISION.

PUMPING AND RAISING WATER.

This invention relates to the construction of what are known as steam vacuum pumps, in which steam is condensed to form a vacuum, into which water is raised by atmospheric pressure, to be discharged either by gravitation or steam pressure on the admission of a fresh discharge of steam.

1873. No. 933. Lake.

Improvements in rotary pumps for lifting and forcing water.

1873. No. 967. Haseltine.

This invention relates to pumps in which a reciprocating valve-piston is employed, and the said invention consists in the combination with the valve-plunger or carrier of an independent acting sectional ring to serve both as a packing and as a supporting valve.


This invention relates to steam pumps, in which the pump, which may be either reciprocating or rotating, is worked by means of a special steam cylinder or combination of cylinders, and consists in fixing in either the delivery or suction pipe of the pump, but by preference the latter, any suitable modification of apparatus of the kind known as "injectors" or "ejectors," such apparatus having connected to it a pipe leading from the exhaust port of the steam cylinder.


Improved pneumatic pump, consisting of two chambers united by a bent pipe. The two chambers must be of the same capacity, and they as well as the bent pipe are full of oil or other suitable liquid. The lower chamber is provided with a plunger, which is worked by a steam engine or other power, and the upper one, in which are the valves, is in communication with the vessel in which the vacuum or partial vacuum is to be formed.

1873. No. 1306. Arnall.

This invention consists in constructing the spear rods of planks (say) nine inches wide by three inches thick, with their ends scarfed one foot in length, or dovetailed and placed on a system of break
joints, each joint being secured by a bolt or bolts passing also through the whole number of planks composing the rod which thus bind the whole system together.

1873. No. 1596. Williamson and Parsell.

Water is pumped up or lifted by successive stages into chambers furnished with float valves and placed at various levels. The air is exhausted from the chambers, and the water rushing in fills them in turn. When the lowest chamber is exhausted, the inflow of the water closes equilibrium valves communicating with the exhaust and opens others communicating with air, which air flows in and drives out the water from that chamber which opens a valve in the lift pipe and rises into the next chamber wherein the operation is repeated, and so on in each chamber.

1873. No. 1688. Lake.

Improvements in rotary pumps.

1873. No. 1732. Keen and Dence.

Improvements in machinery or apparatus for raising or elevating corn, minerals, coal, gravel, sand, or other materials applicable for discharging or loading vessels, dredging, pumping, and other similar purposes.

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1873. No. 1745. Picking and Hopkins.

Improvements in the construction, arrangement, and working of steam cylinders for use in steam pumping machinery and in steam engines, and in the means of governing or regulating the supply of steam thereto. (Too complicated for description without a drawing.)


The machine which forms the subject of the present invention is composed of three principal parts, which are to a certain extent independent of each other, but act in combination. The first part of the machine may be described as an artificial spring of water, and is intended to raise and project the water with great force.

1873. No. 1864. Wirth.

The novelty of the invention consists in transmitting motion to the plungers of pumps situated below ground by means of ropes, rods, or chains, held in tension either by means of their connection with
the discharge pipes of the pumps, or by an arrangement of levers top and bottom that in their movements will give the ropes stretched between them the necessary tension for giving the rise and fall to the plungers of pumps, or for other driving purposes below ground.


This invention relates to improvements in triple engines of a kind described in a Provisional Specification filed by the said Peter Brotherhood on the 24th day of January, 1873, No. 287. Three single acting cylinders arranged equally round a central chamber filled with oil, are fitted with pistons, which act on a single crank within a chamber on a shaft, which projects through the side of the chamber.

1873. No. 2033. Colebrook.

Improvements in steam cylinders for steam pumping machinery and steam engines. (Too complicated to be described without a drawing.)


According to this invention the steam cylinder of a pump is fitted with a long piston, in which are formed passages, which when the piston is near the ends of its stroke communicate with passages in the cylinder leading to the ends of the valve chamber.


Improvements in rotary pumps.

1873. No. 2649. Douds and Hartsuff.

The invention relates to that class of steam pumps in which the steam is caused to act by direct pressure upon the water, and is directed alternately upon two chambers having a common steam and delivery pipe controlled by tilting valves in such a manner as to direct the steam alternately upon each chamber, one being filled with water while the other is being emptied.

1873. No. 3011. Richardson.

Improvements in means or apparatus for ventilating and pumping purposes. This invention has for its object improvements upon an invention for which Letters Patent were granted to B. J. B. Mills, on the 28th day of November, 1870, No. 3117.

An outer casing or cylinder is furnished with an inlet and outlet as usual in rotary engines.

1873. No. 3343. Lake.

The invention consists in arranging the air-vessel over and between the two pumps, to form the fulcrum for the lever, in combination with a water-way.

1873. No. 3478. Worth.

The use of ports and slide-valves similar to those of an ordinary steam cylinder for the admission of water to and from the pump, the ports in the valve passing completely through it, motion being given to the valves of the steam cylinder and pump by means of the piston of an auxiliary steam cylinder and suitable mechanical arrangements. The use of a piston valve to admit steam to cylinder and give motion to the pump valve, the piston valve being actuated by auxiliary steam ports and a valve.

FOURTH DIVISION.

VENTILATION.


This invention relates to employing water under pressure for forcing air. Water under pressure coming through a pipe passes through a rose, the bottom of which is made with small holes, and underneath these holes wires are fixed, for the purpose of cutting or dividing the water passing through the holes; the rose is fitted in a cylinder having air holes at the top, and a suitable air space is left between the rose and the cylinder. Atmospheric air coming through the air holes and space strikes amongst the divided or cut water, and is forced by the pressure of the water through an air pipe, and the water escapes through a discharge pipe made at the bottom of the cylinder or air pipe.


My improved propeller or ventilator consists of a wheel or disc mounted on a propeller shaft, having a number of vanes or blades hinged to the face thereof, each vane or blade being caused in turn to open out from the side of the said wheel or disc and to close inwards again to the surface thereof by the action of either of a fixed eccentric, round which the said wheel or disc rotates, or by the action of spur gearing or of cranks or arms on the exterior ends of the axles of the vanes or blades acting against or sliding over fixed surfaces round the exterior of the wheel, or by other convenient arrangements of mechanism.
1873. No. 2863. Roebuck and Lamb.

Our improved ventilator consists of stationary and moveable vessels with conical nozzles, between which the steam escapes, thereby causing a current of air in the mine or other place to be ventilated; also in conveying the exhaust steam of a steam engine into the interior of the moveable vessel to increase or induce the current.

FIFTH DIVISION.

SAFETY-LAMPS.


This invention is intended to prevent the possibility of a miner opening his "Davy lamp" without detection, and consists principally in the use of a seal in an enclosed case or box fixed to the lamp, and so arranged that it is impossible for the miner to unscrew the top of his lamp without breaking the seal.


This invention consists in extinguishing the flame in Davy's safety-lamps on any attempt being made by miners and others to remove the light therefrom.

1873. No. 1131. Landau.

Improvements in miners' safety-lamps and other lamps and apparatus for lighting, also in furnaces, fire-places, and stoves or apparatus for heating, and in instruments for kindling lights, part of the improvements being applicable for ventilating. At the lower part of the lamp or lighting apparatus is a chamber or box, into which air is forced or otherwise admitted. It sometimes contains a fan or agitator. A bent or tortuous tube is fixed at the top of the lamp. It may be combined with a blower. The heat is condensed in this tube. There are arrangements for removing condensation water. Instead of miners' lamps and the like being separate and portable, they may be fitted in frames in the mine galleries or elsewhere, the frames of the lamps being moveable, hence a number of lamps may be properly controlled.


This invention consists in improving the illuminating power of safety-lamps by making the glass surrounding the flame of a cylindrical figure within and a convex figure without, or convex both
within and without. By this means the light is so concentrated that when the lamp is hung vertically the illumination is for the most part directed horizontally at or about the level of the lamp.


The operation of our improved apparatus or safety-lamp is as follows:—A lamp is suspended from the top of the roof, and is placed near to it, and the tendency of foul air being upward, it will of necessity act upon the lamp before affecting the lower atmosphere, and as soon as the foul air enters the gauze it becomes ignited, the strip of lead which is used to suspend the stalk is quickly melted, when the stalk immediately drops, the outer casing also falls, and the lamp thus becomes extinguished from want of combustion. We employ electricity in combination with our apparatus, and when the said outer metal casing falls, we cause the metal bridle before described to act upon an electric current, which in its turn acts upon a bell or bells, causing them to ring, and to continue ringing until they are stopped by the attendants.


This consists of a cap provided with an opening through which the wick from the

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burner passes. The said cap rotates with the burner whilst screwing the said burner to the protecting chamber, but is secured to the protecting chamber whilst unscrewing the said burner. A piece of wire or suitable material is secured over the opening in the cap to prevent the wick being raised too high.


The body of our improved safety-lamp is provided with a perforated cover, which is soldered or otherwise secured to it. The wick of the lamp is ignited by a fine taper tube connected to a gas burner, and the lamp is put out by an extinguisher which is held up by a spring lever.

SIXTH DIVISION.

COAL-GETTING.

1873. No. 95. Gay.
This invention consists in improved modes of giving the cutting tools a revolving and advancing motion at the same time, for the purpose of making slots or mortices at the sides or other parts of the seam or gallery of the mine or rock, and also in improved arrangements and contrivances for enabling the machinery to be comparatively light in weight, easily moved from place to place, quickly fastened, and its parts changed as required with ease and expedition.


This invention relates principally to improvements in or developments of the modes of working described in No. 1471 of 1870. In one modification the coal or other face is undercut across between two parallel roads by an endless chain with cutters on it and stretched across from one parallel road to the other. In one of the roads or ways a main endless driving rope is arranged to actuate a vertical pulley shaft moveable along the road on a carriage, and this shaft directly actuates a toothed or sprocket wheel for the endless chain of cutters and fixed on it as low down as possible, or fixed on a separate shaft in gear with it.

1873. No. 910. Stubbs and Cottam

The cutting tool has a simultaneously reciprocating and rotary motion imparted to it, and cuts preferably spirally; framework mounted on tram, and the tool moved forward by self-acting or other means. Motion imparted by any suitable motive power.


A number of cutters, drills, and augers, mounted in a frame made to traverse and angle, according to the work within, or between upright standards, or a vertical or other frame. The cutting instruments are caused to rotate together in the same or in opposite directions, and are connected together by wheels or wheel and pinion gearing, and worked by hand from one crank handle, or by power from a pulley or chain wheel, or by crank from a motor.

1873. No. 1936. Hanson.

In carrying out the invention, teeth or cutting surfaces are applied to the end of a cylinder or parts carried so as to rotate, and the desired rotatory motion to this carrying means is given by a pair of reciprocating racks set in motion by any suitable power acting upon a pair of tooth wheels, each of which has connected to it a ratchet or such like wheel, and the teeth of each of these ratchet or such like wheels is taken into by one or more clicks or drivers carried by an arm or
arms affixed to the axis of the carrying means, by which a continuous rotatory motion to cut in a circular direction will be obtained. The progressive forward motion is obtained by rack and pinion, or by lever and weight, or such like means. The cylindrical cut having been thus obtained, the cylinder of coal may be separated by wedges driven into the cut, or by a few blows from a hammer or such like means.

1873. No. 2732. Lucas and Nichols.

In this invention a series of cutters on a revolving bar is employed. The cutter bar has an endwise movement into the coal about equal to the distance from one cutter to the next upon the bar. After an endwise movement is completed the bar is advanced sideways into a position for the next cut, and so on. A supporting bar is employed to steady and support the revolving cutter bar.

1873. No. 3222. Warsop and Hill.

In this invention a trolly or carriage, mounted on four wheels, carries a circular frame, and on which is mounted one or more cylinders, giving a rotative motion by connecting rods, cranks, &c, to a cutter bar. The cutter bar has a spiral groove or grooves in the form of a screw running from end to end. In the raised parts of the bar, left after the groove or grooves are cut, are fixed at intervals a number of cutters. The cutter bar carries a semicircular shield behind it to facilitate the cuttings being drawn away. The circular frame carrying the cutter, cylinder, and connections, is capable of being canted to a position other than horizontal, irrespective of the outer frame or trolly, and of being turned round in a circle.

1873. No. 3248. Stevenson, Ree, and Dunlop.

This invention consists in forming the cutting part of tools for cutting freestone and other minerals, of short flat pieces or nibs of thin steel or iron with the front cutting end made of a half round shape, and having an angular or square cornered recess or projection formed behind to fit a corresponding projection or recess in the back end of one of the gripping jaws of the holder, and which are made to project forward at about the same angle, in the projecting gripping part of the holder, that it is desired to hold the cutters in relation to the face being cut or the motion of the cutter.


This Specification describes modes of constructing revolving bar cutters for cutting grooves into coal or other mineral; also causing such cutters to be swept round in the arc of a circle so as to cut a groove of any desired depth; also construction of machinery to be driven by hand power, or by rotary engines when such descriptions of cutter are used.
1873. No. 926. Roberts.

This invention has for its object improved means of rendering fulminating powders, and all fulminates that are dangerous to handle in a dry state, comparatively safe and useful for blasting and other purposes, by mixing them and using them mixed or combined with water or some other suitable fluid or materials, such as hygroscopic salts, in such proportions as shall render them non-explosive by ordinary agitation, friction, or by a blow or concussion, but yet sufficiently explosive to be capable of being fired by any detonating or fulminating compound, or by some of the same material in a dry state.


This invention consists in the use of paraffin, ozokerite, stearine, naphthaline, or any other fatty or sticky matter insoluble in water, as ingredients in explosive compounds containing nitrates, hygroscopic or not, and nitro-glycerine.


This Provisional Specification describes means by which gun cotton in a fibrous state, as when made from cotton waste or skeins, may be formed into granules or lumps. Granules formed from gun cotton which has been reduced to an impalpable powder, and either alone or mixed with other materials, are rendered compact by causing a plunger to descend into a chamber containing a quantity of such granules, the surfaces of the granules having been previously powdered over to prevent their sticking together. The compressed cake of granules so produced is afterwards broken up. Also an improved process of drying gun cotton and other solid explosives. Also mixing various substances with gun cotton and such like.


Improved construction of electric fuzes for discharging dynamite lithofracteur and other blasting bodies or compounds. This consists in enclosing within a paper or other tube on the end of the conducting wires a composition which becomes incandescent under the action of an electric current, and thereby communicates the heat or spark to the charge.

Combining in certain proportions nitro-glycerine, chlorate of potash, sugar, charcoal, ground coal, sawdust, dextrine, starch, and shumach, so as to form highly concentrated explosive bodies.

1873. No. 3273. Haseltine.

This invention consists in the compression of the grains in sheets that are afterwards broken up into pieces, by which means I attain uniformity of density and comparatively great regularity of size.

1873. No. 4148. Fenton.

A white gunpowder, composed of yellow prussiate of potash, loaf sugar, and chlorate of potash, which are ground fine and then kneaded to the consistency of dough, after which the compound is dried and passed through sieves of various sizes to obtain different-sized grains.


Gas retorts heated by waste heat of coke ovens, and crude lighting gas from the retorts mixed with waste heat from the coke ovens utilized for heating, evaporating, and boiling purposes.

1873. No. 848. Reidy.

By the introduction of a socket head on the end of shaft of pick a taper hole passes through the head and handle, through which a cast steel blade or tool can be put and taken out at pleasure.

1873. No. 936. Pumphrey.

This invention consists of a body or case open at top within which a rotating sifter, screen, or cage made of wire work is supported, and works the hollow spindle of the sifter or screen taking upon a fixed spindle or support in the axis of the body or case. A lid covers the open body or case during the use of the sifter so as to prevent the escape of dust. This lid carries at top a handle for rotating the screen or sifter, a projecting part inside the lid, when the lid is fitted upon the case or body, taking upon a square head on the spindle of the sifter or screen. The ashes being placed in the sifter or screen, the latter is rotated or oscillated by means of the handle on the lid, and the ash is thereby rapidly sifted or screened from the cinders, the ash and the very small cinders falling through the meshes of the screen into the body or case.

Two or more coke ovens heat a salt pan with flues underneath, and through it. The heat from each coke oven may be shut off from the salt pan and led into the chimney.


This Provisional Specification describes a revolving screen made in three sections; the sections are truncated cones with a common inclined axis, the bottom of the screen being horizontal or nearly so. The last two sections dip into a tank of water. Partitions or lifters are fixed in the third section, which lift the material that has been screened over the axis, and then let it drop on to an inclined shoot which conveys it into the trucks to carry it away. The water tank may be omitted and the screen made in two sections.


This invention consists in certain improvements upon the invention for which former Letters Patent were granted to me on the 23rd day of February, 1869, No. 558. I make the boiler or evaporator sufficiently long to reach over two coke ovens, which ovens are charged and drawn alternately, so that a nearly uniform amount of heat is supplied to the boiler or evaporator by the waste heat from the coke ovens.

1873. No. 1478. Smith.

My improvement consists in constructing an apparatus on the principle of Giffard's injector, for drawing the gases from the stacks of smelting and other furnaces

where they are generated, or coking ovens, and forcing them into smelting or other furnaces to be utilized as fuel.

1873. No. 1751. Woodall.

The principal feature of this invention consists in constructing coal tubs or waggons of sheet iron in an improved manner, instead of wood as ordinarily constructed.

1873. No. 1852. Imray.
This invention relates to apparatus for supporting respiration and light in suffocating atmospheres and under water, and consists in improvements in the respiratory apparatus, which is fitted with inlet and outlet valves, and in dense media with governing flexible diaphragms connected to the inlet valve, the distension or collapsing of which adjust the pressure of the air supplied to that of the surrounding medium; in the portable reservoirs for containing a supply of air, which are of bellows form, that can be carried on the back, and have nozzles fitted with valves that open only when the pipes for respiration or light are connected to those nozzles; in the air supply pumps, which for moderate pressures are made like bellows worked by a crank, and for high pressures, as for diving, have two cylinders of different sizes, the smaller of which is supplied with compressed air from the larger, and still further compresses the air delivered by it; in the supply tubes, which have valves opening inwards, so that should the supply from the pump fail, the act of inhaling may draw air into the pipes; in the lamps, which are encased in glass and supplied with air somewhat exceeding in pressure that of the surrounding medium, and which for diving purposes have a light outlet valve for products of combustion; and in the diving dresses used under water, and instruments for closing the nostrils, and spectacles employed in deleterious atmospheres.


The characteristic feature of this invention is the removal from a charge of coal, after it has been emptied into a deep vessel, the bottom of which is moveable and perforated, of all the various components of the same, various in size as well as in quality without any loss or waste whatever. To obtain this result the charge is first acted on by an ascensional and intermittent current in order to drive all the fine particles to the top, then graduated fluctuations of the water are produced from the greatest height that can be usefully employed down to the smallest in order to sort the qualities. The slimy portions are next allowed to become deposited during an interval of rest which varies from 2 to 5 minutes, according to the nature of the coal. Lastly, the washing table is raised up to the orifice of the vessel in order to effect the selection and removal of each quality.


This invention consists in the addition of a return flue, to the ordinary flue, whereby the smoke fumes and gases are passed from the ovens to the further end of the block of ovens instead of being passed direct to the chimney as at present. The smoke fumes and gases are then returned by a return flue either over, under, or at the side of the first flue back to the chimney, thus forming a perfect combustion flue or chamber in which the smoke fumes and gases are completely commingled, returned, and effectually consumed. Suitable dampers are applied between each oven and the first main flue for the purpose of shutting off and excluding the air during the operation of drawing and re-charging the ovens, the employment of such dampers being necessary for the complete consumption of the smoke fumes and gases.
1873. No. 2137. Fowler.

At the places at which the tubs or corves have to be run on to or off the decks of the cage of lifts, frames having two or more decks or floors similar to the cage are so mounted that the cage may be brought to rest between them. The frames are connected to hydraulic presses, by which they can be raised or lowered at pleasure. For the purpose of pushing some or all of the corves or tubs off the floors of the frames or platforms on to the cage, and from the cage on to the platforms, hydraulic presses are also employed; a system of catches is also applied to the several floors of the winding cage, which allow the off-going tubs or corves to leave the cage freely, and lock or stop each on-coming tub or corve when it is in the right position upon the winding cage.


The object of this invention is to conduct the process of gas and coke making in such a manner as to collect all the constituents of the coal and yet obtain them of such a quality as to command a higher market price.

1873. No. 2669. Imray.

This invention relates to a method of and apparatus for discharging coals or other goods from railway trucks, and loading them into vessels. The trucks, consisting of boxes mounted on under frames, are brought on a railway on the quay alongside the vessel. The locomotive, provided with a steam crane, is run along a parallel line and is made to tip each box successively on to a hopper-shaped slope formed on the quay, which can be closed at bottom by a slide or door. From the mouth of the hopper a jointed spout conveys the goods to different parts of the hold of the vessel.


This invention has for its object to improve apparatus for screening coal, and at the same time for facilitating the picking out from it all impurities or dross. For this purpose we employ barrels or rolls in combination with a series of screens. The barrels or rolls we place transversely between the screens, there being a screening surface intermediate of the several barrels.


The invention relates to the production of coke, and consists in the mixing or incorporating anthracite (or stone coal), free burning steam coal with bituminous coal, or any other coal capable of making coke, with pitch, tar, or any form of tar, bitumen, mineral oils containing bitumen, vegetable oils containing bitumen, petroleum, or any of the waste products of petroleum, such coals being in a state of division.

The objects of this invention are to increase the quantity of coke produced from a given quantity of coal, to utilize the gases and heat generated in the burning of coke, to facilitate the charging and discharging of the ovens so as to produce a larger quantity of coke in a given time, and to improve the construction of coke ovens without increasing the cost.

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1873. No. 4227. Aitken.

The feature of novelty which constitutes this invention is the forcing of heated or cold air into the space of coke ovens or kilns above the upper surface of the materials being coked so as to burn the gases and promote the coking process.

1873. No. 4267. Sheppard.

This invention relates to a novel arrangement of apparatus for washing coal, in which the same water may be used again and again to separate the coal from the shale and other extraneous matters contained therein, and by which means no waste of coal can occur.

1873. No. 4269. Lord.

This invention relates to the application of the waste heat from coke ovens to the generating of steam or to the heating of water for useful purposes. In applying it to the generating of steam, the heat is passed along a flue to the flues of a steam boiler, after passing through which the heat escapes into the chimney. The boiler may either be placed alongside or above the coke oven. In applying it to the heating of water the heat is passed along, a flue to the water-heating apparatus, and after passing in or around it, the heat escapes into the chimney.

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