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JOSHUA FIELD, President, in the Chair.

No. 788.—“The Coal-field and the Coal of South Wales.”*—By Joshua Richardson, M. Inst. C.E., F.G.S.

A PLENTIFUL supply of good coal is essentially necessary to the national existence of this country; for without an abundance of this valuable mineral, its manufacturing industry and commercial enterprise would be paralysed, and cease to be the sources of that great wealth for which Great Britain is now distinguished amongst the nations. It also very materially contributes to bodily health and domestic comfort, as, next to food and clothing, fuel is, undoubtedly, one of the most indispensable necessities of civilised life.

Thirty years ago, Sir Humphry Davy said:—“Science had made pit-coal an important instrument in the hands of the chemist and mechanic; it had made the elements of fire and water perform operations which formerly demanded human labour, and it had converted the productions of the earth into a thousand new forms of use and beauty.” Since this was written, great progress has been made, in still further developing the utility and power of these elements, and in applying them not only to the saving of human, but of animal labour, which they have superseded, and in some instances, far surpassed, in celerity and effect. Fire and water have not only been employed to facilitate internal communication, but have also been made to enter successfully into competition with the wind, as a motive power on the ocean, and, by diminishing the time required for communicating with distant countries, have, in effect, brought them nearer to each other.

The progressive extension of this new power,—the consequent amazing increase in the consumption of iron and other metals, in the production of which coal is an indispensable agent,—the augmenting demand for other manufactures, and for export to other countries,—and the rapid increase of the population,—have all tended to augment the present consumption of coal so steadily and progressively, to an amount unprecedented at any former period, that serious apprehensions have been entertained of the exhaustion

* The discussion on this Paper extended over portions of two evenings, but an abstract of the whole is given consecutively.

of the sources of supply, at no very remote period. These fears were chiefly excited in relation to the great northern coal-field, situated in the counties of Durham and Northumberland, from which London and great portions of the country on the east and south coasts of England and Scotland are principally supplied. Several estimates were made of the probable duration of the supply to be derived from this district, and it is curious to observe the great discrepancies which appear in the results of these calculations. In 1801, Mr. Bailey stated, that the supply would only last 200 years; in 1792, Dr. MacNab calculated it would be exhausted in 375 years; in 1830, Dr. Buckland estimated it would all be consumed in 400 years; in 1830, Professor Thomson thought it would serve at least 1,000 years; and, in 1830, Mr. Hugh Taylor proved there was coal enough for 1,727 years.

Apart, however, from these predictions, this valuable coal-field is, undoubtedly, annually approaching to a state of exhaustion. Nor is this a matter of surprise, when it is recollected, that the coal from this district has been extensively used, during upwards of six centuries, both for home consumption and for exportation; and although, in the early part of this period, the quantity was comparatively inconsiderable, yet of late years, owing to the establishment of iron and other large manufactories in the district, and an increasing demand for it elsewhere, the quantity shipped has, alone, been augmented upwards of 5,300,000 tons per annum since the year 1800.* There are no means of ascertaining the amount of the home demand, but there is no doubt that it, also, has recently very considerably increased.† The time must, therefore, come, and that at no very remote period, when the capability of the Newcastle district

	Tons.		Tons.		Tons.
* In 1847 shipped coastwise	5,921,037	over sea	1,806,638	Total	7,727,675
In 1800 ,, ,,	2,217,070	,,	135,438	,,	2,352,508
Increase . .	3,703,967	,,	1,671,200	,,	5,375,167

† This want has been since supplied by the publication of the "Mining Records," by Mr. Robert Hunt, F.R.S.; from which it appears, that in this district, 15,431,400 tons of coal were worked in the year 1855. This quantity was disposed of as follows:—

	Tons.
For home consumption	3,850,000
Shipped for London and the coast . .	8,567,028
Shipped for foreign countries . . .	3,014,372
	<u>15,431,400</u>

For an account of the quantity of coal raised in this and other districts in the year 1855, see the tabulated statement in the Appendix.—[J. R., Jan. 1858.]

to supply coal equal to the progressive demand for it, both at home and abroad, will become so limited, from the increased difficulty and additional expense in producing it, that other sources of supply must be resorted to, where coal is to be found in greater abundance, and where it may be procured at a cheaper rate. The extinction of the coal trade in the North will probably be gradual, and long precede the total exhaustion of the coal-field; for although the consequent increased cost of production may exclude it from the London and other distant markets, yet it may still, for a much longer period, prove more economical to use it in its own district, than to import from other places.

The certain and progressive exhaustion of coal is not confined to the Newcastle district. In Staffordshire, where the area of the coal-field is only rather more than one-half that of Northumberland and Durham, the immense consumption in the iron-furnaces and foundries renders it probable, that the extinction of the collieries in this district will precede that of the northern counties. The Derbyshire, Yorkshire, and Lancashire coal-fields are situated amidst numerous manufactories and great populations, and have a demand for home consumption quite equal to their means of supply.

It becomes, therefore, a subject of interesting inquiry to ascertain if there are any other sources of supply whence the present enormous and constantly-increasing demand for coal can be supplied, for the consumption of London and other places similarly circumstanced as to their geological position. If the importance of a subject is measured by its utility, there are few which have stronger claims on the attentive consideration of the Institution than this question, when it is viewed in all its bearings and consequences. In most, if not in all engineering operations, coal is an indispensable auxiliary, and on its goodness and cheapness much depends, both as to the stability of the work and the ultimate success of the project; nor can there be a greater hindrance to the internal improvement of a country, than an inadequate supply of inferior fuel.

In the event of such a dearth of coal occurring in England, as has been anticipated, and towards which there is, undoubtedly, a progressive and steady advance, it is fortunate, that there is a coal deposit in South Wales, from which an almost exhaustless supply may be obtained. The coal of this district is comparatively little known, save as a subject of geological interest, and its being extensively used in the production of iron, the smelting of copper, and the manufacture of tin plates. Its introduction into general consumption in London and other places has only been very partially effected; and its value, from many causes which will be afterwards

noticed, is not only imperfectly appreciated, but strong prejudices are entertained against it. Necessity will induce a more intimate acquaintance with it, and as the merits of this coal become more generally known, prejudices will subside, and it will assume that importance among the national productions, to which it is really entitled. In the meantime, it may be an interesting, if not an instructive inquiry, to ascertain the extent and quality of this coal, and whether it can be produced as cheaply as in other districts; for however plentiful the supply might be, the requirements would be but very imperfectly answered, if the coal was of a very inferior description, or more than ordinarily expensive. The localities and quantity of the coal in South Wales, therefore, will be first described, its various kinds and qualities will be then shown, and the cost of producing it will be subsequently stated.

The area of this coal-field has been variously estimated, by different authors, at from 100 square miles to 1,200 square miles. In order to ascertain which of these estimates approximated most nearly to the truth, the Author computed its area from the geological maps published by Mr. Knipe and by the Board of Ordnance, and found it to be 1,055 square miles; and that about two-thirds of it is of a bituminous quality, and one-third anthracite, or of a non-bituminous description. The dimensions were taken from the inside boundary of the Millstone Grit, or Farewell Rock, (as it is locally called,) or its equivalent; and the results from each map were very nearly coincident. The respective quantities of bituminous coal and anthracite were taken from Knipe's map only, and must be considered as approximate and not certain data, as the one description frequently merges into the quality of the other, so as to render a distinct line of geographical limit to each kind impossible; and it sometimes happens, that both bituminous and anthracitous coals are found in the same ground.

This coal-field commences on the east, in the county of Monmouth, and extends westward through Glamorganshire, Brecknockshire, and Carmarthenshire to the western boundary of the county of Pembroke. It is parallel with the Bristol Channel, the numerous harbours of which give every facility that is required for its export; and the railways which are now being constructed in the principality, will tend to lessen the expense of its carriage from the collieries to the shipping ports and markets for home consumption.

In Monmouth, the coal is found in the western part of the county, abutting on Glamorganshire in the south-west, and on Brecknockshire in the north. Its average length is about 7 miles, and its

breadth $15\frac{1}{2}$ miles. The whole area of the coal, which in this county is bituminous and 'free-burning,' is 110 square miles. It is extensively used in the smelting and manufacture of iron at the Tredegar and other large works on the northern boundary, and considerable quantities of it are shipped at Newport, which is about 6 miles distant from the nearest part of the coal-field, in a south-easterly direction.

Coal extends over four-fifths of the entire county of Glamorgan; it embraces every description, as well as every quality of coal found in South Wales, and covers an area of 546 square miles, of which 462 square miles are bituminous and free coal, and 84 square miles are anthracitous. Of the above quantity, 26 square miles are under the sea, in Swansea Bay. Both descriptions of this coal are extensively used in making iron, and large quantities of the bituminous quality are used in copper-smelting, and in the manufacture of tin plates, &c. Both kinds are exported, but not to the same extent as the coal in Monmouthshire.

There are only 78 square miles of coal in Brecknockshire, the whole area of which is shown by Mr. Knipe as anthracitous. It is principally situated on the south-west corner of the county, adjoining the counties of Glamorgan and Carmarthen. It is extensively used in the iron-works near Merthyr Tydvil, and large quantities of iron-stone are obtained from near the lower coal-measures.

In Carmarthenshire, there are 241 square miles, 105 of which are under the sea, in Carmarthen Bay. Of the whole quantity, 117 square miles are shown as bituminous and 124 square miles as anthracitous. It is used, like the former, in the smelting and manufacture of iron, and a considerable quantity of this coal is annually shipped at Llanelly. Argillaceous iron-stone of superior quality is also obtained from the inferior measures of this district.

The coal continues westward, through the whole length of Pembrokeshire, in a strip, narrowing as it proceeds to Bride's Bay, at the extremity of the county, where it continues its course along the bay, at right angles with its former direction. The whole area occupied by it, in this county, is only 80 square miles, and all of it is anthracite, some of which is of a very superior quality; it is exported to the agricultural counties to be used in stoves,—for drying hops, malt, &c.,—and for burning lime, for which purposes it is preferred to bituminous, or any other description of fuel.

The following Table exhibits a recapitulation of the areas in each county, and of the whole coal-field :—

	Bituminous.	Anthracitous.	Totals.
	Sq. Miles.	Sq. Miles.	Sq. Miles.
Monmouthshire . .	110	..	110
Glamorganshire . .	462	84	546
Brecknockshire . .	..	78	78
Cardiganshire . .	117	124	241
Pembrokeshire . .	..	80	80
Totals . .	689	366	1,055

From various causes there is great difficulty in correctly ascertaining the average depth, or thickness of the coal, for although some of the veins, or seams, can be traced for a considerable distance, it yet remains to be proved, that any one vein of coal extends over the whole area. Even those veins which are indisputably recognised, in different localities, as being identical, vary so much in thickness, or are so interrupted by abrasions and gaps, produced by denudation, or other remote causes, as to preclude the possibility of making any true estimate of its thickness throughout the entire basin, or even over any great portion of it. It appears from sections published by the Rev. W. D. Conybeare, and from the Ordnance Survey, exhibiting the general disposition of the strata, in a line from north to south, across this coal-field, that there are two deposits of coal, which are separated from each other by a rock of considerable, but varying thickness, called the Pennant Grit. The coal of the upper series is not equal in quality to that of the lower; and it is in the lowest shales, that iron ore is found in the greatest abundance. The effects of denudation are clearly shown in these sections, particularly in the upper series; abrasions and gaps, where the coal has altogether disappeared, are occasionally to be observed. The lower series has suffered diminution from the same cause, and in some situations, the loss has been very great; and there is good reason to believe, that a great portion of the original deposit has long since been wasted away. This view of the subject is strikingly confirmed by the relative quantities of coal found in different places, as shown in the sections recently published by the Ordnance, and by others in the possession of the Author. For instance, in the section of the strata of the lower series, taken on the east crop, at Pontypool, (Monmouth,) there are only twenty-three veins, amounting in the aggregate to 42 feet of coal, whilst at the Plymouth iron-works, which are situate on the north crop, and about 15 miles north-west of Pontypool, there are thirty-three veins containing 50 feet of coal; and at Cefn Crebwr, which is on the south crop and about 28 miles south-west of Pontypool, there are only twenty-three

veins, of an aggregate thickness of 80 feet. These discrepancies occur in the lower series, in such situations as have exposed the veins to the effects of denudation, the results of which are by no means uniform. In the upper series, there is a still greater difference in the quantities of coal shown in the several sections taken at different, but not very distant places; and the area of these veins is so much cut up and divided by valleys, as to leave the coal only in strips and patches. That portion, therefore, of this coal-field in which all the veins are to be found, is of a very limited extent, and in estimating its quantity, very liberal deductions must be made from the dimensions of the original deposit. It would require great labour, as well as an intimate and exact knowledge of the coal-field, to estimate its contents truly and correctly; and in the absence of more satisfactory information, the following statement of the number and thickness of the veins of coal in the upper and lower series, is extracted from the "Memoirs of the Geological Survey of Great Britain," by Sir Henry De la Bèche.

	Under 2 Feet.		2 Feet.		3 Feet.		4 Feet.		5 Feet.		6 Feet.		7 Feet.		9 Feet.		10 Feet.		Totals.	
	Veins.		Veins.		Veins.		Veins.		Veins.		Veins.		Veins.		Veins.		Veins.		Veins.	
	No.	Ft. in.	No.	Ft. in.	No.	Ft. in.	No.	Ft. in.	No.	Ft. in.	No.	Ft. in.	No.	Ft. in.	No.	Ft. in.	No.	Ft. in.	No.	Ft. in.
Upper Series	21	23·10	6	13·0	5	15·6	2	8·6	4	20·6	2	14·0	1	9·0	1	10·0	41	104·4		
Lower Series*	7	7·0	4	10·0	.	.	4	16·0	3	15·0	2	12·0	1	7·6	1	9·0	1	10·0	23	86·6
Totals	28	30·10	10	23·0	5	15·6	6	24·6	7	35·6	2	12·0	3	21·6	2	18·0	1	10·0	64	190·10

It thus appears, that there are sixty-four veins, or seams of coal, the aggregate thickness of which is 190 feet, and the area of this coal-field, as before shown, is 1,055 square miles.†

The authority generally referred to, and most relied on, as to the extent of the South Wales coal-field, is a Paper by Mr. Martin,‡

* The lower series is said to contain 60 inches of argillaceous, and from 18 inches to 36 inches of carbonaceous iron ore, which are calculated to produce 11,000,000 tons of ore, per square mile.

† The Newcastle coal-field has been estimated by the Author at 840 square miles, and it is said to contain 12 feet of workable coal; 105 square miles of which were exhausted in the year 1826. The areas of the following coal-mining districts, are as follows:—

Great Britain and Ireland . . . 7,995 square miles.

France 914 ,,

Belgium 486 ,,

‡ *Vide* Philosophical Transactions, vol. 96, p. 345.

in which the area is estimated at 1,000 square miles, and the thickness of the workable coal extending over the whole of this area, is said to be equal to 95 feet. Mr. Martin takes only half of the aggregate thickness, shown in the foregoing extracts from the Ordnance sections, yet for reasons before stated, it may be fairly doubted, whether his estimate does not exceed the probable average thickness of the coal throughout its whole area. In the absence of exact measurements of the existing extent of the several veins and their varied thicknesses, any precise estimate of this description must be viewed only as conjectural; there can, however, be no doubt, from the facts already stated, that the quantity of this valuable mineral in South Wales is immense, and that, in area and thickness, it far exceeds any other coal-field in Europe.

In connection with this subject, the present consumption ought to be considered, so as to show the rate at which the process of exhaustion is proceeding, and what relation it bears to the whole quantity, and to the consumption of other districts. A brief notice of the several sources of demand may be interesting, and serve to prove the great national importance of this coal-field in sustaining the vast manufactures of metals which are dependent on it.

The rapid and increasing growth of these establishments affords presumptive evidence of the value of this coal, and of its fitness to be more extensively introduced into general consumption. The largest quantity is used in the smelting and manufacture of iron, which was first introduced into this district about a century ago.* There are now one hundred and eighty-seven blast-furnaces in this district, of which one hundred and forty-eight are in blast. The quantity of iron annually made in South Wales, amounts to 840,000 tons.† The quantity of coal used in making this iron, and in manufacturing a large proportion of it into bar-iron, is estimated at

* "The smelting of iron with charred pit-coal was first successfully effected, on a large scale, at Coalbrook Dale, (Shropshire,) about the year 1740. In 1755, Mr. Bacon obtained the lease for ninety years, of a district of country near Merthyr Tydvil, 8 miles in length and 4 miles in width, at the very low rent of £200 per annum. It is understood, that his right extended only to the iron and coal mines found on the estate, and that he had a very small portion of the soil, or surface, on which he erected works for the smelting and forging of iron. Soon afterwards, about the year 1783, he granted leases of his remaining term in the following parcels:—Cyfartha works, the largest portion to Mr. Crawshaw, and the remainder to Mr. Hill."—"Malkin's Walk through South Wales," vol. i., p. 278.

† The quantity of iron made in Great Britain in 1846, was 1,750,000 tons, of which 500,000 tons were exported.

2,850,000 tons per annum; and the value of the iron smelted and manufactured with it, is stated to be £3,050,000 per annum.

Copper-smelting was first instituted in this district about the year 1690, in the neighbourhoods of Swansea and Neath, where it is still pursued on an increasing scale, and has been extended to Port Talbot on the east, and Llanelly on the west. In this district, 26,000 tons of copper are annually produced,* the ores being imported principally from Cornwall, Chili, Cuba, and Australia. These works consume 400,000 tons of coal annually, and the value of the copper thus produced is estimated at £2,600,000.

The manufacture of tin plates, (thin plates of iron tinned over,) appears to have first taken place in 1681, and the establishments of this district in which this simple and interesting process is carried on, are the most extensive in the world. When in full operation, they produce five hundred and twenty thousand boxes of tin plates per annum, but at present, the produce does not exceed three hundred and thirty-five thousand boxes. The tin annually used for this purpose, which amounts to 1,500 tons, is imported from Cornwall, and costs £135,000. The coal consumed in the process annually, amounts to 250,000 tons, and the value of the tin plates manufactured with it, is said to be £550,000.

A considerable quantity of coal is used in the spelter, chemical, patent-fuel and other manufacturing works in the district; also in the burning of lime, for building, agricultural and other purposes. It also serves for the domestic uses of a resident population of about six hundred thousand souls; and its abundance and consequent cheapness induce a much larger consumption in this district than is usual for such purposes. The annual consumption under this head has been safely estimated at 750,000 tons, and its value is about £180,000.

Although the export of coal from this district may appear inconsiderable, when compared with that of the Newcastle coal-field, and the relative means of supply, yet as its superior adaptation for many purposes becomes more generally known, the demand for it will, doubtless, greatly increase. From 1833 to 1847, the shipments have augmented upwards of 60 per cent., which may be viewed as an indication of the enhanced appreciation of its economical value. Its distance from London by water, being twice that of the northern coal-field, necessarily renders the cost there rather

* In the United Kingdom, the whole produce is 28,000 tons, of which 17,000 tons are exported.—Mr. Hunt estimates the quantity of pig-iron made in Great Britain, in 1855, at 3,218,000 tons.—[J. R., Jan. 1858.]

greater than that of the Newcastle coal; but as is afterwards shown, this increased price per ton is amply compensated for, by the more peculiar, durable, and other qualities of the fuel.

The following account of the shipments of coal, culm, and cinders from South Wales, in the year 1847, is extracted from the Parliamentary returns:—

	Coastwise.	Over sea.	Totals.
	Tons.	Tons.	Tons.
Newport	436,099	116,098	552,197
Cardiff	432,726	81,032	513,758
Swansea, Neath, &c..	373,307	46,715	420,022
Llanelly	204,391	14,178	218,569
Totals	1,446,523	258,023	1,704,546

This quantity is considerably less than that shipped in the three years preceding, owing to the extraordinary depression of commerce and manufactures. Taking the average of 1844, 1845, 1846, and 1847, the exports are 1,757,050 tons; the amount of shipments is, therefore, taken as 1,750,000 tons, the annual value of which is estimated at £620,000.

The following is the recapitulation of the quantities of coal now annually consumed, and the estimated value of the manufactures in the production of which it is employed. The consumption in 1834 is added, so as to show the great increase which has taken place since that period:—

	1834	1847	Value of Products in 1847.
	Tons.	Tons.	£.
Iron works	1,000,000	2,850,000	3,050,000
Copper works	150,000	400,000	2,600,000
Tin works.	100,000	250,000	550,000
Chemical, &c., works and domestic uses }	650,000	750,000	180,000
Shipments.	1,100,000	1,750,000	620,000
Totals	3,000,000	6,000,000	7,000,000*

It thus appears, that the consumption of this coal has been doubled since the year 1834; the extension of the iron and

* Some of the foregoing statistical information is derived from two able and very interesting publications by Thomas William Booker, Esq., [Now, (Jan. 1858,) T. W. Booker Blakemore Esq., M.P.,] viz., "The prize Treatise on the Mineral Basin of Glamorgan and adjoining district," 1834; and his "Speech delivered at the Meeting of the British Association held in Swansea, 1848."

copper works, the increase of the shipments, and the progressive introduction of the railway system into the principality, will tend very materially to increase the demand for it and add to the exhausting process now in operation.* Presuming that this coal-field extends over 1,000 square miles, and that it is of an average thickness of 95 feet of workable coal, Mr. Martin calculates, that there are 64,000,000 tons in each square mile; taking, therefore, the consumption at the present amount of 6,000,000 tons per annum, it will require upwards of ten thousand years to exhaust the coal in South Wales. As has been already stated, reasonable doubts may fairly be entertained of the correctness of Mr. Martin's estimates, but supposing there to be only two-thirds, or even one-half of this quantity, still there is an ample supply for ages to come.

The value of the coal now produced, and of the manufactures supplied by it, amounts to £7,000,000 annually; and when it is recollected, that this large sum is chiefly expended in manual labour, some notion may be formed of the vast amount of human comfort which is derived from it, and of the benefits which this mineral district bestows, not only on the United Kingdom but on the whole civilized world.

Having approximately ascertained the available quantity of this coal, its quality is the next subject that demands attention. There are few, if there be any, coal-fields, which contain a greater variety, or fuel better suited to the many purposes for which it is required. About two-thirds of it contain bituminous coal, and one-third is anthracite; a great portion partakes of the nature of both these kinds, and is called 'free-coal,' from its not 'binding,' or caking in the fire. The qualities of each kind are also different and numerous, ranging from highly bituminous to almost pure anthracite, so that the best quality of almost any kind of coal which may be required, can be obtained in this extensive and valuable field.

Coal is shown, by chemical analysis, to be composed of carbon, hydrogen, nitrogen, sulphur, oxygen, and of some earthy matters. These are found to exist in various proportions, scarcely two veins of coal being exactly alike; and a considerable difference is frequently found in the coal from the same vein in different localities. In the coal of South Wales, the carbon varies from 60 to 95 per cent.;—the hydrogen from 3 to 6 per cent.;—the nitrogen from 0·18 to 2 per cent.;—the sulphur from 0·23 to 8 per cent.;—the oxygen from 0·39 to 7 per cent.;—and the ashes from 0·62 to 14

* Mr. Hunt gives the total produce in 1855, as 8,522,270 tons.

per cent.* When these constituents are united in such proportions as to produce the greatest effects on combustion, leaving little residuum, they form the best coal. The greater the proportions of carbon and hydrogen to the other constituents, the better is the coal; and the proportions in which these elements exist, show the relative fitness of the coal for any particular purpose; for instance, the coal required for producing steam, should have a large proportion of carbon, whilst that used for making gas, ought to be rich in hydrogen.† In estimating the value of coal, therefore, especial reference must be had to the purposes to which it may be applied; and in testing the coal of South Wales in this way, it will be necessary to consider its fitness for the smelting and manufacture of metals,—for the production of steam,—for other manufacturing purposes,—for the burning of limestone,—and for household and other miscellaneous uses.

The large quantity of this coal which is consumed in the smelting and manufacture of iron, copper, and tin plates, and the superior quality of the produce, sufficiently and conclusively prove its value for such purposes; and in the following observations upon its several kinds and qualities, ample evidence will be adduced of its fitness for other services, equally important. In this district there is a greater variety of coal than in any other, and the consumer is, therefore, enabled to select that which is best adapted to his object; and although, as in other coal-fields, there is much inferior coal, yet there is a very great proportion of excellent quality. In purchasing coal, consumers should have especial regard to the kind as well as to the quality, otherwise they may be disappointed in the results.

It has been stated, that the value of coal for producing steam, is

* Penner Vein (Newport)	60·25	Carbon.
Pentyrch Vein (Cardiff)	95·68	
Pentrepeth	0·18	Nitrogen.
Ebbw Vale	2·16	
Ebbw Vale	0·39	Oxygen.
Graigola	7·19	
Jones' Veins	3·46	Hydrogen.
Bedwas	6·01	
Weigfach	0·23	Sulphur.
Tonmawr Isha	8·35	
Cwm Buchan	0·62	Ashes.
Porthmawr Rock	14·72	

† In his Paper on the evaporation of water from steam-boilers, Mr. Parkes says, that he has seen Scotch Cannel coal give out 85 per cent. of gas. *Vide Transactions Inst. C. E., vol. i., p. 169.*

directly as the quantity of carbon it contains; and this opinion is partly confirmed by the Report of Sir Henry De la Bèche and Dr. Playfair on the coal best suited to the steam-navy, and by the statement of Messrs. Parkes and Pellatt,* that they found 9 lbs. of coke equal, in effect, to 12 lbs. of coal. Mr. Pellatt added, that he obtained 70 per cent. of coke from the coal, and as the coke represents the carbon and ashes contained in the coal, the effect produced is attributable to the carbon only. Could this fact be clearly and incontrovertibly established, a certain and ready means of ascertaining the relative value of different coals for steam and other purposes, would be found in analysing their constituent parts. But there are difficulties to be obviated, before an implicit reliance can be placed on this mode of determining the value of coal. A reference to the annexed Table, extracted from the first Report of Sir H. De la Bèche and Dr. L. Playfair, giving the number of lbs. of water evaporated from 212°, by 1 lb. of the several coals named, and the mean composition of their average samples, shows, that although, in the majority of instances, the evaporative power of the coal is in some ratio to its carbon, yet there are several exceptions to this rule. For instance, Nos. 1, 2, 3, 4, 5, 6, 8, &c., show the evaporative power to be in some near proportion to the carbon, but No. 6 evaporates 9·52 of water with 84·71 of carbon, whilst No. 19, with 85·52 of carbon, only evaporates 6·36 of water. Other discrepancies of the same kind may be observed, nor is there anything in the other component parts of the coal at all sufficient to account for the difference in the results, when viewed in reference to the whole. Whether this difference arises from some peculiar property in the exceptional coals, or is to be attributed to some defect in the testing apparatus, it is difficult to determine. It is possible, if not probable, that it may be owing to the latter cause. Referring to the able and very interesting Papers on the evaporation of water from steam-boilers, communicated to the Institution by Mr. Parkes,† it is stated, in the Annual Report of the Institution for 1840, “that in one class of boiler, the same quantity of coal is burnt eight times as rapidly as in another class,—that the quantity consumed on each square foot of one grate, is twenty-seven times that on the grate of another,—that the quantity of water evaporated bears some definite relation to the quantity of heated surface,—that there is twelve times more water evaporated by each foot of heated surface, in one class of boiler than in another,—and finally, that the quantity of water

* *Vide Minutes of Proceedings Inst. C. E., vol. i., 1839, p. 35.*

† *Vide Minutes of Proceedings Inst. C. E., vol. i., 1839, p. 54, and 1840, p. 6.*

TABLE showing the Number of Pounds of Water evaporated from 212°, by One Pound of the following Coals, and the mean composition of their Average Samples.

No.	Locality, or Name of Coal.	Evapo- rating Power.	Specific Gravity.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Per Cent. of Coke left by each Coal.
1	Ebbw Vale	10.21	1.275	89.78	5.15	2.16	1.02	0.39	1.50	77.5
2	Duffryn	10.14	1.326	88.26	4.66	1.45	1.77	0.60	3.26	84.3
3	Binea Coal	9.94	1.304	88.66	4.63	1.43	0.78	1.03	3.96	88.1
4	Bedwas	9.79	1.32	80.61	6.01	1.44	3.50	1.50	6.94	71.7
5	Resolven	9.53	1.32	79.33	4.75	1.38	5.07	{ Included in ash. }	9.41	83.9
6	Mynydd Newydd	9.52	1.31	84.71	5.76	1.56	1.21	3.52	3.24	74.8
7	Anthracite, (Jones and Co.)	9.46	1.375	91.44	3.46	0.21	0.79	2.58	1.52	92.9
8	Ward's Fiery Vein	9.40	1.344	87.87	3.93	2.02	0.83	{ Included in ash. }	7.04	..
9	Graigola	9.35	1.30	84.87	3.84	0.41	0.45	7.19	3.24	85.5
10	Oldcastle Fiery Vein	8.94	1.289	87.68	4.89	1.31	0.09	3.39	2.64	79.8
11	Llangennech	8.86	1.312	85.46	4.20	1.07	0.99	2.44	6.54	83.69
12	Three-Quarter Rock Vein	8.84	1.34	75.15	4.93	1.07	2.85	5.04	10.96	62.5
13	Pentrepeth	8.72	1.31	88.72	4.50	0.18	..	3.24	3.36	82.5
14	Cwm Frood Rock Vein	8.70	1.255	82.25	5.84	1.11	1.22	3.58	6.00	68.8
15	Cwm Nant-y-gros	8.42	1.28	78.36	5.59	1.86	3.01	5.58	5.60	65.6
16	Coleshill	8.00	1.29	73.84	5.14	1.47	2.34	8.29	8.92	56.0
17	Porthmawr Rock Vein	7.53	1.39	74.70	4.79	1.28	0.91	3.60	14.72	63.1
18	Pontypool	7.47	1.32	80.70	5.66	1.35	2.39	4.38	5.52	64.8
19	Pentrefelin	6.36	1.358	85.52	3.72	Trace.	0.12	4.45	6.09	85.0

evaporated by a given weight of fuel is, in one class, double the quantity evaporated in another.”*

Any experiments, therefore, with such an apparatus, must give variable and uncertain results. Different kinds of coal require differently-constructed furnaces to develop their full vaporizing power; and to test a highly-bituminous coal in the same furnace that is used for a free-burning, or anthracite coal is doing a great injustice to the character and capability of one of them. It is well known, that highly-bituminous coal on being thrown into the furnace, suddenly gives out large quantities of hydrogen, which requires a corresponding quantity of oxygen to insure its perfect combustion. In many cases, this is permitted to escape unconsumed, in dense black smoke, and a great portion of the evaporating power is thereby lost. But supposing the furnace to be so constructed as to consume the whole products of this coal, then it is unfit for the use of non-bituminous coal, the combustion of which is slower and more enduring, but which, with too great a supply of air, would burn feebly, without giving out the requisite heat. It will, probably, be found, that the failure of many furnaces in producing the anticipated results, originates from this cause. Sufficient attention does not appear to have been paid to this subject, and the kind and quality of the fuel to be used has not been adequately considered by Engineers, in designing their furnaces and boilers. Of this a striking instance was mentioned by Mr. John Taylor,† at one of the Meetings of the Institution, in 1839:—“Soon after Messrs. Grose had erected, in Cornwall, their famous eighty-million engine, one in every way similar was erected in North Wales. A duty of seventy, or eighty millions was expected. It never rose above forty-five. They tried some Swansea coal,—the duty immediately reached seventy millions. The bituminous effect of the North Wales coal is lost,—it distills off; and this is shown by the fact, that when fresh coal is thrown into the furnaces in North Wales, a cloud of smoke issues from the chimney, but in Cornwall, no smoke is visible.” The mode, therefore, of testing the value of coal by ascertaining its evaporative power, must be viewed as uncertain and unsatisfactory, unless special provisions be made in the apparatus to suit the peculiar properties of different coals; and until this is done, it will be somewhat difficult to lay down any precise rule, as applicable to all descriptions that may be tried in this manner. The best proof may, probably, be found in the duty it performs where the coal is best known, and where its

* *Vide* Minutes of Proceedings Inst. C. E., vol. i., 1840, Annual Report, p. 9.

† *Vide* Minutes of Proceedings Inst. C. E., vol. i., 1839, p. 41.

peculiar properties have been duly considered in the mode of using it. Such data cannot always be had, or if obtained, they may not always be relied on as correct; in such cases, an opinion of the value of the coal must be based on an analysis of its component parts, which, in most cases, and until better tests are discovered, may perhaps sufficiently indicate its economical value.

There is a strong prejudice, among consumers, in favour of highly-bituminous coal, although for most purposes, its use is attended with very great waste; a great portion of its gaseous matter generally passes off unconsumed into the chimney, and thence into the atmosphere, to the discomfort and injury of the neighbouring population. On the other hand, a non-bituminous coal, like anthracite, is so difficult to kindle, or inflame, and to keep in an incandescent state, especially in open grates, and requires so much peculiar management, as to be unfit for general consumption. The most generally useful and economical coal, is that which contains only so much of the bituminous property as readily and freely enters into perfect combustion with the carbon, and from which little, or no smoke arises. This description is abundant in South Wales, and only requires to be more generally known to be properly appreciated.

Besides the proportion which the bituminous quality of the coal may bear to the carbon, there are others of its component parts which require notice, for if they are present in too great quantities, they tend materially to its deterioration:—these are the sulphur and ashes. The former is found, with some exceptions, in all coal, and when it is abundant, very seriously lessens its value. For domestic, steam, and manufacturing purposes, such coal is both unpleasant to use and prejudicial in its effects: in ascertaining the value of any coal, the precise amount of sulphur it contains, ought, therefore, always to be carefully determined by analysis. The quantity and nature of the ashes also demand particular attention. The less there is of non-combustible matter, the better and purer, of course, is the coal; for the loss occasioned by a large proportion of ash is not confined to the mere loss of its weight in coal, but it deadens the fire, chokes the interstices, thus preventing the free admission of air, rapidly fouls the flues, and in a dwelling-house, covers the furniture with dust, whenever the fire is stirred. The nature of the ash is generally indicated by its colour, which ought always to be carefully noticed. Upon this subject Mr. Mushet says:—“As far as the

* *Vide* “Papers on Iron and Steel, Practical and Experimental.” By David Mushet. London, Weale, 1840, p. 907.

external appearance is concerned, ashes may be classed under heads of red, brown, fawn, white, and grey coloured ; the colouring matter of the red being evidently derived from the presence of iron, which, before burning, had existed in the state of sulphuret. The brown may be considered as deriving its colouring matter from the presence of oxide of iron, sometimes mixed with sulphuret, when passing into red. The fawn colour, which is most common, may owe its colour to the presence of a small portion of carbonate of iron, which, by the admixture of a minute portion of red, sometimes deepens into orange. The white may be considered to denote the absence of colouring matter altogether, but when alloyed with a portion of the red, forms a variety of delicate pink tints. The grey ash may probably owe its colour to a portion of the oxide of manganese being present." In many processes, the colouring matter in the ashes of the coal used, may be very prejudicial, and hence the necessity of carefully noting the colour as well as the quantity of the ashes.

In Mr. Mushet's interesting and truly valuable book on Iron and Steel, there are numerous analyses of the coal of this district in its several localities, of which the Author of the Paper has freely availed himself in the following brief descriptions of the several kinds. To avoid prolixity, and a partial, or unfair selection, an analysis is given of a specimen containing the least carbon, and of another containing the most carbon, with the average result of as many specimens of each kind as the Author has been able to obtain from Mr. Mushet's Papers, and from other sources. These average analyses will give the best notion of the general character of the coal of South Wales, concerning which further information is to be found in the work above mentioned, and in the more recent Report of Sir Henry De la Bèche and Dr. Playfair.

The coal of South Wales may be classed under five distinct heads :—bituminous, semi-bituminous, partially-bituminous, anthracitous, and anthracite.

The bituminous coal closely resembles that of Newcastle ; although it has not quite so much bitumen, yet it has more carbon and less ash than the coal of that district. It is not, therefore, quite so good for the manufacture of gas, but for most purposes, it is quite equal to it. The nature and properties of this kind of coal are so well known, as not to require a long description. Its quantity, as compared with that of the other kinds, is only small ; and it frequently, if not generally, happens, that highly-bituminous coal passes into the other descriptions on a change of locality, even in the same veins. These variations in the nature of the coal deprive the miner

of any certainty as to its quality on opening a new colliery, and thus, in some measure, increase the risk of these speculations. The following are the analyses of the bituminous coal of this district; the first is stated to be "highly bituminous," and the second "strongly bituminous."

Containing least carbon	Volatile	31·87	Carbon	63 63	Ashes	4·50
Containing most carbon	"	10·31	"	87·69	"	2·00
Average of 57 specimens	"	21·55	"	75·34	"	3·11

The ash of the first was grey, and that of the second, a light fawn colour.

The coal classed as semi-bituminous, is very valuable, and with the exception of making gas, is fit for almost every purpose, as a good and economical fuel. It is sufficiently bituminous to be easily inflamed, and makes a bright cheerful fire, giving out little smoke, and imparting great and lasting heat. The coke, or cinder, of highly-bituminous coal is so soft, that it crumbles, or is broken into such small pieces as to fall through the grate into and among the ashes, from which it is not easily separated; and a great waste of fuel ensues in this way, as well as in the large quantity of combustible matter that escapes from it unconsumed, into the chimney. What the precise amount of the loss thus sustained may be, has not been ascertained, but it must be very considerable. In the use of the semi-bituminous coal, no such waste occurs. The ashes are as easily separated from any partially-consumed matter, as those from wood, or charcoal. The smoke, instead of being black and dense, issuing in large volumes as in highly-bituminous coal, is brown, producing little soot, and is inconsiderable in quantity. It is sufficiently bituminous to 'bind,' or coke, without melting, and makes a bright, glowing fire. For all domestic purposes, it is an excellent and an economical fuel. It is well adapted for steam navigation, and its use in the Government and other steam-vessels, is steadily and rapidly increasing. It makes a good, strong coke, well adapted for the smelting and manufacture of metals, the use of locomotive engines, and for other purposes. In describing this coal, a specimen of which he had chemically examined, Dr. Ure says:—"Of the vast variety of coals which I have analysed, this is the most valuable for the purpose of fuel, either in private houses, or in public works." A considerable proportion of the coal in the counties of Monmouth and Glamorgan is of this description, and the largest quantities of it are shipped at Newport and Cardiff. The analyses of it are as follows:—(in the first specimen the ashes are drab, and in the second of a fawn colour:)

Containing least carbon	Volatile 34.28	Carbon 61.78	Ash 3.94
Containing most carbon	„ 10.00	„ 88.50	„ 1.50
Average of 63 specimens	„ 21.40	„ 74.66	„ 3.94

The partially-bituminous coal partakes of the nature of anthracite, yet still retains some bituminous properties. In this district it is generally known as 'free-burning' coal, from its not 'binding,' or caking in the fire. In many respects it resembles the semi-bituminous coal, and in others, it is like anthracite. For general purposes it is not equal to either of the foregoing kinds, but some of it makes good iron, and it is a good steam coal: it also answers well for lime-burning. It is very abundant in the middle and the eastern portions of the coal-field. In analysis, it closely resembles the semi-bituminous, and its ash is of a light red, and fawn colour.

Containing least carbon	Volatile 33.80	Carbon 61.26	Ash 4.94
Containing most carbon	„ 10.00	„ 88.13	„ 1.87
Average of 17 specimens	„ 20.43	„ 76.12	„ 3.45

The anthracitous coal is the least valuable kind in this district; it has few of the peculiar properties of the bituminous coal, but more nearly resembles anthracite. It is known as 'culm,' or bastard anthracite, and is used principally for lime-burning, for which purpose it is exported to Ireland and other places; but some of the best is used in making iron. The quantity of it is only inconsiderable, and the ash is of a reddish-brown and light-brown colour. The following are the analyses of it:—

Containing least carbon	Volatile 14.26	Carbon 82.99	Ash 2.75
Containing most carbon	„ 6.14	„ 92.11	„ 1.75
Average of 17 specimens	„ 9.24	„ 88.41	„ 2.35

The anthracite of South Wales is of an excellent quality, and possesses all the peculiar properties of that mineral. It burns without emitting flame, or smoke, does not 'bind,' or cake, nor soil the fingers on being handled, and it has a metallic lustre. It is found in great abundance in Pembrokeshire, Carmarthenshire, and in some parts of the county of Glamorgan. Its ash is of a light pink and of a dark-grey colour. Comparing its analyses with those of the anthracites of America and Ireland, it appears to be quite equal to, if not superior in quality to both of them.

Containing least carbon	Volatile 9.00	Carbon 81.00	Ash 10.00
Containing most carbon	„ 2.81	„ 95.69	„ 1.50
Average of 21 specimens	„ 7.24	„ 90.12	„ 2.64

The following Table is a recapitulation of the foregoing analyses.

Kind of Coal.	Containing least Carbon.			Containing most Carbon.			General Averages.			
	Volatile.	Carbon.	Ash.	Volatile.	Carbon.	Ash.	No. of Specimens.	Volatile.	Carbon.	Ash.
Bituminous . . .	31·87	63·63	4·50	10·31	87·69	2·00	57	21·55	75·34	3·11
Semi-bituminous .	34·28	61·78	3·94	10·00	88·50	1·50	63	21·40	74·66	3·94
Partially-bituminous	33·80	61·26	4·94	10·00	88·13	1·87	17	20·43	76·12	3·45
Anthracitous . .	14·26	82·99	2·75	6·14	92·11	1·75	17	9·24	88·41	2·35
Anthracite . . .	9·00	81·00	10·00	2·18	95·69	1·50	21	7·24	90·12	2·64

It will be observed, that although the proportion of carbon is sufficiently indicative of bituminous coal and anthracite, yet that it does not constitute a certain and invariable test of the quality of either kind, more especially of the bituminous descriptions. This may generally be more nearly ascertained, by referring to a more complete analysis, in which the component parts of the volatile matter are shown, as in the following instances:—

	Bryn Dewy, Neath.	Lower Graig Vein, Llanelly.
Carbon	79·78	88·06
Hydrogen . . .	4·98	2·71
Nitrogen . . .	1·58	1·06
Oxygen and loss .	7·16	4·52
Earthy matter . .	5·05	1·20
Moisture . . .	1·45	2·45

In these examples, the semi-bituminous coal is indicated by its greater proportion of hydrogen, and the partially-bituminous, by its excess of carbon; but this cannot be relied on as a universal rule, as a reference to the analyses of Mr. Mushet, and those published by the Ordnance, unequivocally prove.

The most distinctive characteristics of coal may probably be found in the kind, quality, and quantity of coke it produces. The classification previously adopted, has been made on this basis, and derived from Mr. Mushet's work, before mentioned; it is, with some slight alterations, as follows:—

“*Bituminous*.—Those coals which in coking, either in whole, or in part, dissolve and enter into fusion, so as to form an entire and compact mass, are decidedly bituminous.

“*Semi-bituminous*.—When the angles of the cokes are not only

rounded, but the masses have lost their original form, with considerable adhesion of the parts, the coal is semi-bituminous.

“*Partially-bituminous*.—Those coals, which after coking, present the masses with rounded edges, and a slight disposition to adhere together, are partially-bituminous.

“*Anthracitous*.—Coals which do not lose their form in coking, and in other respects partake of the nature of anthracite, are classed under this appellation.

“*Anthracite*.—Properly speaking, this coal does not form a coke, in the usual acceptance of the term. Water and hydrogen are expelled in small quantities during the distillation, and a slight diminution of bulk is sustained, but no new arrangement takes place, as is usual in the transition of coal into coke; the fracture remains the same, and as conchoidal as before, and is without the cellular structure peculiar to coke; a structure to secure which in the most limited degree, would require the coal in coking to evolve at least 10 per cent. of carboniferous flame. When coal is passing into a state of anthracite, it is sometimes found divided into laminae of flame-coal and anthracite; in coking, the former assumes the cellular arrangement, but the latter remains unchanged as to structure, though a good deal discoloured by the discharge of the gas from the flame part of the coal.”

The vast increase in the consumption of coke, by the establishment of railways throughout the country, and the large sum which is absorbed in this item of expenditure, invest with additional interest, all questions of economy in its production and use. Considerable attention has been paid to this subject as connected with the making of iron; and a saving of from 25 to 100 per cent. of the quantity consumed for certain purposes, has been effected. But the kind and quality of the coke used in locomotive engines, does not appear to have received that consideration which its importance demands; and it is, therefore, a subject urgently requiring the attention of the Institution, with a view of decreasing the expenses of railways. This object may, probably, be best attained by selecting with great care, and in some instances, mixing the kinds of coal used, and by adopting the best process for coking it. In many cases, the choice is necessarily limited by local circumstances, but in others, it may be extended by importing the coal from different places. Highly-bituminous coal, from the large proportion of volatile matter which it contains, not only produces a small percentage of coke, but its quality is much inferior to that obtained from less bituminous descriptions. It is specifically light, spongy, and much honeycombed; it is soft and easily crumbles, and there-

fore, is attended with great waste, and it is less effective in producing steam. The best description of coal for making coke for steam purposes, is that classed as semi-bituminous, 1 lb. of which, it will be seen, on referring to Sir Henry De la Bèche and Dr. Playfair's Report, evaporated upwards of 10 lbs. of water; but as this coal cannot always be obtained at a moderate price, where it may be required, the kind most nearly approximating it in the component parts and easily and cheaply procured, ought to be selected.

The Author has long thought, that anthracite might be used with advantage in locomotive engines, either in part, or altogether. Its tendency to decrepitate, or fall into small pieces when heated, is, however, a serious obstacle to its adoption. It is said to have been successfully tried on the Liverpool and Manchester Railway, in 1838, or 1839;* but as that experiment has not induced the adoption of anthracite, notwithstanding the great saving in the weight of fuel effected, it may be concluded, that the employment of it was attended with other disadvantages not mentioned. Some experiments have been made, with the object of avoiding the decrepitation of anthracite, when put on the fire, by first submitting it to a slow heat, and in other instances, by submitting it to a coking process. Both experiments are said to have been attended with success, but neither have been generally adopted. Further trials will be required, before the expediency of using anthracite in this way, can be satisfactorily proved; and even if this should be established, the carriage, or freight added to the original cost, would probably render it too expensive for many of the railways in the kingdom. The use of anthracite in steam-ships is a subject of great importance, as, if it could be successfully adopted, a great amount of space, now occupied by the stowage of coal, might be saved, and be appropriated to an increased cargo. The necessity for calling at coaling stations, in long voyages, would be decreased, and in some cases, might be altogether avoided. As it has been shown, that 100 tons of anthracite will do the duty of 144 tons of bituminous coal, taking also into account the greater specific gravity of the anthracite, a saving of one-third of the space now occupied for this purpose might be made. Many obvious advantages would also arise from the absence of smoke. In America, anthracite has long been used for marine engines, and with very satisfactory results.†

* *Vide* "The Civil Engineers' and Architects' Journal," 1839, p. 182.

† In 1853, the 'Great Britain' made two voyages to Australia with the Pembrokeshire anthracite, upon which Captain Matthews reported, that "the coal answered the most sanguine expectations, and the fire-bars were by no means deteriorated." The royal yacht 'Fairy' was also frequently supplied with the same fuel.—[J. R., Jan. 1858.]

Some interesting experiments, bearing upon this subject, have recently been made at the Neath Abbey Iron Works, by Mr. Charles H. Waring, who mixed certain proportions of small anthracite with the small of bituminous coal, and coked them together. The produce was a conglomerate coke; for after having been twelve hours in the patent oven, the anthracite appeared unchanged in nature, or quality, but was firmly embedded in the coke of the bituminous coal, which was perfectly charred. It was tried in the cupola at the Neath Abbey Works, on more than one occasion, with the most satisfactory results. Mr. Waring states, that it melted fourteen times its weight of iron, whilst the bituminous coke made from the same coal unmixed with anthracite, only melted, at the most, ten times its own weight. The proportions of coal used, were three parts of bituminous coal to one part of anthracite. Further experiments, which are in contemplation, will show whether the proportions of anthracite may be advantageously increased, or diminished. The iron is said to have been of better quality, to have attained greater fluidity with less blast, and to have been produced with much less dross, than when bituminous coke was used. There can be little doubt, therefore, that this conglomerate coke may be very beneficially used in locomotive engines, and that a saving of at least one-third of the present cost of fuel may be thus effected, in this large item of railway expenditure.

Small anthracite coal is at present in little demand, and may be obtained at Neath, Swansea, or Llanelly, at from 4s. to 5s. per ton, and the freight to London, and the south and east coasts of England, is from 6s. to 10s. per ton; it can, therefore, be delivered, for mixing with other coal, on the metropolitan and other railways communicating with the coast, at about the same, or less cost than the bituminous coal of the North of England. The probability of the successful application of anthracite in this manner is so great, and the risks to be encountered are so inconsiderable, as to entitle it to a fair trial, and to the favourable consideration of those Members of the Institution who are interested in the full development of the railway system. There can be no question, but that the superior performances of the engines on the Great Western Railway, are partly attributable to the excellence of the coke, which is made from a semi-bituminous coal from this district; and the extraordinary duties effected by the Cornish pumping engines may also be cited as a proof of its superior steam-producing qualities.

As far as the economical value can be appreciated from analyses,

the following comparative statement clearly indicates the superior quality of the coal of South Wales. It will be seen, that the analyses given are the average results of an examination of one hundred and seventy-five specimens, and that no partial, or unfair selection has been made. Had those specimens which contain the most carbon been taken, the comparison would have been still more favourable to this district.

Locality of Coal.		Number of Specimens.	Volatile.	Carbon.	Ash.
South Wales	Bituminous	57	21·55	75·34	3·11
	Semi-bituminous	63	21·40	74·66	3·94
	Partially-bituminous	17	20·43	76·12	3·45
	Anthracitous	17	9·24	88·41	2·35
	Anthracite	21	7·24	90·12	2·64
Forest of Dean		11	35·79	61·64	2·57
Shropshire		8	37·16	60·98	1·86
South Staffordshire		15	42·54	54·53	2·93
North Staffordshire		15	36·17	61·68	2·15
North Wales		28	34·47	62·92	2·61
Derbyshire		14	36·50	60·60	2·90
Yorkshire		21	33·75	64·63	1·62
Scotch (Glasgow)		26	45·64	49·33	5·03
Newcastle-upon-Tyne (Garesfield)		1	25·90	72·71	1·39
" " (Wylam)		1	37·60	48·49	13·91
Irish "Kilkenny Anthracite"		1	4·25	92·87	2·88
American (Lehigh Anthracite)		1	6·60	90·10	3·30

The highest evaporative power of this coal is said to be 10·21, (see Table, page 95), but the average of nineteen specimens being only 9 lbs., the latter number is taken, in the following statement of the comparative value of different coals in producing steam, which is the result of a series of experiments, reported in the 'Atlas;' and it very nearly agrees with the Report to the Admiralty before mentioned.

1 lb. of (South) Welsh coal will evaporate	9 lbs. of water.
" Newcastle, or Yorkshire	" 7½ "
" Lancashire	" 7 "
" Scotch	" 6 "

Therefore, if the value of (South) Welsh coal be 20s. per ton
that of Newcastle and Yorkshire is . 16s. 8d. "
Lancashire 15s. 6½d. "
Scotch 13s. 4d. "

It also follows, that 100 tons of Welsh coal, for working and stowing, is equal to 120 tons of Newcastle and Yorkshire, and 150 tons

of Scotch coal. The bulk is estimated in proportion to the evaporative strength; but as the coal of South Wales is from 12 to 15 per cent. specifically heavier than the other descriptions, an addition to that amount must be made on account of the superior facility of stowage.

From the preceding considerations on the quality of the coal, it will be seen, that by whatever test it be tried, it will bear a favourable comparison with that of any other coal-field; and that, with the exception of making gas, it is well adapted for all the purposes to which such fuel is applied. Yet there is one circumstance which materially depreciates its value, and to which the attention of the coal-owners ought to be directed;—the negligence which extensively prevails throughout the whole district, in not separating the coal from shale, stone, earth, and other prejudicial substances, before it is sent into the market. This is attributable to insufficient care in mining the coal, and not ‘waling,’ or ‘picking’ these foreign substances out of it, after it has been brought to the surface, and before it is sold, or shipped. It is an evil which is easily remedied and ought to be rigorously attended to; for it not only very materially injures the quality of the coal, but gives that of the whole district a bad name, which it really does not deserve.

The quantity and quality of the coal in South Wales having been discussed, the inquiry remains as to whether it can be produced as cheaply as that of any other district; for however abundant and good the coal may be, the wants of the country would be but imperfectly satisfied, if the cost of fuel was considerably increased. It is, therefore, fortunate, that with the advantages already mentioned, this deposit exists under the most favourable circumstances for mining operations. The whole of the coal measures have been raised towards the surface, by two great faults, in a direction from east to west;—one on the north of the coal-field, which has elevated the whole series of veins on that side;—and another, which forms an anticlinal line, and has raised the coal on both sides of it. The coal is thus made much more accessible than it would have otherwise been. As is well known, the country is mountainous, and is intersected by deep valleys in the course of the numerous rivers, which generally run in a direction from north to south, and by the gorges caused by the streams which supply the rivers, from the east and the west. The stratification of the whole field is much disturbed and broken by numerous faults, slips, and dykes, but as the direction of most of them is north and south, and parallel with the rise and dip, less inconvenience results than if they were in a different direction; whilst the benefits arising from the interruption which they cause to the flow of water over any very great area, tend

materially to economise the expense of working the coal. By far the greatest quantity of this coal, is obtained by mining for it in levels, or adits, driven into the sides of the valleys, the facilities for which are very great; and, wherever it can be adopted, the advantages in allowing the free egress of water and transport of the produce, without the aid of pumps, or machinery, render this mode of mining preferable to any other. There are also sloping headings, or slants, which are driven in at the inclination of the strata, which dip from 5 inches to 18 inches to the yard. The water is pumped, and the trams, or waggons are drawn up these slants, by a steam-engine on the surface. This mode of working by slants, although usually requiring a smaller investment of capital, than sinking pits to the deep, is by no means to be recommended, as the working of the coal is not only more costly, but it also limits the quantity produced, to at least one-half of what may be obtained by a properly-constructed pit, sunk to the deep of the measures. The perpendicular pits are not so numerous as the levels, or slopes, and the deepest does not exceed 150 fathoms. The mode of working generally pursued in this district, is by 'stalls.' Some mines are worked on the Newcastle plan, and others in the broad, or long way, but the former method is the most prevalent.

The cost of getting the coal varies considerably, owing to the peculiar circumstances of each mine, to the methods of working, and to the general systems of management; for there are few undertakings which are so pecuniarily sensitive of good, or bad management as collieries. The whole cost of the coal at the mouth of the level, or pit, may be fairly stated at from 2*s.* to 3*s.* 6*d.** per ton, and in the whole district, the average cost may be safely estimated as not exceeding 2*s.* 8*d.* per ton.† To this must be added the expense of carriage from the collieries to the places of consumption, or shipment, which varies according to the distance and the means of transit, and which is, generally, by far the greatest item in colliery expenditure.

The coals are conveyed on common roads, canals, tramways, and railways. Most of them are rudely constructed and inefficiently maintained, especially all those which belong to the coal-owners; the Taff Vale Railway forms, however, an exception, and is one of the most successful speculations of this kind in the kingdom. The more extended introduction of public railways into the principality, some of which are now in progress, will be advantageous, not only

* Now 3*s.* to 4*s.* 6*d.*—[J. R., January, 1858.]

† Now 4*s.* per ton.—[J. R., January, 1858.]

by giving additional facilities to the traffic, but by inducing a spirit of improvement in the existing means of transit. The canal dues charged on coal are from three-eighths of a penny to three-farthings per ton per mile, and the haulage, with the wear and tear of boats, costs, at least, one halfpenny per ton per mile. The charges on coal conveyed on the Taff Vale Railway, are for dues, two-thirds of a penny, and for engine haulage, one halfpenny per ton per mile. This is considerably lower than the carriage of the coal, on some of the private railways, as may be shown in the instance of one in the neighbourhood of Neath, which communicates with the canal, at about five miles' distance from the shipping port. The railway is rather more than six miles and a half in length, and in its passage the coal has to descend 1,136 feet, by a series of self-acting inclined planes, with gradients of from 1 in 3 to 1 in 5, alternating with 'flats' also descending with the load, and worked by horses. There is an ascending inclined plane rising 132 feet with a gradient of 1 in 5, which is worked by a steam-engine of 40 H.P. The load has, therefore, to descend and ascend 1,400 feet in six miles and a half, and the cost of the carriage of the coal on this mountain railway, is rather more than threepence per ton per mile.

Docks have been constructed at Newport, Cardiff, Porthcawl, Port Talbot, and Llanelly.* Considerable sums have been expended in these works and in improving the navigation of the rivers at Neath and Swansea; and other projects of the same kind are in contemplation, so as to increase the existing facilities for the shipment of the mineral produce of the district.

The prices of the coal obtained depend principally on its size, less attention being paid by the purchasers to quality, than to hardness and comparative freedom from small. The selling prices at the ports, delivered on board the ships, are for small, 4s. to 5s. per ton,—for 'through and through,' that is, coal as it comes out of the mine, 6s. to 7s. per ton;† and for large, 7s. 6d. to 9s. per ton.‡ These prices are rather lower than those obtained for coal on the Tyne and Wear; and when considered in relation to its superior steam-producing power, as well as its greater specific gravity, the coal of South Wales is cheaper and much more economical, than that of any other district in the kingdom.

Reviewing the premises, and taking into consideration the extraordinarily large quantity of coal in this deposit,—the variety of

* Docks are in the course of construction at Neath and Swansea.—[J. R., January, 1858.]

† Now 7s. to 10s. per ton.—[J. R., January, 1858.]

‡ Now 8s. to 11s. per ton.—[J. R., January, 1858.]

its kinds and qualities,—as well as the cheapness with which it can be procured,—it must be admitted, that when the other sources of supply have become diminished, or are altogether exhausted, the continued maintenance and the increased prosperity of British manufactures and commerce may be sustained for ages, by the coal of South Wales.

The Paper is illustrated by a geological section, (No. 4,384,) showing the stratification of the coal-field of South Wales.

APPENDIX.

TABLE of the COAL produced in GREAT BRITAIN and IRELAND, during the Year 1855.

DISTRICTS.	Number of Coal-mines.	Tons of Coal produced by each Mine.	Tons of Coal Exported to Foreign Countries.	Tons of Coal used for Home Consumption.	Total Tons of Coal produced.
Northumberland and Durham . . . }	273	56,452	3,014,372	12,417,028	15,431,400
Cumberland . . .	23	35,250	2,441	808,108	810,549
Yorkshire . . .	333	23,265	78,451	7,669,019	7,747,470
Derbyshire and Nottinghamshire . . }	191	16,049	..	3,065,400	3,065,400
Leicestershire . .	11	38,635	..	425,000	425,000
Staffordshire and Worcestershire . . . }	500	14,646	..	7,323,000	7,323,000
Lancashire . . .	357	25,070	426,139	8,523,861	8,950,000
Shropshire . . .	56	19,333	..	1,105,250	1,105,250
Gloucestershire, Somersetshire, and Devonshire . . }	88	16,257	7,149	1,423,471	1,430,620
England	1,832	25,321	3,528,552	42,760,137	46,288,689
South Wales . . .	245	34,907	1,120,947	7,431,323	8,552,270
North Wales . . .	65	17,307	..	1,125,000	1,125,000
Scotland	403	18,171	246,988	7,078,012	7,325,000
Ireland	19	7,611	..	144,620	144,620
Totals	2,564	24,741	4,896,487	58,539,092	63,435,579

The above quantities are extracted from Mr. Hunt's Mining Records, but they are differently arranged, and a column is added, showing the average quantity worked in each colliery in the respective districts. The results shown by this column are new and interesting, and may be taken as indicative of the state of the coal-trade, and of the comparative amount of capital invested, in each district.

Of the large quantity produced, it appears, that 92½ per cent. is consumed in the United Kingdom, and that only 7½ per cent. is exported to foreign countries.

[J. R., January, 1858.]