NEW SOUTH WALES.

DEPARTMENT OF MINES.

GEOLOGICAL SURVEY.

J. E. CARNE, F.G.S., Government Geologist.

MINERAL RESOURCES.
No. 23.

THE COKE INDUSTRY
OF
NEW SOUTH WALES.

DESCRIPTIVE NOTES.

BY

L. F. HARPER, F.G.S., Geological Surveyor.

ANALYSES AND NOTES ON BY-PRODUCTS.

BY

J. C. H. MINGAYE, F.I.C., F.C.S., Analyst and Assayer.

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LETTER OF TRANSMITTAL.

Geological Survey,
Department of Mines,
4th July, 1916.

Sir,

I have the honor to submit for publication No. 23 of the Mineral Resources Series dealing with the Coke Industry of New South Wales, that has been prepared by Messrs. L. F. Harper, F.G.S., Geological Surveyor, and J. C. H. Mingaye, F.I.C., F.C.S., Analyst and Assayer.

This work, though complete in itself, must be regarded as a preliminary statement, as the very important question of the production of by-products could only be briefly touched upon without unduly delaying publication.

It can be confidently stated that Messrs. Harper and Mingaye's work will not only be of interest but of great assistance to those engaged in this growing industry.

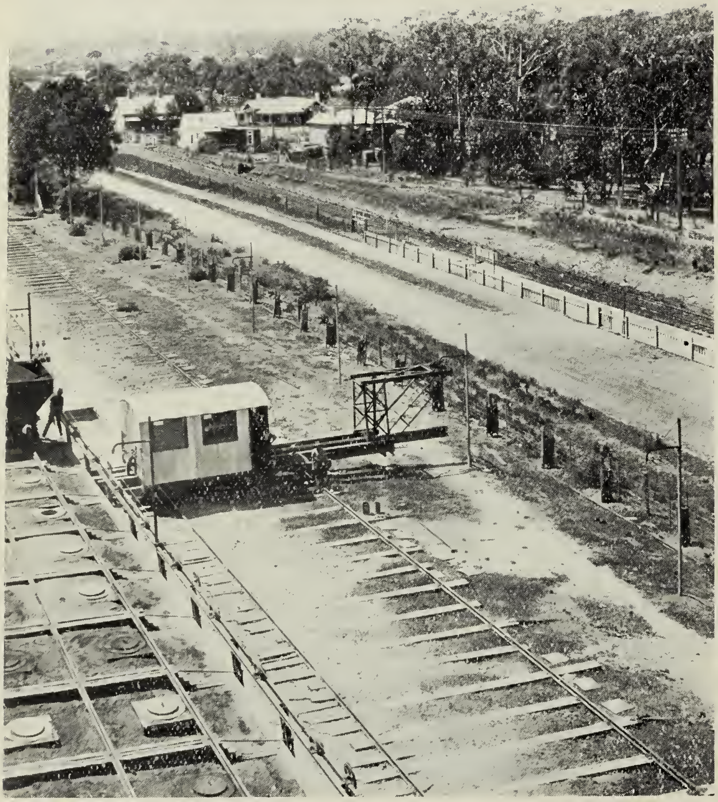
I have the honor to be,
Sir,
Your obedient Servant,
JOSEPH E. CARNE,
Government Geologist.

The Under Secretary for Mines.

Frontispiece

† 67323

Bird's-eye View of Coking Plant. The Corrimal-Balgownie Collieries, Ltd., Corrimal.



The Coke Industry of New South Wales.

In February, 1916, the Writers were instructed by the Acting Under-Secretary for Mines, Mr. R. H. Cambage, to prepare a comprehensive report on the Coke Industry of the State. This was regarded as highly necessary owing to the great expansion of the industry generally, and the promising future before it.

The work presented herein is essentially a statistical record, with chemical analyses of coals used, coke produced, and ash contents, together with crushing strain tests, and a short epitome of the by-products question. Certain general information has been incorporated, however, which may prove of interest to the coke producer.

In submitting this work, the Writers would like to take the opportunity of pointing out the variation that must occur in the ash contents of coke samples obtained for analysis at different periods.

In the first place there is the difficulty of procuring a thoroughly representative sample of the individual day's output, but this is of minor importance compared with the fact that the quality of the coal used from any one colliery is liable to vary from day to day, such being dependent upon the " district " from which it is won, or by reason of an excess of stone being filled into the skips.

Another probable factor is the way the charge is sampled. There is always an appreciable thickness of burnt coke-ash on top of a charge, and during quenching, portion of this is liable to be washed into the coke cells at the top of the charge. For this reason, by excluding the top two or three inches of coke from the sample taken, a reduction in ash percentage might result.

The samples of coke analysed for this report were taken from top to bottom of, and distributed over, the charge, in pieces the size of a walnut, in the proportion of one top, one bottom, and ten from the remainder of the prism selected.

The samples were more or less damp when received, and were partially crushed and air-dried before analysis.

The finely-crushed coke was carefully burnt to ashes in a muffle furnace, the ashes being finely ground in an agate mortar, and placed in glass-stoppered bottles for the analyses.

All analyses of the ashes have been conducted on modern lines, and are complete. The occurrence of barium oxide in the ashes is interesting, those from the Southern District containing the most—*i.e.*, from 0·10 per cent. to 0·48 per cent. of barium oxide.

Vanadic oxide was detected in the ashes from traces, up to 0·15 per cent. of V_2O_3, and in several, minute traces of chromium sesquioxide was present.

A spectroscopic examination gave the presence of a minute quantity of lithia, and strontia in all but one of the samples.

The Authors desire to acknowledge the assistance rendered them by all sections of those engaged in the coke industry of the State.

Thanks are due to Mr. A. A. Atkinson, Chief Inspector of Coal-mines, for the help he afforded in obtaining information and facilitating inspections of various coke works.

Mr. G. W. Card, A.R.S.M., Curator and Mineralogist to the Geological Survey, personally supervised the cutting of coke cubes for crushing-strain tests, and was able to supply many valuable references to articles on the coke industry in other parts of the World, as also did Mr. W. S. Dun, Librarian to the Geological Survey.

The crushing-strain tests were made at the Sydney Technical College, and special thanks are due to Mr. Nangle, Superintendent of Technical Education, for permitting this work to be carried out by Mr. H. T. Swain, B.Sc., B.E.

To Messrs. H. P. White, W. A. Greig, and W. G. Stone, of the Departmental Laboratory, belong the credit for a number of ash analyses made.

Use has been made of a large number of articles on coke by modern writers, the information contained in this portion of the work being mainly derived from such sources. Except when actual quotations are given, no special reference is made to the source of information, but the reader is specially referred to the following publications :—

COKE LITERATURE.

Modern Coking Practice, T. H. Byrom and J. E. Christopher. London, 1910.

Chemistry of Coke, by Simmersbach and Anderson (W. Hodge & Co. Glasgow and Edinburgh, 1899.)

The Bye-product Coking Industry and its relation to the Manufacture of Iron and Steel, by G. Stanley Cooper, B.Sc. (London). Published in the Journal of the Iron and Steel Institute, No. 2 for 1914.

Metallurgical Coke, by A. W. Belden, Technical Paper 50. Department of the Interior, Bureau of Mines. Washington, 1913.

Coking Tests, U.S. Geol. Survey. Bulletin 336. 1914.

Products and By-products of Coal, by E. Stanfield, M.Sc., and F. E. Carter, B.Sc., Department of Mines, Canada. Ottawa, 1915.

The Manufacture of Coke, by W. H. Blauvelt; *Do. Do.*, by F. E. Lucas. Transactions Am. Inst. Mining Engineers, XLIV. (Read at October meeting, 1912.)

Notes on the Utilization of Coke Oven and Blast Furnace Gas for Power Purposes, by H. J. Freyn. Transactions Am. Inst. Mining Engineers, L, p. 56, 1915.

The Manufacture of Coke, by C. E. Lesher. Technical Paper 25, Department of the Interior, U.S. Geol. Survey. Washington, 1915.

PREVIOUS REFERENCE.

Notes on the Manufacture of Coke in New South Wales.

Acting under instructions from the Under Secretary for Mines, in September, 1890,* the Analyst furnished a report to the Department giving analyses of the New South Wales cokes and their ashes, and their comparison with the cokes manufactured in England and foreign countries. At that time some 1,313 tons were used per week at Broken Hill, the bulk of which was imported.

The following is a summary of the report given :—

The objection to the New South Wales Cokes by the Broken Hill companies seems to have been the excessive amounts of ash present as compared with British and foreign cokes. It was suggested that the cokes would be greatly improved in quality and ash contents by a thorough system of washing the coal before coking.

The Broken Hill Proprietary Company furnished the following figures as to the cost of the various cokes delivered at Port Pirie :—

	Tons.	Average cost per ton. £ s. d.
English coke	18,144	3 7 8
German coke	2,750	2 19 6
New Zealand coke	2,000	2 17 6
New South Wales coke	4,800	2 13 6
British Broken Hill Prop. Co., English coke	10,581	3 4 3

A very important official step was taken with regard to the Coke Industry of New South Wales in the year 1892, when Mr. E. F. Pittman, A.R.S.M., at that time Government Geologist, submitted a detailed report. There is little doubt that as a result of the information therein supplied, coke-making went ahead enormously in New South Wales.

Tables published in this report are as follows :—

Table A.—Table showing Analyses of Washed and Unwashed Samples New South Wales Coals.

Description of Coal.	Analysis of Coal as received.						Analysis of Coal after being washed in the Laboratory.					
	Moisture at 100°C.	Volatile Hydro-carbons.	Fixed Carbon.	Ash in Coal.	Percentage of Coke.	Ash in Coke.	Moisture at 100°C.	Volatile Hydro-carbons.	Fixed Carbon.	Ash in Coal.	Percentage of Coal.	†Ash in Coke.
Unwashed coal, from the Co-operative Colliery's Coke Ovens	2·85	34·70	55·60	**6·85**	62·45	**10·96**	1·60	37·35	57·20	**3·85**	61·05	6·30
Unwashed screened coal, from Mount Pleasant Colliery	0·95	24·90	63·50	**10·65**	74·15	**14·36**	0·65	26·20	68·45	**4·70**	73·15	6·42
Washed coal, from Purified Coal and Coke Company's Coke Ovens, Wallsend	2·50	35·90	56·40	**5·20**	61·60	**8·44**	1·35	36·80	57·20	**4·65**	61·85	7·51
Washed coal, from Singleton Colliery Coke Ovens	3·05	35·85	53·35	**7·75**	61·10	**12·68**	1·65	36·70	56·50	**5·05**	61·65	8·19
Unwashed, unscreened coal, from Mount Pleasant Colliery	0·85	23·85	64·85	**10·45**	75·30	**13·87**	0·75	26·10	67·15	**6·00**	73·15	8·20
Unwashed, crushed slack, from Unanderra Coke Works, Wollongong	1·15	24·40	64·40	**10·05**	74·45	**13·49**	0·55	25·90	67·25	**6·30**	73·55	8·56
Unwashed coal, from Brown's Minmi Colliery	2·55	34·15	53·35	**9·95**	63·30	**15·71**	2·10	37·80	54·95	5·15	60·10	8·56
Unwashed small coal, from Singleton Colliery Coke Ovens	3·40	32·60	48·60	**15·40**	64·00	**24·06**	2·20	36·80	55·45	**5·55**	61·00	9·09

* Annual Report Dept. of Mines, 1890, pp. 289–305.

† This represents the percentage of ash in the coke made by hand in the Laboratory from the hand-washed Coal. It is probable that better results could be obtained if the coke were made on the large scale in rectangular coke ovens.

TABLE B.—Analyses of Foreign and New South Wales Cokes.

Description of Coke.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.
A.—FOREIGN COKES.						
Hood's (Welsh) Coke, from Broken Hill Proprietary Smelting Works	0·70	1·00	92·71	4·75	0·84	1·864
Brancepeth (Welsh) Coke, from Port Pirie	0·80	0·85	91·93	5·50	0·92	1·843
Hood's (Welsh) Coke, No. 1, taken from Port Pirie	0·20	0·30	92·71	5·85	0·94	1·928
Westport (New Zealand) Coke, taken from Port Pirie	0·85	1·05	89·53	7·15	1·42	1·827
"Shamrock" Westphalia (German) Coke, taken from Port Pirie	0·35	0·15	89·69	7·30	2·51	1·820
Brancepeth (Welsh) Coke, from Broken Hill Proprietary Smelting Works	0·62	1·63	89·20	7·80	0·75	1·942
Hood's (Welsh) Coke, sample No. 2, taken from Port Pirie	1·30	1·00	88·19	8·20	1·31	1·834
Hamburg (German) Coke, taken from Port Pirie	0·35	0·55	88·58	9·20	1·32	1·851
Hood's (Welsh) Coke, from the Central Broken Hill Smelting Works	0·36	0·37	88·86	9·70	0·71	2·030
B.—COLONIAL COKES.						
Purified Coal and Coke Company's Coke, Wallsend, sample No. 1, made from washed coal	0·40	0·02	91·33	7·82	0·43	1·964
Purified Coal and Coke Company's Coke, Wallsend, sample No. 2, made from washed coal	0·41	0·51	90·54	8·01	0·53	1·837
Purified Coal and Coke Company's Coke, sample No. 3, made from washed coal	0·42	0·00	90·79	8·38	0·41	1·850
Singleton Colliery Coke, Rix's Creek, made from washed coal	0·67	0·11	89·02	9·67	0·53	1·798
Co-operative Colliery Coke, sample No. 1, made from unwashed coal	1·87	0·27	87·77	10·45	0·64	1·844
Unanderra (Wollongong) Coke, made from unwashed crushed slack	0·20	0·15	87·55	11·56	0·45	1·934
Co-operative Colliery Coke, sample No. 2, made from unwashed coal	0·22	0·34	86·71	12·06	0·67	1·813
Brown's Minmi Colliery Coke, made from unwashed coal	0·62	0·22	85·65	12·62	0·79	1·737
Balli Colliery Coke, made from washed coal	1·15	0·90	83·98	13·40	0·57	1·629
Mount Pleasant Coke, No. 1, made from unwashed screened coal	0·67	0·18	84·40	14·11	0·64	1·902
Mount Pleasant Coke, No. 2, made from unwashed screened coal	0·75	0·26	84·41	14·15	0·43	1·879
Mount Pleasant Coke, No. 3, made from unwashed unscreened coal	1·07	0·31	83·78	14·45	0·39	1·877
Vale Colliery (Lithgow) Coke made from washed coal	1·08	0·12	82·74	15·47	0·59	1·829
Mount Pleasant Coke, No. 4, made from unwashed screened coal	0·90	0·18	83·01	15·66	0·25	1·660

TABLE C.—Crushing Strength of Coke Samples tested by Professor Warren, M.I.C.E.

No. of Sample.	Description of Coke.	Size of cube in inches.	Area in square	Volume in cubic inches.	Weight in grains.	Weight in grains per cubic inch.	Total crushing force in pounds.	Crushing strength per square inch.	Remarks.
1	Hood's South Wales (Welsh) Coke No. 2, taken from Port Pirie.	1·045	1·092	1·1412	267·5	234·4	800	765	Sound specimen.
2	Brancepeth North Wales (Welsh) Coke, taken from Port Pirie.	1·035	1·071	1·1087	280·0	252·5	570	551	Cracked.
3	Shamrock, Westphalia (German) Coke, taken from Port Pirie.	1·045	1·092	1·1412	264·4	231·7	500	478	Sound specimen, cracked at 250 lb.
4	Westport (New Zealand) Coke, taken from Port Pirie.	1·010	1·020	1·0303	203·0	197·0	755	747	Sound specimen.
5	Purified Coal and Coke Company's Coke, Wallsend.	1·038	1·077	1·1184	243·1	217·4	1,700	1,368	Slight crack at base.
6	,, ,, ,, ...	1·290	1·664	2·1467	502·2	234·0	2,450	1,899	Slightly cracked all over.
7	,, ,, ,, ...	2·030	4·121	8·3654	1963·7	234·7	3,500	1,724	Cracked across base.
8	,, ,, ,, ...	1·660	2·756	4·5743	1066·8	233·2	3,955	2,383	,,
9	Co-operative Colliery (Newcastle) Coke.	1·010	1·020	1·0303	201·7	195·8	625	619	,,
10	,, ,, ,, ...	1·295	1·677	2·1718	481·0	221·5	1,500	1,158	,,
11	,, ,, ,, ...	1·154	1·332	1·5368	341·3	222·1	1,550	1,343	,,
12	Singleton Colliery Coke (Rix's Creek). ...	1·275	1·626	2·0727	433·8	209·3	2,350	1,843	,,
13	,, ,, ,, ...	1·039	1·080	1·1216	251·2	224·0	1,155	1,112	,,
14	,, ,, ,, ...	1·740	3·028	5·2680	1162·8	220·7	3,500	2,011	,,
15	Bulli Colliery Coke	1·276	1·628	2·0775	535·2	257·6	3,155	2,473	Sound specime
16	,, ,, ...	1·040	1·082	1·1249	310·0	275·6	3,250	3,125	,,

The reader is also referred to the information contained in "The Mineral Resources of New South Wales,"* and to a work by F. Danvers Power †

The quantities of coke produced in New South Wales are given in the following table, extracted from the Annual Report of the Department of Mines for 1915.

The quantity of coke manufactured during the year amounted to 417,753 tons, valued at £313,241, which shows an increase of 112,953 tons and £100,172 in value when compared with the year 1914.

The increase in the output was participated in by all the districts, Northern, Southern, and Western. In the Northern district, the Broken Hill Proprietary Company commenced operations at their Iron and Steel Works, Port Waratah, early in the year, with a bench of 66 ovens.

* By E. F. Pittman, Sydney, 1901, pp. 349 to 357.
† Coalfields and Collieries of Australia, Sydney, 1912.

The following table shows the quantity and value of the coke made in the State of New South Wales to the end of 1915 :—

Year.	Quantity.				Total.		Value.					
	Northern District.		Southern and Western Districts.				Total.			Per ton.		
	tons	cwt.	tons	cwt.	tons	cwt.	£	s.	d.	£	s.	d.
1890	15,886	2	15,211	0	31,097	2	41,147	3	7	1	6	5
1891	9,474	2	20,836	5	30,310	7	34,473	5	10	1	2	9
1892	5.245	0	2,654	0	7,899	0	8,852	8	6	1	2	5
1893	12,262	0	5,596	0	17,858	0	20,233	2	0	1	2	8
1894	13,602	5	20,855	19	34,458	4	33,209	5	7	0	19	3
1895	11,326	8	16,304	0	27,630	8	24,683	5	0	0	17	10
1896	10,398	10	15,953	0	26,351	10	21,850	16	3	0	16	7
1897	21,012	0	43,190	0	64,202	0	45,391	18	0	0	14	1
1898	34,422	0	47,800	0	82,222	0	64,134	17	0	0	15	7
1899	43,912	0	52,618	0	96,530	0	77,129	10	1	0	16	0
1900	49,374	0	76,839	0	126,213	0	109,620	2	6	0	17	4
1901	35,939	0	92,943	0	128,882	0	105,665	0	6	0	16	5
1902	24,219	0	102,653	0	126,872	0	89,604	19	0	0	14	2
1903	34,730	0	125,862	0	160,592	0	108,763	13	6	0	13	7
1904	31,825	0	139,181	0	171,006	0	110,692	2	6	0	12	11
1905	25,329	0	137,632	0	162,961	0	100,306	2	7	0	12	4
1906	55,991	0	130,069	0	186,060	0	110,606	13	4	0	11	11
1907	31,453	0	223,156	0	254,609	0	159,315	17	3	0	12	6
1908	29,132	0	254,741	0	283,873	0	199,933	3	6	0	14	1
1909	23,564	0	180,710	0	204,274	0	137,194	1	8	0	13	5
1910	24,352	0	257,985	0	282,337	0	189,069	0	0	0	13	5
1911	26,376	0	238,311	0	264,687	0	184,337	0	0	0	13	11
1912	27,217	0	213,942	0	241,159	0	162,454	0	0	0	13	5
1913	29,659	0	268,953	0	298,612	0	208,989	0	0	0	14	0
1914	28,264	0	276,536	0	304,800	0	213,069	0	0	0	13	11
1915	84,134	0	333,619	0	417,753	0	313,241	0	0	0	14	11
Totals	739,098	7	3,294,150	4	4,033,248	11	2,873,966	8	2	0	14	3

HISTORICAL.

The manufacture and use of coke as a fuel was first started in the year 1619, but it was not until the nineteenth century that the industry was developed to any great extent, this development being associated with improvements in the manufacture of iron and steel.

Coal was originally coked in mounds or heaps in the open air, similar to charcoal, until bee-hive ovens were introduced, and these, until recent years, were the sole type used. The general shape of the bee-hive oven is indicated by the name, but a still more recent development has been to contruct rectangular ovens operated on the bee-hive principle—*i.e.*, top heat only, or provided with flues which cause the heat to be applied all round the charge. This shape enabled the use of a ram for discharging the coke, instead of the almost universal manual discharge from the true bee-hive pattern, and is now largely adopted in New South Wales.

In 1861, the retort oven was invented by Coppée—the improvement consisting in complete exclusion of air from the coking chamber, resulting in an increased yield of coke and other economic advantages. In the year 1869 a further improvement was made by Simon Carves, which enabled the by-products to be saved, and from these have developed the modern type, of which there are several (Semet-Solvay, Otto-Hoffman, Otto-Helgenstock, &c.). All these types of oven aim at saving the by-products resulting from the coking of coal, and afford greater facilities for handling.

Apparently no official record of the first manufacture of coke in New South Wales was kept, but from the following information collected by Mr. J. G. Hutton, Inspector of Collieries, it would appear that the first ovens were erected at Minmi about the year 1861, the coal used being won from the Borehole Seam.

Mr. Chas. Brown, a surface overseer at Duckenfield Colliery, Minmi, supplied the following statement :—

> "The coke ovens were going at Minmi when I first came to the district 40 years ago (1876). My wife is 58 years of age and came to Minmi 54 years ago, and the ovens were there then. She remembers quite distinctly playing near them when she was going to school at 8 years of age. They were put up by Mr. Eales, who was owner before Mr. Brown" (presumably of the Duckenfield Colliery).

Mr. Wm. Woods, a man 54 years of age, and at present working on the surface at Brown's Minmi Colliery, made the following statement to Mr. Hutton in April, 1916 :—

> "I have been at Minmi for fifty years. The coke ovens were at Minmi from my earliest recollection. For a number of years I was a coke burner, in the early "eighties." There were 32 ovens, two rows of 16 each, built back to back. They were circular inside, and flat-bottomed, the side walls being straight up for about 3 feet or 3 feet 6 inches, and then domed over. There was a round chimney, 18 inches in diameter at the top, and the diameter of each oven was 9 feet. The height of the oven inside was 6 feet, and the outside walls were built straight up, and the top was flat, to enable workmen to walk about on them

when necessary. In the front of each oven there was a doorway or opening 3 feet 6 inches high, and 2 feet 3 inches wide. The charge was a waggon lode (seven tons) of small coal direct from the screens. The bottom of the waggon was let down, and the small coal allowed to run on to the ground in front of the oven door or opening. It was then shovelled into the oven, and the opening built up with bricks and mud, small openings being left for draught. At the end of five days, the small openings were closed, and a damper put over the chimney. The oven was left in this sealed state for three more days, when the bricks in the doorway or opening were taken out (the damper being left on the chimney) and the coke withdrawn by means of a long iron rod with two prongs turned down at one end. The damper was left on top of the chimney while the drawing was being done to prevent the coke burning up again. The coke was red-hot when taken out of the oven, and no water was used to cool it, but it was spread on the platform to cool, and then stacked."

According to the records at the Duckenfield Colliery, operations ceased at these coke ovens in June, 1898, and they were pulled down about two or three years ago.

About the year 1875 or 1876, a small coking plant was established at Plattsburg, near Wallsend, in conjunction with the Co-operative Colliery, which is winning coal from the Borehole seam of the Upper or Newcastle-Bulli Coal Measures. The number of these ovens has been greatly increased, and they are still running. (*See* page 59).

In 1877, coke ovens were erected by the Purified Coal and Coke Co. at Wallsend, the coal being also obtained from the Borehole seam. This company is a large coke producer even at the present day (*see* page 56), but the plant has been greatly improved, and the number of ovens increased.

Mr. Ivo Clarke, Secretary to the Illawarra and Western Coke Works Proprietors' Association, kindly supplied the following information with reference to the coke-making industry in the Illawarra District (Southern Coal-field):—

The first coke ovens in the Illawarra district were built by Messrs. Osborne and Ahearn in September, 1878, and were worked by them until June in the following year, after which they were carried on more successfully by Mr. W. M. Ashley. The ovens, four in number, and of the bee-hive type, were erected near the Wollongong wharf, the small coal being obtained at a very nominal sum from the Mount Keira Colliery. A few years later Mr. Thos. Bertram, one of the proprietors of the Corrimal Coal Co., built seven ovens near the colliery and worked them several years with indifferent results, when they were closed down. It was not until the year 1888 that the industry, on a large scale, became a commercial success, when the Australian Coke-making Co., Ltd., built 20 ovens of the Welsh type at Unanderra.

For some years there was considerable prejudice amongst the consumers against the locally-made article, which was eventually overcome, and the Australian Coke-making Co., Ltd., subsequently added a further 72 bee-hive ovens to their plant, making a total of 92, which were worked until they were out of date in 1912. Messrs. G. S. Yuill & Co., Ltd., then erected 40 ovens of a larger type at Corrimal.

Following the lead of the Australian Coke-making Co., Ltd., Messrs. Robshaw and Figtree (now Figtree Bros.) built ovens at Mount Pleasant; then the Bulli Coal and Coke Co., Ltd., the South Clifton Coal-mining Co., Ltd., and the Mount Lyell Mining and Railway Co., Ltd., at Port Kembla; the Broken Hill Associated Smelters Proprietary Co., Ltd., at Bellambi; the Federal Coke Co., Ltd., at Mount Keira; the North Bulli Colliery, Ltd., at Coledale erected coking-plants; and the Illawarra Coke Co., Ltd., at Coal Cliff, so that from four small ovens in 1887, the industry has grown to its present proportions, there being now over 530 ovens in the district of a modern tpye, except at one works, with a possible annual output of about 350,000 tons.

GENERAL INFORMATION.

Coking Coals.

For the purposes of this work, coal may be divided into two broad classes, namely, coking and non-coking, but it is impossible to say definitely from a chemical analysis which is which, and only a practical test would appear to determine the relative coking properties. A coking coal is one which when subjected to heat, is more or less fusible, with the result that individual fragments become caked together.

This factor enables slack or small coal and dust to be used in the production of a fuel admirably suitable for metallurgical purposes, for not only is it converted from its previously loose, finely-divided condition into strong massive blocks or large fragments, but it is better adapted in every other character for the metallurgist.

On the other hand, non-coking coals either do not possess this characteristic at all, or only to a very limited extent, with the result that a charge is passed out of the oven in a carbonised state without the necessary cohesion.

It has frequently been proved that coals having an almost identical chemical composition will behave quite differently under the same coking conditions, and the chemical analysis leads more or less to generalities only. In every attempt to formulate theories on this question, it has been proved that the exceptions are quite as numerous as the supposed rule.

A few factors with regard to coking coals, now more or less accepted by many authorities, are as follows, but they are so interdependent that much of their value is lost.

A coking coal may be expected to contain from 5 to 6 per cent. of hydrogen, 10 per cent. of oxygen, 4 per cent. of free hydrogen, about 25 per cent. of volatile matter, and have a specific gravity of 1·35, and the objectionable impurities are undoubtedly sulphur, phosphorus, and ash.

As the oxygen content of coal increases, the coking power decreases, and more than 8 per cent. oxygen on an ash—and moisture—free basis is considered by some authorities* to indicate an inferior or non-coking coal. Hence contact with air gradually reduces the coking properties of coal by increasing the oxygen and decreasing the hydrogen contents, even two or three days exposure in a finely-divided state seriously affecting the coal from a coking point of view.

The Blending of Coal for Coking Purposes.

In reference to this phase of the coking industry it is stated in a work on coke production by A. W. Beldon† that "The necessity of producing a metallurgical coke that will meet the exacting demands of the modern blast furnace, and the fact that the available supply of good coking coal for this purpose is rapidly diminishing have made a study of the future supply imperative. The best results seem to be obtained when coals are mixed in proportions that give about 25 per cent. volatile matter."

* The Bye-Product Coking Industry and its relation to the manufactur of Iron and Steel by G. Stanley oper, "Journn. Iron and Steel Institute," II, 1914, p. 30.

Metallurgical Coke, Technical Paper 50, Bureau of Mines, U.S. Geol. u vey, 1913, pp. 33–34.

This statement is apparently very applicable to New South Wales cokes, for not only is the present available supply of coking coal limited, but there is an enormous waste of non-coking slack, which, by a suitable and economic blending, would probably yield a coke up to the required standard.

The principle seams from which good coking coal is at present being obtained in New South Wales are—

1. The Borehole seam in the Northern Coal-fields.
2. The Bulli seam in the Southern field.
3. Restricted areas of the Lithgow seam in the Western field.

The first-named seam occurs near the base of the Upper or Newcastle Coal Measures, the second at the very top of the same measures within the Southern field, whilst the latter is the lowest seam within the Western Coal-field.

The Borehole seam yields a coking coal wherever worked. The Bulli seam coal is more or less adapted for coking throughout, with the exception of its extreme northern extension within the Illawarra Coal-field, but the areas of good coking coal within the Lithgow seam are far more restricted, and whilst one colliery will yield a coal admirably adapted for that purpose, the product from an adjoining colliery may be practically useless.

Seams No. 2, 3, and 4, within the Southern Coal-field undoubtedly yield an excellent coking coal, but up to the present, only the former has been utilised, and that to a very limited extent.

This is due largely to the fact that within the area at present operated on by working collieries, seams No. 3 and 4 are negligible by reason of the dirty nature of the coal, and the large number of included bands.

South from Mount Kembla, however, and extending to the neighbourhood of the Jamberoo Mountains, conditions of sedimentation were more favourable, and seams No. 2. 3, and 4 undoubtedly have potentialities, even if from a coking point of view only.

One of the writers deals with this area at some length in a "Memoir on the Geology and Mineral Resources of the Southern Coal-field."* A short resumé of the evidence available and deductions drawn is as follows:—

From the south side of Mount Kembla the Bulli seam undoubtedly deteriorates to such an extent that it ceases to have potentialities as a source of coal supply. Here a local basin or area of deposition is evidenced with regard to seams No. 2, 3, and 4, with its main axis apparently some few miles west of the Illawarra Coastal Range, and extending from Mount Kembla to the Jamberoo Mountains.

Towards the northern end of this area, seams No. 2 and 3 improve very much in quality, whilst in the central and southern portion seam No. 4 becomes an important factor. Up to the present only the eastern edge of this local basin has been prospected, and the coal is slightly inferior to that obtained from the Bulli seam further north; but, as stated, only the edge of the basin has been prospected, so far, and until the central portion has been tapped by means of the diamond drill, the quality of its coal contents must remain in doubt.

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* Memoirs Geol. Survey New South Wales, Geology, No. 7. Sydney, 1915, pp. 93–139.

In any case, existing prospecting operations prove that there are seams in this locality yielding an excellent coking coal, even if washing has to be adopted to reduce the ash percentage. The ash contents is largely present in the form of shale bands, so that good results may be expected from washing, or the use of a picking belt, and moreover the coal is naturally friable, thus lending itself to disintegration.

Analyses of coal from the various prospecting tunnels south of Mount Kembla, as published in "The Geology and Mineral Resources of the Southern Coal-field," are as follows:—

Seam.	Hygroscopic moisture.	Volatile hydro-carbons.	Fixed carbons.	Ash.	Sulphur.	Specific Gravity.	Coke.	Calorific value.	Remarks.
No. 2 or the 4-feet Seam.	0·94	24·41	63·20	11·45	0·370	1·36	74·65	12·8	Coke well swollen, firm, and lustrous.
No. 3 or the Thick Seam.	0·30	25·85	61·96	11·89	0·59	1·456	73·85	12·7	" "
No. 4 or the Tongarra Seam.	0·79	26·62	60·07	12·52	0·65	1·355	72·59	12·9	" "

The best coking results in other parts of the world would appear to result from coal containing about 25 per cent. volatile matter. The average percentage of volatile matter in the principal coals of New South Wales is as follows* :—

Upper Measures, Northern Coal-field .... 36·01 per cent.
" " Western Coal-field .... 32·31 "
" " Southern Coal-field .... 23·65 "
Lower Coal Measures... 41·35 "

Seams No. 2, 3, and 4, south of Mount Kembla, have the following approximate percentage of volatile matter :—

No. 2 Coal Seam ... . 24 per cent. Volatile hydrocarbons.
No. 3 " " .... 26 " " " "
No. 4 " " .... 26 " " " "

Thus it will be seen that a mixture of these and the Bulli seam coal would come very close to the desired theoretical percentage of volatile hydro-carbons in a coal most suited for coking purposes.

Quite a number of bulk tests of coal from these seams have been made in various coke ovens on the South Coast, and according to coke-burners the results were most satisfactory, but only three samples were obtainable at the time this publication was being prepared. There appears every probability, however, that further attention will be paid to this source of coal supply in the near future, and if effective coal washing, or picking, be carried out before coking, results should prove satisfactory.

* "The Coal Resources of New South Wales," E. F. Pittman, 1912, p.p. 25-26.

Cokes made from the coal seams south of Mount Kembla were analysed with the following results :—

South of Mount Kembla—Coke.
Proximate Analysis.

	No. 2 Seam. per cent.	No. 3 Seam. per cent.
Hydroscopic moisture	1·70	0·74
Volatile matter	1·93	0·24
Fixed carbon	86·04	76·55
Ash	9·87	21·99
Sulphur	0.46	0.48
	100·00	100·00
Specific gravity	1·805	1·926

Ashes.—Grey in colour; semi-flocculent.

Coke.—Dark grey in colour; dense, hard and compact. The sample from No. 2 Seam is a good quality of coke for metallurgical purposes. The coke from No. 3 Seam has excellent physical properties, but the ash contents are too high for a good metallurgical coke. Experiments are needed to show what percentage of impurities could be removed from the coal by washing prior to coking.

No. 962/16. Coke. No. 3 Seam, Wongawilli, South of Kembla.
Proximate Analysis.

	Per cent.
Hygroscopic moisture	0·68
Volatile hydrocarbons	0·97
Fixed carbon	73·23
Ash	24·59
Sulphur	0·53
	100·00

Specific gravity :—1·899

Ash.—Grey in colour; flocculent.

Coke.—Dark grey in colour. firm and compact. The large amount of ash in the coke will militate against its use for smelting purposes, but it is possible that by washing the coal, before coking, the ash contents would be largely reduced.

No. 3736/14. Coke. No. 3 Seam, South Kembla.
Proximate Analysis.

	Per cent,
Hygroscopic moisture	0·75
Volatile hydrocarbons	1·20
Fixed carbon	81·55
Ash	16·50
	100·00

Sulphur in coal :—0·590.

Specific gravity :—1·801.

Ash :—Buff coloured, granular.

This sample was made at the Mount Pleasant Coke Works, and the coal used was more or less cleaned by hand picking, thus indicating that by the use of a picking belt, the ash percentage can be largely reduced.

Preparation of Coal for Coking.

By far the largest proportion of coal used for coke making in New South Wales is in the form of screenings known as slack, and ranges in size from coal-dust up to fragments the size of a walnut. In the case of one or two of our coke works, however, run-of-mine coal—*i.e.*, both large and small —is sometimes used, such being dependent upon supplies available, or the yield of a coke better suited to consumers requirements.

Generally speaking, crushing a coal before it is charged into ovens, improves the quality of the coke produced. Fine crushing makes the distribution of impurities more uniform, and subsequent breakage of the coke is reduced, the coke being drawn in larger pieces. The coke-cells are closed, and the product is stronger and better able to carry its burden in the furnace. On the other hand, it is recognised that the ash percentage is increased owing to the intimate mixture of clay-band fragments which would otherwise largely fall away on handling the coke. The relative advantages of either method would appear to be entirely dependent upon the qualities most sought after by the consumer, but it has been thoroughly demonstrated that certain coal will only cake after finely crushing.

If run-of-mine coal is used, it is first screened at the colliery, the largest being usually fed into some form of rock-breaker. In the case of Rix's Creek Coke Works (pp.), however, the coal is passed direct from the mine to the coke ovens. The slackfrom the colliery screens and rock-breakers may be either washed to eliminate some of the contained ash, or fed to a disintegrator. Practically the only crusher in use in New South Wales is known as the "Carr Disintegrator," which has been described as follows*:—"Two reels mounted on shafts, and running in opposite directions, and each consisting of two concentric rings in which steel spindles are fixed from 2 to 3 inches apart. The coal after passing through this machune is in a finely-divided state, the size of the largest individual particles being determined by the number of spindles used, and is then known as 'duff.'"

As stated, the slack coal may be submitted to a process of washing, for which there are several types of plant in use in other parts of the world Only two coke producers are washing their slack coal at the present time the Mount Lyell Coke Works, and the Purified Coal and Coke Company, a description of each being given on pp. 28 and 56,

The ash contents in coal is derived from the dirt mixed with the coal, which can be largely eliminated by a process of washing or concentration; or the natural mineral constituents of the coal, which do not lend themselves to reduction by washing under economic conditions. At this stage the reader is advised to refer to the report on "Cokes," by E. F. Pittman, late Government Geologist and Under-Secretary for Mines†, who deals at some length with the question of washing coals before coking.

The purity of coke is of great importance to the metallurgist and foundry master, and whilst the former requires a coke of considerable density in order to bear the burden of the charge, the latter is mainly concerned in obtaining a uniform standard of coke, and one relatively free from ash, sulphur, and phosphorus.

Coal washing before coking appears to be very largely adopted in other countries, and the following definite statement has been published in a recent publication dealing with coke:‡—"Most of the coal used in Great Britain for coking purposes is subjected to a washing operation before being carbonised." A comparison of the ash percentage in coke from New South Wales and other countries is given in the following table, and it will be seen

* "Modern Coking Practice," by T. H. Byrom and J. E. Christopher, London, 1910, p. 69.

† Annual Report Dept. Mines, 1892.

‡ "The Bye-Product Coking Industry, and its relation to the manufacture of Iron and Steel," by G. Stanley Cooper, "Journ. Iron and Steel Institute," II, 1914.

that if the best results are to be obtained, in order to place the coke industry of this State on a more equal footing with other producers, it is highly desirable that more attention be paid to the question of coal-washing.

Average Analyses of Coke from some of the World's Principal Producing Centres.

	Locality.	Volatile matter.	Carbon.	Ash.	Sulphur.	Moisture.
Foreign.	Cumberland—					
	Average from three collieries	0·93	89·15	8·12	1·18	0·62
	Derby—					
	Mickley, unwashed	0·89	93·49	5·51	1·69	0·11
	,, washed slack	......	92·04	6·09	1·41	0·46
	Durham—					
	Average from twenty-two collieries	0·68	91·32	6·90	0·96	0·80
	Gloucester—					
	Average from two collieries	11·20	88·17	6·05	0·69	0·27
	Lancashire—					
	Average from four collieries	1·00	93·14	5·88	0·55	0·36
	Yorkshire— ...					
	Average from seven collieries	0·52	90·42	7·80	0·90	0·71
	Scotland	1·95	94·22	4·27	0·52	0·50
	South Wales	......	93·26	5·70	0·55	0·45
	Pennsylvania	0·29 to 2·26	92·53 to 80·84	6·95 to 15·99	0·81 to 1·87	0·23 to 0·91
	West Virginia	0·46 to 2·35	95·47 to 84·09	4·00 to 12·96	0·53 to 2·26	0·07 to 0·60
N.S. Wales.	Southern District—					
	Average from coking plants.........	1·20	80·71	16·90	0·38	0·80
	Northern District—					
	Average from coking plants	1·14	84·95	11·93	0·49	1·48
	Western District—					
	Average from coking plant	1·12	78·42	18·84	0·66	1·12

It is generally admitted by coke producers and consumers that some of the evil effects of excessive ash in coal are as follows :—

1. With few exceptions, high ash percentage helps to nullify the coking power of coal, or the coking power is decreased unless an excess of lime be present.
2. Ash causes a lowering in the temperature of the oven.
3. A diminished quantity of carbon per ton of coal results, thereby increasing the coke consumption.
4. An increase in the quantity of flux necessary in the furnace charge.

In connection with No. 1, the desirability of experimenting on coal from non-coking areas within the Lithgow seam presents itself, for it may be that careful washing, or the addition of a little lime, will render such coal suitable for coking.

No. 4 is liable to be apparently explained away by saying that certain ores require the addition of flux similar in composition to the coke ash, but is it not extravagant to pay coke prices and freight charges for a flux which could probably be obtained locally?

In dealing with the question of washing, it must be borne in mind that all coals will not lend themselves to efficient washing, some of the reasons for this being :—

1. A coal which produces too much fine dust in the winning, if washed in the ordinary way would produce much coal-slurry, requiring settling vats and further mechanical handling to recover it. This difficulty might be got over, however, by extracting the dust in a dry-air suction machine before passing the slack to the washery.
2. The relative difference in the specific gravities of the coal and impurities must be sufficiently marked.
3. Experiments would require to be carried out with a view of determining the relative specific gravity of individual layers of coal in the seam, for they might differ very much from the main bulk, and thus militate against efficient washing by gravity methods.

Presumably the question of ash in coke is largely a matter of relative costs, and if the consumer is satisfied with the quality of the coke supplied, then there is no call for further comment, apart from the statement of fact that coke consumers in other parts of the world insist upon a lower ash percentage than that present in New South Wales coke.

Charging the Ovens.

Coal is either charged to the ovens from canisters running along the top and discharging into one or more ports, after which it is levelled off by hand, or the charge is first compressed by machinery in a stamping-box, and then passed into the oven as a more or less compacted mass on the floor of the box, which is afterwards withdrawn. This latter means can only be used in rectangular-shaped ovens, and has now been largely adopted in other coke-producing countries.

The question of compressing the charge is not only one of primary cost, running expenses, and the class of coke required, but would also appear to depend upon the chemical composition of the coal used. According to one authority*—A coal containing above 25 per cent. of volatile matter has to be compressed, whilst coal with less than 25 per cent. is charged in the normal way."

There seems little doubt of the many advantages of this method of charging, providing other factors are favourable, but at the present time the Mount Lyell Coke Works is the only one in this State where a combined stamping and ramming machine is in use, although one was installed by the Australian Coking and Bye-Products Co., not now working.

With reference to this method of charging, the following is extracted from a publication on "Modern Coking Practice."†

> "These charges of loosely-filled slack have now been displaced very largely by compressed charges. This system of compressed charges is a great improvement on the old system. The advantages derived are :—
>
> 1. Output increased at least 10 per cent.
> 2. Denser coke.
> 3. Amount of coke-breeze reduced.
> 4. Saving in labour.
> 5. Less wear on oven linings.

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* The Bye-Product Coking Industry and its relation to the manufacture of Iron and Steel by G. Stanley Cooper, "Jour. Iron and Steel Institute," No. II, 1914.

† T. H. Byrom and J. E. Christopher London, 1910, p. 68.

The slack after compression is almost half as dense again as in a loose charge, but the time taken to thoroughly coke the denser charge is also longer, and the net result is a gain in output as stated above. The coke from compressed charges is certainly denser and contains less breeze than that from loose charges, using the same quality of slack. The time taken in charging an oven is also reduced, and the smoke nuisance during charging with tubs and levelling is lessened considerably."

A full description of the machinery is given in this publication, and much other useful information, and it is strongly recommended to those interested in coke production.

Added Moisture to the Coal Charge.

The practice of adding moisture to the coal charge has advantages when applied to some coals, but with others, it does not seem necessary, and if a good coke can be produced without moistening the duff, there is no lowering of temperature in the oven.

It is recognised in other parts of the world that not more than from 6 to 7 per cent. of moisture should be present in a charge, under which condition* "the coking coal still packs together well, does not include too much air, and settles itself together sufficiently fast in the oven, which of itself has an influence upon the structure of the coke."

On the whole, it would seem that local conditions and requirements must entirely govern the question of charging coal to the ovens in either a moist or dry condition.

Types of Oven used in New South Wales.

Three main types of ovens are in use in New South Wales, namely, the true beehive, rectangular beehive, and by-product ovens.

The first was the original oven type, and coking was dependent upon top heat only, the ovens in New South Wales being generally built on the double-row principle, that is, back to back. There are still a number of these ovens in use, but they are gradually being replaced by the rectangular shape. The essential features of the beehive oven are a circular vaulted brick chamber with a port-hole in the top, through which the coal may be charged, and the products of combustion escape. An arched opening is left at the bottom to admit the air necessary for combustion and for the quenching and withdrawal of the coke, such being temporarily bricked up during the coking process, with the necessary air-vents so manipulated that the supply is more or less under control all the time. The opinion is held that this type of oven is best for high-class coals.

The rectangular ovens are really a modification of the old Belgian type, and were evolved primarily to compensate for unskilled labour and higher costs. The name indicates the shape, and they are built to various patterns, the main differences being the flue arrangements, by which heat is applied to the charge, and mechanical discharge of the coke.

Some are built with side flues in which the evolved gasses are burnt whilst passing between the oven walls; other have bottom flues only, with a similar object; whilst a third type are fitted with both side and bottom flues, thus assuring a more general distribution of the heat. This arrangement

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* "Chemistry of Coke," by Simmersbach and Anderson, Edinburgh, 1899, p. 40.

† A. W. Belden. "Metallurgical Coke," Technical Paper 50, United States Bureau of Mines, Washington, 1913, pp. 20 and 21.

also enables the waste gasses to be used in the heating of boilers for steam power production, which according to a recent writer * amounts to from 12 to 20 horse-power per coke oven. Up to the present, in New South Wales, only one coke works has adopted this source of steam power, but another company are constructing ovens with the same object in view.

There appears to be very little doubt that the rectangular oven will continue to be used in New South Wales, and it is apparent that they have many advantages. Amongst the claims made for the rectangular ovens are increased yield, a better product, and lower cost of operation, but the more conservative consumers in other countries are inclined to favour the product from the older type of ovens. There may be a certain amount of justification for this opinion, but the writers' investigation of the literature on coke production, leads them to the belief that if such is the case, it is more applicable to by-product coke, as compared with beehive, than to coke made in rectangular ovens.

The third type of oven has been adopted by only two coke works in the State, namely the Broken Hill Proprietary Company's Steel Works and the Australian Coking and Bye-products Company. The first of these has only been running a little over six months, and the second were erected about three and a half years ago, but up to the present has not proved a success. This would appear to be largely due to faulty material and construction, and an effort to remedy these evils is now being contemplated by the company.

The relative value of by-product coke would appear to still be a debatable question, as is evidenced from the following remarks by Mr. J. H. W. Laverick, a well-known Sheffield (England) steel manufacturer :—*

> "He should like members to know . . . that bye-products coke had been tried, and was being tried at the present time in the crucible steel trade of Sheffield. But the crucible steel makers—who it might be presumed knew their own business—preferred to pay from one and a half times to twice as much for beehive coke as for bye-product coke. The reason simply was that they got a greater output of crucible steel from beehive coke. . . . Steel makers would have beehive coke for crucible steel, because they got their heats quicker and maintained them better."

Still it must be admitted that the by-product type of oven has many economic advantages, and it is to be hoped that time will demonstrate their adaptability, and overcome the objections of a section of the coke consumers.

In pursuance of this subject it may be interesting to note an American view of the question :—†

> "The trouble formerly experienced by by-product coke makers in getting a trial for their product in the blast furnances of this country is an illustration of the suspicion in which bye-product coke was held. The coke was condemned without trial because of its dark, dull, dirty appearance. Subsequently experience has disproved the old idea that beehive coke is the best metallurgical fuel."

* "The Uses and Markets of By-Products." The Iron and Coal Trades Review, January 28th, 1916, p.90.

† "Metallurgical Coke," by A. W. Belden. Technical Paper 50, Bureau of Mines, Washington, 1913,

Burning Periods.

The period occupied in burning a charge of coke varies not only with the size of the charge, and the nature of the coal, but also with the amount of air admitted into the oven.

It is recognised that the size of coke depends largely upon the height of the charge, and degree of heat reached. A heavy charge generally results in an undue percentage of small coke, and similar trouble may arise from a low charge.

In order to produce coke in large pieces, the temperature must not be allowed to rise above a certain definite limit such being largely dependent upon the nature of the coal used. The more intensely an oven is heated, the more frequently do cleavage surfaces occur; moreover, a powerful draught, the admission of cold air, and with it rapid burning, are liable to cause "fingering," or splitting, and crumbling.

In New South Wales, with the ordinary type of rectangular oven, it is, as a rule, found most advantageous to arrange the burning period on a 72 and 96 hour basis, in order to tide the works over a Sunday shift. In many cases an increased quantity of duff is charged for the longer period, namely, an increase say, from 15 to 20 per cent., but this does not seem essential, and by regulating the air supply either a longer or shorter period of burning may give practically the same result.

Quenching.

In coke-making it is desirable, as soon as ever the charge is "ripe," *i.e.* thoroughly coked, to terminate combustion as rapidly as possible, for if this is not done, the *coke* commences to burn itself away, with resultant loss in the form of ash. In the old type of true beehive ovens, internal quenching was of necessity adopted, that is, the oven door having been removed, a jet of water was played upon the incandescent mass within the oven. The introduction of the rectangular-shaped ovens, and the ram discharge, however, led to external quenching being adopted, and the charge is either sprayed by hand on the coke bench, or as it leaves the oven by means of a "cage" sprayer. This latter consists of a three-sided iron frame suspended in front of the oven, and fitted with perforated pipes through which water is played automatically on the charge as it is pushed out.

The object is to quench the incandescent mass as soon as possible when brought into contact with the air, thus minimising oxidation.

There are still two schools of advocates with regard to quenching, namely, those who favour internal methods as against those who prefer external.

The former contend that not only is the bright metallic lustre of the coke largely lost by external quenching, but the moisture percentage in the finished product is also much higher, whilst the latter point to the saving in time, and oven wear and tear by external quenching, particularly when a "cage sprayer" is used.

No doubt the latter method is more economical to the coke manufacturer, and less trying to the workmen, but it means that the resultant product contains a far higher percentage of moisture, thus increasing its weight and lessening its efficiency.

The advocates of internal quenching point out that by adopting this method, the heat of the oven walls drives off most of the excessive moisture before the charge is withdrawn, and that there is sufficient heat left in the coke after withdrawal to expel the remainder. This means that under normal atmospheric conditions during transport, the coke is better adapted to metallurgical processes, and that the consumer gets from 4 to 10 per cent. more coke by weight than when coke containing superfluous moisture is supplied.

There would appear to be many points in favour of this contention, but it all resolves itself into a question of costs as between supplier and consumer, and no hard-and-fast rule on the question appears possible.

Breeze, "Ash," "Black Ends," &c.

The term "breeze" is applied to the small fragments of coke resulting from breakage during discharge, and subsequent handling, and the quantity varies according to the nature of the coke produced. It occasionally amounts, in New South Wales, to as much as 5 per cent. of the total charge, and as there is practically no sale for breeze at present, it is a more or less serious loss to the coke producer.

In this connection it may not be out of place to quote a recent American authority on the subject of metallurgical coke :—*

> "Modern practice no longer demands coke in large, long pieces, but coke of a uniform size. The action of blast furnaces and cupolas is more regular and uniform if coke of uniform size is used. The author has been unable to ascertain whether any furnace plant in this or any other country reduces coke to uniform size by crushing, but he is inclined to believe that, in spite of the added cost and attendant loss due to fine coke, crushing would still prove economical by reason of the better working of the furnace, the prevention of slips and scaffolds, and the uniformity of the metal produced."

It does not seem possible to prove this contention at the present, but the attention of metallurgists is called to such an authoritative expression of opinion.

"Ash," in addition to the included shaley material, comprises the burnt coke always occurring, to a greater or less extent, as a layer over the upper surface of the charge, and due to combustion of the coke formed.

Under ideal conditions, this is reduced to a minimum thickness, but its percentage is dependent upon the regulation of the air supply, and to the charge being withdrawn and quenched as soon as possible after coking is completed.

"*Black Ends.*"

The faces of the charge, fronting both doors of an oven, are invariably only partially coked, when the remainder of the charge is "ripe" for withdrawal. This is due to there not being sufficient heat adjacent to the doors to overcome the cooling influence of the outer air, and the thickness of the black ends varies somewhat according to atmospheric conditions, and may range from an inch or two up to a foot. "Black ends" consist of more or less friable, partially-coked material, in which carbonisation is not quite complete, and they have always been a source of trouble to both the producer and consumer. To the former it means an increase in the percentage of breeze, and the latter finds it objectionable in metallurgical operations.

In some cases (the Broken Hill Proprietary Bye-product Coke Ovens, Newcastle), the black end appearing at the rear of the charge is not pushed clear of the oven, but left to be reburnt in the following charge, but this,

* "Metallurgical Coke," by A. W. Belden. Technical Paper 50, Bureau of Mines, Washington, 1913 p. 39.

however, is only a partial remedy, for one " end " passes to the consumer, and the other is liable to be "over-cooked " in the following burn off, when loss still ensues from burnt coke ash.

Another remedy practised is to allow the ends to burn off to some extent after opening the doors, and before discharging; but here again the remedy is accompanied by an equally undesirable action from the producer's standpoint, for the " ripe " coke suffers from oxidation with a resultant increase in coke ash.

Black ends are more pronounced in the wide rectangular beehive ovens owing to the surface area of the ends exposed to cooling influences being greater than in a narrow but longer oven, and it frequently happens that an otherwise good batch of coke is somewhat spoiled by a noticeable quantity of black end.

Several remedies have been tried in other parts of the world, such as recessed doors, flued doors, &c., but the former lessens the output of the oven somewhat, and the adaptability of the latter would appear to depend upon a complete flue arrangement throughout the ovens.

Many of our coke ovens are not provided with flues, but the possibility of cavity doors, which will overcome the difficulty to some extent, presents itself. The general principle might be worked out on the basis of openings being left at either side in the upper portion of the oven, these to coincide with corresponding openings on the inside of the cavity door, thus enabling the burning gasses to pass through from one side to the other, a draught being created by a small opening at the top of the door, over the cavity.

About an hour's extra burning under favourable conditions has been found sufficient to remedy the black-end trouble, and it should be possible by a system of dampers to so regulate matters that sufficient extra heat is applied to the front and back of the charge during the latter stage of the burning only.

Until experiments have been made, however, it is difficult to estimate the efficiency or feasibility of this method, but that the evil of " black ends " requires remedying is self-apparent.

Blackbutts are the soft black ends of the coke prisms adjacent to the floor, and may be due to an over-cooked oven or dirty bottom; the first arising from neglect in regulating the air supply during the burning of the previous charge; or a third cause may be the overcharging of ovens. The remedy in either case is apparent, and emphasises the necessity for continual vigilance on the part of the coke master.

Physical Properties of Coke.

The external appearance of coke varies greatly, as do the physical properties and chemical composition. The colour may range from dull grey to a bright silvery or metallic appearance, with occasional iridescent or black smutty surfaces, but it is questionable whether the appearance has any marked bearing upon the general quality of the coke. The bright metallic appearance is due to the deposition of carbon derived from the heavier hydrocarbons given off at lower temperatures and redeposited—" coke hair " and stalactitic structure having the same origin. It is recognised that, as a rule, the more metallic-looking portions of the coke are freer from ash.

The general colour may be due to the nature of the coal used, temperature of oven, period of burning, or to the method of quenching adopted—*i.e.*, internal or external. This latter factor is all-important, and it is admitted that internal quenching yields a much brighter coke than if it is done externally.

The physical structure of the coke is of far greater importance to the consumer, however, for upon it depends largely the results obtained in the blast furnace.

A coke may be either dense and hard, or porous and soft, density as opposed to porosity being used to signify cell-space, whilst hardness and softness is applied to the strength of the cell-walls. A dense coke is, as a rule, soft, although in appearance it may look far more capable of withstanding the furnace burden than does a more porous or cellular coke. This does not always follow, however, and hard dense cokes are common, such being well adapted for blast furnace uses where rapid permeation of gases is not essential.

The development of a high-grade cell structure is of the greatest importance, for if well developed a larger surface is exposed to oxidation by air, thus producing rapid combustion. At the same time it is most vital that the cell-walls should be sufficiently strong to carry the furnace charge without crumbling up and producing a compact mass difficult for the blast to permeate.

The question of porosity or density, according to A. W. Beldon,* is largely dependent upon the following factors:—" The porosity of coke depends on the nature of the coal from which it is made; the washing of the coal; the fineness of crushing; the tamping and compacting in charging; the process of making; the kind of oven used; the depth of the charge; the temperature of coking; and the length of time applied."

Thus it will be seen that there is a wide field for experimenting on the part of the producer, and before a coal is condemned from a coking point of view, exhaustive tests should be made.

Speaking in general terms, the cokes produced in New South Wales may be classified as follows, but it must be remembered that different producing conditions vary the nature of the coke even from the same coal.

The Southern Coke Works, using Bulli seam coal, produce a coke less porous than is obtained from the Borehole seam coal within the Northern Coalfield, but with considerable hardness in the cell-walls, whilst coke from the Lithgow seam in the Western Coalfield might be placed midway between the two.

Rix's Creek coal yields a hard, very porous, coke of low ash percentage, and apparently suited for blast furnace purposes.

Coke produced from seams Nos. 2 and 3 within the Southern Coalfield is more of the nature of the Borehole seam coke, but exhibiting greater strength in the cell-walls, and here again we have evidence of the probable advantage of blending coal from these seams with the Bulli seam coal, with every prospect of producing a hard porous coke well suited to the metallurgist.

Reference to the accompanying analyses will convey some idea of the relative ash percentages, but it must be remembered that washing, or the use of a picking belt, is urged with regard to coal from coal seams Nos. 2 and 3.

Comparative Table.

The following comparative table with regard to the Coke Industry of New South Wales, places much of the available information in a condensed form.

Where possible the ash content is that supplied by the various companies, and represents the commercial basis as between supplier and consumer.

* "Metallurgical Coke. Technical Paper 50," Bureau of Mines, Washington, 1913, p. 37.

COMPARATIVE TABLE.

	Company.	Locality.	Coal used.	Type of Oven.	Number of Ovens.	Men employed.	Coal consumption, 1915.	Coke production, 1915.	Average Ash percentage.	Remarks.
							Tons.	Tons.	per cent,	
Northern.	Broken Hill Proprietary Co.'s Steel Works.	Newcastle	Borehole seam	Semet Selvay By-product.	66	135	71,160 (6 months).	43,968 (6 months).	16·2	
Northern.	Co-operative Coal and Coke Co.	Wallsend (Plattsburg)	,, ...	Beehive	67	14	13,020	7,161	12·0	
Northern.	The Great Cobar Co..........	Rix's Creek, Singleton	,, ...	,, ...	26	8	......	......	11·5	
Northern.	Wallsend Purified Coal and Coke Co.	Jesmond (Wallsend)...	Borehole seam	,, ...	76	45	44,000	21,144	13·0	Made from washed coal.
Southern.	The Broken Hill Associated Smelters.	Bellambi	Bulli seam ...	Rectangular beehive.	115	71	73,581	53,102	16·5	
Southern.	Bulli Colliery and Coke Works, Ltd.	Bulli	,, ...	,, ..	54	25	31.704	22,872	16·5	
Southern.	Corrimal-Balgownie Collieries, Ltd.	Corrimal	,, ...	,, ..	40	......	......	......	15·0	
Southern.	The Federal Coke Co., Ltd.	Wollongong	,, ...	,, ...	45	40	65,000	44,000	14·7	
Southern.	Illawarra Coke Co., Ltd....	Coal Cliff	,, ...	,, ...	50	......	......	......	16·0	
Southern.	Mount Lyell Co., Ltd.	Port Kembla	,, ...	,, ..	36	45	36,300	27,400	16·0	Made from washed coal, and charges stamped.
Southern.	Mount Pleasant Coke Co. (Figtree and Sons).	Wollongong	,, ...	,, ...	40	22	50,350	35,294	14·5	
Southern.	NorthBull. Coke Co.	Coledale	,, ...	,, ...	106	50	70,000	50,000	17·0	
Southern.	South Clifton Coal and Coke Co.	Scarborough	,, ...	Beehive	66	30	21,725	16 300	15·5	
Western.	G. and C. Hoskins' Steel Works.	Lithgow	Lithgow seam..	Rectangular beehive.	93	30	......	......	17·6	
Western.	Oakey Park Coal and Coke Co., Ltd.	,, ...	,, ...	Rectangular and ordinary Beehive.	40 / 32	25	26,087	16,007	18·0	
					952	540	......	258,769		

DESCRIPTION OF INDIVIDUAL COKE WORKS.

Southern District.

No. 1.

Mount Lyell Coke Works.

This company has a coking plant at Port Kembla, which was established in 1899, and has been running ever since, apart from suspension of work owing to labour troubles.

Mr. E. Tuxworth has been Works Manager throughout, and there is no doubt that considerable efforts have been made on the part of the management to make working conditions easier for the employees, and at the same time produce efficient and satisfactory economic results.

It must be admitted that whilst the desired end is attained in producing a coke up to the standard required by the Smelting Company, the coal used at present is far from ideal in its normal state, and considerable care must be exercised in producing an economical and satisfactory coke.

The ovens are situated opposite No. 2 Jetty at Port Kembla, and whilst no doubt mistakes were made in the past as regards equipment and general layout, such are rapidily being remedied as opportunity offers, with the result that these works should be second to none as regards equipment in the near future.

The position of the works afford exceptional opportunities for economic shipment, and whilst practically the whole of the present output is absorbed by the owners, one cannot but realise that as the production of coking coal extends south from Mount Kembla, these works should be in an ideal position for the manufacture of large quantities of coke suitable for export.

The coal used (all "slack" or small coal) is obtained from the Mount Kembla Colliery, distant some 4 miles by rail from the works. Analysis of coal from this colliery, as published recently by the Department of Mines,* are as follows :—

Locality.	Section.	Analysis.								Remarks.
		Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	Calorific value.	
84 chains W.N.W. from tunnel mouth.	Root shale; coal, 3 ft. 2½ in. (from long wall face), floor shale.	1·01	23·41	63·30	12·08	0·237	1·382	75·58	12·4	Coke: not swoll[en] firm; lustre du[ll]
120 chains N. 35 W. from tunnel mouth.	Roof shale; coal, 5 ft. 8 in., floor shale.	1·00	23·20	66·39	9·41	0·310	1·386	75·80	12·7	Coke: not swoll[en] firm; lustre du[ll]

* Memoirs Geol. Survey, N.S. Wales, Geology No. 7 "Geology and Mineral Resources of the Southern Co[al] Field," Sydney, 1915.

Mount Lyell Coke Works, Port Kembla.

† 67323

An elaborate system of washing or concentration has been installed, and the following particulars have kindly been supplied by Mr. Tuxworth. The coal from the colliery is received in a storage bunker holding about 600 tons, from which, by a system of scraper conveyors, it is delivered to the washing plant with a minimum of handling.

On reaching the washery, the coal is mechanically graded into four sizes, the finest dust being withdrawn by a centrifugal blower, and fed direct into the mixing chamber, where, being in a dry state, it helps to reduce the moisture percentage in the mix. The two sizes over the $\frac{3}{16}$ inch gauge are dealt with in two nut-coal pulsating washers, whilst the remaining finer material goes to felspar jigs, of which there are five, but three are usually sufficient to deal with the output.

The product from the nut-coal washers is partially dried over a reciprocating screen, and passes to the Stedman grinder, whilst the fine coal from the felspar jigs is similarily drained. A quantity of fine sludgy coal and water flows over the face of the coal lying next to the screen, and this is also saved by a system of settling vats.

The "Tailings" or extracted "dirt" consists for the most part of carbonaceous clay shale and calcite or "spar." A cleaner "wash" could be ensured, but it means that an appreciable proportion of highly carbonaceous material useful in the charge, is lost, and it is found more economical not to concentrate too thoroughly, even at the cost of a slightly higher ash percentage in the finished product.

The drainage system after washing, together with the addition of the dry coal dust reduces the moisture to about 10 per cent., which is found most satisfactory in the stamping machine and subsequent kiln charge.

The results obtained by washing the coal is evidenced by the two following analyses.

No. 1 is the slack coal taken from the storage bunker, and No. 2 is a sample of the mix ready for charging into the ovens.

Analyses.

No. 1.

No. 518. Unwashed coal, Mount Lyell Coke Works.

Proximate Analysis.

Hygroscopic moisture	0·77
Volatile matter	22·30
Fixed carbon	60·81
Ash	16·12
	100·00

Sulphur in coal—0·266 per cent. Sp. gravity—1·406. Ash—Light grey in colour, semi-granular.

No. 2.

No. 519. Washed coal, Mount Lyell Coke Works. Coal damp, air dried before analysis.

Proximate Analysis.

Hygroscopic moisture	0·72
Volatile matter	23·56
Fixed carbon	63·62
Ash	12·10
	100·00

Sulphur in coal.—0·269 per cent. Specific gravity—1·385. Ash—Light grey in colour, semi-granular.

The washing process has removed 4·02 per cent. of impurities (shale, &c.).

From the mixing chamber the coal is elevated to and distributed in the charge storage bunker, holding about 180 tons, and placed at a sufficient elevation to deliver to the Buchanan ramming and charging machine.

This machine, which travels on a track of four rails, also carries the ram for discharging the ovens, and sufficient coal for three separate charges. It weighs about 60 tons without the charges, and is operated by steam power.

The coal is fed from the feed bin in layers of about 12 inches to a thickness of about 4 feet into a box 29 feet long and 1 ft. 10 in. wide, along which a Caledonian stamping machine travels, fitted with two stampers, each weighing 3½ cwt. with a drop of 12 inches, and falling thirty-two strokes per minute.

Whilst a coke charge is being pushed out by the ram, the new charge of about 6 tons 10 cwt. is undergoing stamping sufficient to enable it to be pushed into the oven on the floor of the box, which is then withdrawn, the coal being retained in position during this operation by lowering the back door of the oven until it rests on the floor of the charge box, and is there wedged in position. The doors are finally fastened, and luted with clay, and burning proceeds, usually occupying forty-eight hours.

The ovens, of which there are thirty-six, are 30 feet long at the floor, average 2 ft. 7½ in. in width, and are 7 feet high, each oven being isolated from its neighbour by a solid wall 16 inches thick, so that repairs can be effected with a minimum of interference to adjoining ovens.

The walls of the ovens are built out of South Coast firebricks, and the floor of Hurstville dry pressed bricks, with a horizontal flue system designed to produce uniform heating throughout.

The quenching platform is level with the floor of the ovens, and about 7 feet above the coke platform. The coke before falling on to the latter, passes between a cage sprayer, which sprays a considerable quantity of water against the coke, so that very little watering has to be done on the coke platform. The surplus water runs back into the dam, and is re-used when cool.

The coal charged to ovens during the year 1915 was 36,300 tons, and the coke produced approximated 27,400 tons. Almost the whole of the coke produced is used in the blast furnaces of the company's plant at Queenstown, Tasmania, being bagged and shipped at Port Kembla.

The waste gases from the ovens are used under the boilers, and practically meet all steam requirements. The working conditions are undoubtedly good at these coke works, and the number of men employed averages forty-five.

The following is the result of an analysis of a sample of coke from these works, obtained on 17th February, 1916 :—

Analysis.

No. 473.—Coke from Mount Lyell Coke Works (made from washed coal).

Proximate Analysis.

Hygroscopic moisture	0·73
Volatile matter	1·14
Fixed carbon	81·87
Ash	15·95
Sulphur	0·31
	100·00

Specific gravity—1·812.

Ash—Slight reddish tinge, semi-granular.

Coke—Dull grey in colour, very dense, hard rough surface. Should readily stand handling without breaking, and bear a heavy burden for smelting purposes.

Ram and Charger, Mount Lyell Coke Works, Port Kembla.

The composition of the ash contents of this coke is shown in the following analysis :—

No. $\frac{595}{16}$. Coke ashes from Mount Lyell Coke. Analysis by H. P. White.

Chemical Composition.

Moisture at 100° C.	0·07
Silica (SiO_2)	54·11
Alumina (Al_2O_3)	33·46
Ferric oxide(Fe_2O_3)	4·75
Ferrous oxide (FeO)	0·23
Manganous oxide (MnO)	*trace
Lime (CaO)	1·92
Magnesia (MgO)	0·53
Barium oxide (BaO)	0·30
Strontium oxide (SrO)	†present
Soda (Na_2O)	0·61
Potash (K_2O)	1·74
Lithia (Li_2O)	†present
Titanium oxide (TiO_2)	1·45
Phosphoric anhydride (P_2O_5)	0·50
Vanadic oxide (V_2O_3)	0·01
Sulphur trioxide (SO_3)	0·55
Chromium Sesquioxide (Cr_2O_3)	abs
	100·23

* Trace—less than 0·01 per cent. † Spectroscopic reaction only.

No. 2.

The Federal Coke Works.

This Company was established in October, 1900, the works being situated near Wollongong, and the Head Office of the Company at 109 Pitt-street, Sydney.

The works are adjacent to the Illawarra Railway line, about half a mile north of Wollongong station, 48 miles from Sydney, and about 6 miles from Port Kembla. The natural assumption would be that the latter is the loading port for interstate shipments, but such is not the case. This is due to a minimum freight charge on the Government Railways, and to the fact that there is only a difference of 4d. per ton in favour of Port Kembla shipment as against Darling Harbour. Such is outweighed by the fact that shipping firms find it much more convenient to load at Darling Harbour on account of the loss of time and weather risks attached to Port Kembla loading.

The management of the works is in the hands of Mr. J. Figtree, whose father was one of the first coke-burners in New South Wales The advantage of a lengthy experience, and the care exercised in burning is evidenced by the accompanying analysis of coke produced at the Federal Works, and the fact that coke from there was awarded a diploma for Grand Prix, at the Franco-British Exhibition of Science, Arts, and Industries, held in London during 1908.

The coal used is obtained from the Osborne-Wallsend Company's Colliery at Mount Keira, distant about half a mile from the Coke Works.

Slack coal only is used, but analyses of average samples of coal from this colliery, as published in the Southern Coal Field Memoir* are as follows, and should approximate the average chemical composition of the slack used :—

Locality.	Section of Seam.	Analysis.								Remarks
		Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	Calorific Power.	
									lb.	
Most northerly heading, 1911, No. 4 right narrow bord (Old No. 3).	Roof, shale; coal, 6 ft. 6 in.; floor, carbonaceous shale.	0·88	25·09	64·89	9·14	0·394	1·377	74·03	13·0	Ash, buff coloured semi-granular; coke, fairly swollen, firm and lustrous.
Most westerly heading, 1911, 4 chains west of air shaft.	Roof, shale; coal, 6 ft. 6 in.; floor, shale.	0·78	26·18	64·38	8·66	0·451	1·393	73·04	13·2	Ash, buff coloured semi-granular; coke, fairly swollen, firm and lustrous.

The slack is not washed, but passed directly through a Carr type of disintegrator.

Mechanical conveyors are used to transfer the coal from the delivery bins to the disintegrator, and again from thence to the main storage receptacle, from which it is charged to the ovens by overhead trucks operated by manual labour, and discharging into two ports in the crown of each oven.

The ovens, forty-five in number, and known as the McLanahan type, are vertical flued, and rectangular in shape, the dimensions being 30 feet long, 8 feet wide, and 5 feet 11 inches high to the crown of the arch, the ends tapering from 3 feet to 2 feet 9 inches, so that the thickness of the charge very seldom exceeds 2 feet 6 inches.

The time occupied in burning is seventy-two hours and ninety-six hours alternately, this arrangement tiding the ovens over a Sunday. For the seventy-two hours burning a charge of 12 tons 10 cwt. of coal is placed in the oven, whilst for the longer period the ovens are charged with 15 tons.

The oven doors are raised and lowered by hydraulic power; internal quenching is adopted with a view to minimising the moisture contents and inconvenience to workmen on the landing stage, and the coke is discharged by a steam ram.

Further limited watering is necessary on the landing stage, but the inconvience is reduced to a minimum.

The percentage of loss due to spongey coke, "breeze" and burnt coke is estimated at 2 per cent., but judging by personal inspections, this must at times be greatly exceeded.

The output from the Federal Coke Works is 850 tons per week as a maximum, but the average is slightly less owing to various causes, such as repairs to ovens, &c.

* Memoirs Geol. Survey N.S. Wales, Sydney, 1915.

Federal Coke Works, Wollongong.

The generated gases are allowed to go to waste at present, and Mr. Figtree expressed the opinion that the excess of tar over that required in the coking process is not sufficient to justify a by-product plant, such opinion being based on expert advice from England.

Some of the principal consumers are the Melbourne Steamship Co., Great Cobar Copper Mine, G. and C. Hoskins (for use in the blast furnace at the Lithgow Iron Works), Mount Elliott Mine, and the Wallaroo and Moonta Mine, whilst a fair proportion is also exported.

About 65,000 tons of slack coal are used per annum, producing about 44,000 tons of coke, or 67·69 per cent.

The bricks used in the ovens are made by Pendlebury and Son at their Woonoona works, and are the ordinary dry pressed variety, the life of an oven without renewals approximating two years.

About 100,000 gallons of water are used per week, the supply being obtained from a dam with a capacity of two and a half million gallons.

About 5 per cent. of the coke is bagged, such being consumed at places where delivery necessitates considerable handling.

The Company employ an average of forty men and the major portion of the output is shipped at Pyrmont, Sydney Harbour, for interstate and oversea transportation.

Samples of the coal used and coke produced were obtained on the 10th of February, 1916, and analysed in the Departmental Laboratory, with the following results:—

No. 794/16. "Duff" coal, Federal Coke Works, Wollongong.

Proximate Analysis.

Hygroscopic moisture	0·72
Volatile matter	24·92
Fixed carbon	62·41
Ash	11·95
	100·00

Ash—Buff coloured, semi-granular.

Sulphur in coal—0·384 pr cent.

No. 389/16. Coke made from "Duff" coal, Federal Coke Works.

Proximate Analysis.

Hygroscopic moisture	1·38
Volatile matter	1·59
Fixed carbon	82·63
Ash	14·08
Sulphur	0·32
	100·00

Specific gravity.—1·816.

Ash—Buff-coloured, semi-granular.

Coke—Dark gray in colour, dense, hard and compact; should readily stand handling without breaking, and the weight of a heavy burden for metallurgical purposes.

An analysis of the ash contents gave the following result:—

No. 596. Ashes from Federal coke. Analysis by W. G. Stone.
16

Chemical Composition.

Moisture at 100° C.	0·05
Silica (SiO_2)	52·94
Alumina (Al_2O_3)	34·49
Ferric oxide (Fe_2O_3)	4·10
Ferrous oxide (FeO)	0·45
Manganous oxide (MnO)	0·04
Lime (CaO)	2·32
Magnesia (MgO)	0·68
Barium oxide (BaO)	0·40
Strontium oxide (SrO)	†present
Soda (Na_2O)	0·78
Potash (K_2O)	1·34
Lithia (Li_2O)	†present
Titanium oxide (TiO_2)	1·35
Phosphoric anhydride (P_2O_5)	0·64
Vanadic oxide (V_2O_3)	0·02
Sulphur Trioxide (SO_3)	0·76
Chromium sesquioxide (Cr_2O_3)	*trace
	100·36

* Less than 0·01 per cent. † Spectroscopic reaction only.

No. 3.

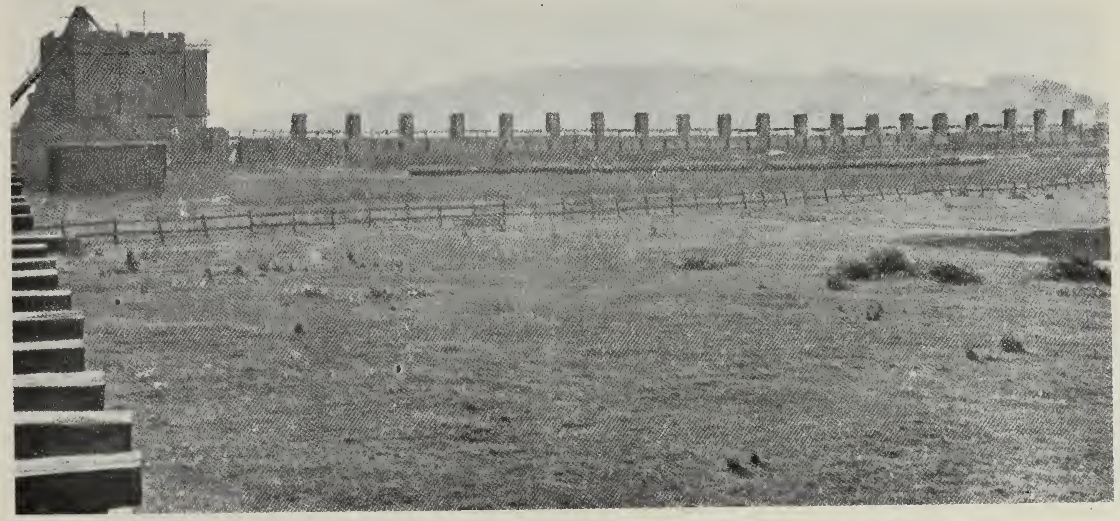
Mount Pleasant Coke Works.

Operations at the present ovens were started in 1910, but the firm first commenced work in 1889. Messrs. Figtree and Sons, of Wollongong, are the owners, and the ovens are situated alongside the Illawarra Railway line about 1¼ miles north of Wollongong station. They are distant only 7 miles from Port Kembla, and 47 miles from the Port of Sydney, but practically all the coke made is shipped at the latter place.

Slack coal only is used, and is obtained from the Bulli seam at Mount Pleasant Colliery, distant 3½ miles from the coking plant. Analyses of average samples of coal from this colliery, as published in the Southern Coal Field Memoir* are as follows:—

Locality.	Section.	Analysis.								Remarks
		Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbons.	Ash.	Sulphur.	Specific Gravity.	Coke.	Calorific value.	
86 chains N. 40 W. from tunnel mouth (face June, 1911).	Roof shale; ft. in.; Coal .... 4; Floor splint 0 4	0· 0	25·35	63·93	10·02	0·325	1·377	73·95	lb. 13	Ash; grey, … lar. Coke; … swollen, fir… lustrous.
99 chains W.N.W. from tunnel mouth (face June, 1911).	Roof, shale; ft. in.; Coal .... 8 0; Splint 0 4	0·65	24·30	65·30	9·75	0·347	1·368	75·05	13	Ash; grey, … lar. Coke … swollen, fir… lustrous.

* Geology No. 7, Department of Mines, Sydney, 1915, p. 147.



Mount Pleasant Coke Works, Wollongong

The slack coal is not washed, but passed through a Carr disintegrator, of which there are two, and mechanically conveyed into the storage bin, from which it is fed into the ovens by canisters running on two sets of rails, and discharging into two ports in the crown of each oven.

The ovens are built on the longitudinal beehive pattern (McLanahan type), and are forty in number, with the following dimensions :—30 feet long, 5 feet 10 inches to crown of arch, and tapering from 4 feet to 2 feet 10 inches at the doors.

The charges are adjusted to suit the seventy-two hours or ninety-six hours burning, 15 tons of duff being used for the former and 18 tons for the latter. As stated, an overhead feed is adopted, operated by gravity, the empties being returned to the storage bin by manual labour. After the coking process is completed, the charges are pushed out by a steam ram, the doors of the oven being raised by hydraulic power. Internal watering is adopted, thus minimising the inconvenience on the coke bench, but final quenching takes place there. The loss after withdrawal from the oven is estimated by the management at 2 per cent.

The generated gasses are not used, either for by-product extraction or heating the boilers, and here again the view is held that such are largely negligible from an economic standpoint. The bricks used in the ovens are the ordinary dry-pressed, and fire-bricks, made by Pendlebury and Sons at Wonoona, the life of an oven, without repairs, ranging from fifteen months to two years.

About 20 per cent. of the coke is bagged for interstate shipment, the remainder being delivered in bulk, and the principal consumers are G. and C. Hoskins (for use in the blast furnace at Lithgow Iron Works), Cobar Copper Mine, Victorian Railway Foundries, The Clyde Engineering Works, Cockatoo Dock, and most of the principal foundries in Sydney and Melbourne.

Twenty-two men are employed, and during 1915, 50,350 tons of slack coal were used, yielding 35,294 tons of coke, or 70·09 per cent.

An average sample of coke obtained from these works on 17th February, 1916, was analysed with the following result, but the ash contents was abnormally high. Probably about this time a slightly inferior coal was being utilised, as further evidenced by the result of an analysis made by Mr. Alexander Orr. (See analysis for 17th March, 1916, in attached table). :—

No. 1.

No. $\frac{471}{16}$. Coke. Mount Pleasant (Figtree and Sons), Wollongong.

Proximate Analysis.

Hygroscopic moisture	0·82
Volatile matter	1·24
Fixed carbon	82·42
Ash	15·19
Sulphur	0·33
	100·00

Specific gravity—1·843.

Ash—Grey in colour, semi-granular.

Coke—Dark-grey in colour, firm, and compact. Not readily broken on handling, and should stand a heavy burden for smelting purposes.

On 5th April, 1916, a further average sample was procured and analysed, with the following result:—

No. 2.

No. 1094/16. Coke, Mount Pleasant (Figtree and Sons), Wollongong. Second sample, taken on 5th April, 1916.

Proximate Analysis.

Hygroscopic moisture	1·33
Volatile matter	0·70
Fixed carbon	83·29
Ash	14·35
Sulphur	0·33
	100·00

Specific gravity—1·809.
Ash—Grey in colour, semi-granular.
Coke—The same remarks apply to this sample as to No. 1.

Averages of this coke from over a given period were assayed by Mr. Alexander Orr, and the following results are given by Messrs. Figtree and Sons.

	Ash.	Moist.
1910.		
July 6	13·40 per cent.	0·20 per cent.
September 6	14·10 „	0·90 „
November 8	14·00 „	0·40 „
January 9	14·20 „	0·70 „
March 7	13·50 „	1·00 „
May 3	13·00 „	0·30 „
1913.		
June 6	14·20 „	0·80 „
August 11	14·80 „	0·60 „
October 13	14·30 „	1·90 „
1914.		
January 16	14·60 „	1·60 „
March 10	13·80 „	0·60 „
1915.		
November 30	14·40 „	0·60 „
1916.		
March 17	14·80 „	0·80 „

An analysis of the ash contents of coke from these works is as follows:—

No. 598/16. Ashes from Mount Pleasant Coke. Analysis by H. P. White.

Chemical Composition.

Moisture at 100° C.	0·07
Silica (SiO_2)	50·94
Alumina (Al_2O_3)	32·01
Ferric oxide (Fe_2O_3)	3·30
Ferrous oxide (FeO)	0·27
Manganous oxide (MnO)	0·01
Lime (CaO)	5·72
Magnesia (MgO)	0·45
Barium oxide (BaO)	0·48
Strontium oxide (SrO)	†present
Soda (Na_2O)	0·71
Potash (K_2O)	1·02
Lithia (Li_2O)	†present
Titanium oxide (TiO_2)	1·65
Phosphoric anhydride (P_2O_5)	0·69
Vanadic oxide (V_2O_3)	*trace
Sulphur trioxide (SO_3)	2·34
Chromium Sesquioxide (Cr_2O_3)	abs.
Carbon	0·74
	100·40

* Less than 0·01 per cent. † Spectroscopic reaction only.

Mount Pleasant Coke Works, Wollongong.

† 67323

Corrimal-Balgownie Co.'s Ovens, Corrimal.

No. 4.

The Corrimal-Balgownie Collieries, Ltd.

The head offices of this company are at No. 6 Bridge-street, Sydney, and the original company's* works were situated adjacent to the Illawarra Railway line, near Unanderra, the old type of Beehive ovens being in use. In 1912 a complete new and up-to-date plant was erected adjoining the Illawarra Railway at Corrimal, and the old ovens of the Australian Coke Company, Ltd., were abandoned in 1913.

At the present time, apart from the Broken Hill Proprietary Steel Works, these are the only coke works in the State at which all the steam power required is obtained by burning the waste gasses generated in the coke ovens under the boilers. Sufficient horse-power is produced to provide for the coke works requirements, and a complete electrical installation at the Company's colliery, distant about 1½ mile from the ovens.

The necessary coal is obtained from No. 1, or the Bulli seam, but No. 2 or the Four Feet seam is thought to have possibilities within the company's leases, and excellent coke should result from blending (*see* page 14) in addition to the economic advantages. The sinking of two or more prospecting staples from the present colliery workings to No. 2 seam (about 35 feet below No. 1) is thought to be well worthy of consideration.

The following analyses of average samples of coal from this colliery are published in the Southern Coal-field Memoir.†

Coal from Corrimal–Balgownie Collieries.

Locality.	Section.	Analysis. Hygroscopic Moisture.	Volatile Hydr carbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	Calorific value.	Remarks.
Most westerly face (June, 1911).	Roof, grey shales with fragmentary plant remains. ft. in. Carbonaceous shale 0 1; Bright coal 0 3; Clay band 0 1; Coal 6 9	0·58	22·38	67·64	9·40	0·361	1·383	77·04	lb. 13·2	Ash: grey, granular. Coke: fairly swollen, firm, dull lustre.
Most southerly face (June, 1911), 2 miles from tunnel mouth.	Roof, grey shales. ft. in. Carbonaceous shale 0 1; Bright coal 0 2; Carbonaceous shale 0 1; Coal 7 9	0·40	24·55	66·38	8·67	0·320	1·349	75·05	13·60	Ash: grey, granular. Coke: well swollen, firm and lustrous.

* The Australian Coke Co., Limited.

† "Geology and Mineral Resources of the Southern Coal-field," by L. F. Harper, F.G.S., Geological Surveyor, Mem. Geol. Survey of New South Wales, Geology No. 7, Sydney, 1915, p. 151.

Slack coal only is used at the coke works, and washing is not considered necessary, the slack being fed direct to a Carr disintegrator by a scraper elevator.

Canisters, electrically driven, charge the duff to the ovens, which are of the "Thomas" type, with the following dimensions:—30 feet long, 6 ft. 7½ in. wide, and 6 ft. 6 in. high. Forty ovens are in use, and the burning periods are seventy-two and ninety-six hours, the charge for the former being 12 tons and for the latter 14 tons. The coke is pushed out by an electrically-worked ram, and then quenched on the landing bench.

Owing to broken time due to strikes, &c., the company was not able to supply figures as to the quantity of coal used, and coke produced, but the works have a maximum capacity of 760 tons of coke per week.

The following commercial analysis as between buyer and seller, as determined during December, 1912, was supplied by the company:—

	per cent.
Volatile hydrocarbons	1·10
Fixed carbon	83·04
Ash	14·80
Sulphur	·46
Moisture	·60
	100·00

Ash Analysis.

Silica	69·30
Iron oxide	3·30
Alumina	21·40
Magnesia	·20
Sulphur	trace
Lime (Cal.)	5·30
	99·50

During April, 1916, one of the writers thoroughly sampled the coke then being produced, and the sample gave the following result on being analysed in the Departmental Laboratory:—

No. $\frac{1185.}{16}$ Corrimal-Balgownie Coke Works.

Proximate Analysis.	per cent.
Hygroscopic moisture	0·96
Volatile matter	0·91
Fixed carbons	81·97
Ash	15·85
Sulphur	0·31
	100·00

Specific gravity.—1·857.
Ash.—Slight reddish tinge; loose.

Corrimal-Balgownie Co.'s Ovens, Corrimal.

A further sample was procured on the 10th of May, and analysed with the following result:—

No. $\frac{1443}{16}$. Corrimal-Balgownie Coke Works.

Proximate Analysis.	per cent.
Hygroscopic moisture	0·53
Volatile matter	0·17
Fixed carbon	83·60
Ash	15·25
Sulphur	0·45
	100·00

Specific gravity—1·850.
Ash—Buff coloured, loose.

The chemical composition of the ash contents is as follows:—

No. $\frac{1186}{16}$. Ashes, Corrimal-Balgownie Coke Works. Analysis by W. G. Stone.

Chemical Composition.	per cent.
Moisture (at 100° C.)	0·04
Silica (SiO_2)	52·38
Alumina (Al_2O_3)	33·53
Ferric oxide (Fe_2O_3)	6·50
Ferrous oxide (FeO)	0·18
Manganous oxide (MnO)	0·13
Lime (CaO)	2·58
Magnesia (MgO)	0·44
Barium oxide (BaO)	0·36
Strontium oxide (SrO)	*present
Soda (Na_2O)	0·61
Potash (K_2O)	1·17
Lithia (Li_2O)	*present
Titanium oxide (TiO_2)	1·15
Phosphoric anhydride (P_2O_5)	0·53
Vanadic oxide (V_2O_3)	†trace
Sulphur trioxide (SO_3)	0·46
Chromium Sesquioxide (Cr_2O_3)	†trace
Carbon	0·16
	100·22

* Spectroscopic reaction only. † Less than 0·01 per cent.

No. 5.

The Associated Smelters (Bellambi Coke Works.)

These works were started by the Broken Hill Proprietary Company in 1901 and were taken over by the present owners, the Broken Hill Associated Smelters, in June, 1915, with Mr. F. H. Fleming as manager.

The ovens are situated about half a mile north of Bellambi station, 43 miles from Sydney, and 8 miles from Port Kembla, the coke being shipped in about equal proportions from both places, and there is practically no difference in costs, despite the big discrepancy in railway haulage.

The coal used, all in the form of slack, is obtained from the Bulli seam as worked at the South Bulli colliery, the quality of which is indicated by the following analyses published in The Coal Resources of New South Wales :*—

Name of Colliery, Locality, &c.	Section of Seam.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	lb. of water converted into steam by 1 lb. of the coal	Remarks.
South Bulli Colliery, near Bulli. Top of Bulli Seam.—Sample from the upthrow side of the 67-feet fault in Hansen's heading to the left of the main west tunnel.	Roof, shale. ft. in. Spar-coal and bands 0 2 Coal .... 7 6= 7 8 Floor, shale.	0·77	25·41	64·38	9·44	0·388	1·372	73·82	13·5	Coke, fairly swollen, firm and lustrous; ash, light grey, semi granular.
South Bulli Colliery. — Sample taken in Williams and Son's bord right side of north-west heading, west tunnel.	Roof, shale. ft. in. Spar .... 0 6½ Coal.......... 7 7½= 8 2 Floor, shale.	0·46	24·64	66·07	8·83	0·501	1·371	74·90	13·3	Coke, fairly swollen, firm and lustrous; ash, light grey, semi-granular.

The coke ovens are alongside the Colliery company's railway line, and distant 1¼ mile from the mine.

The slack is mechanically delivered from the main storage bin, without washing, to a Stedman type of disintegrator, and conveyed to the duff hopper, from which it passes into three sets of overhead skips for discharge into the oven ports. The ovens are of the rectangular Beehive type, the generated gasses not being used, each provided with six horizontal flues, and arranged in two benches of fifty each, in addition to which fifteen ovens are now being constructed. They are built of Illawarra Brick Company's and Pendlebury and Son's dry-pressed ordinary and fire bricks, the dimensions being : length 30 feet, width 2 feet 11 inches, tapering to 2 feet 7 inches, and 6 feet high.

The burning periods are seventy-two and ninety-six hours alternately, the charge for the former being 4 tons 15 cwt., and for the latter 6 tons 13 cwt., the coke percentage working out at 72·16.

The coke is pushed out by a hydraulic ram, external quenching being adopted, and it is estimated that the loss from breeze, burnt coke, &c., approximates 4 per cent. The product is fork filled into barrows, and either wheeled into the railway waggons or to the reserve supply heap, the latter evidently being an important factor with the company, judging by its size.

The past twelve months' output from these works was 53,102 tons of coke, from 73,581 tons of slack, seventy-one men are employed, and the output is entirely absorbed by the company. In fact it was pointed out by the management that, if sufficient slack coal could be obtained, an additional fifty ovens would be erected at once.

* E. F. Pittman, Sydney, 1912.

Associated Smelters' Coke Works, Bellambi.

Associated Smelters' Coke Ovens, Bellambi.

An average sample of coke obtained at these works on the 18th February, 1916, was analysed, with the following result:—

No. $\frac{472}{16}$. Coke from Bellambi Coke Works.

Proximate Analysis.

Hygroscopic moisture	0·49
Volatile matter	0·73
Fixed carbon	82·40
Ash	15·99
Sulphur	0·39
	100·00

Specific gravity—1·851.

Ash—Light, reddish tinge, semi-granular.

Coke—Dark grey in colour, dense, and hard; not readily broken in handling, and should stand a heavy burden for smelting purposes.

The ash contents had the following chemical composition:—

No. $\frac{597}{16}$. Ashes from Bellambi Coke Works. (Associated smelters). Analysis by W. G. Stone.

Chemical Composition.

Moisture at 100° C.	0·08
Silica (SiO_2)	50·38
Alumina (Al_2O_3)	33·80
Ferric oxide (Fe_2O_3)	5·65
Ferrous oxide (FeO)	0·36
Managnous oxide (MnO)	0·05
Lime (CaO)	3·80
Magnesia (MgO)	0·73
Barium oxide (BaO)	0·35
Strontium oxide (SrO)	*present
Sodu (Na_2O)	0·60
Potash (K_2O)	1·13
Lithia (Li_2O)	*present
Titanium oxide (TiO_2)	1·25
Phosphoric anhydride (P_2O_5)	0·71
Vanadic oxide (V_2O_8)	0·02
Sulphur Trioxide (SO_3)	1·37
Chromium Sesquioxide (Cr_2O_3)	†trace
	100·28

* Spectroscopic action only. † Less than 0·01 per cent.

No. 6.

The Bulli Coke Works.

These works were established in 1889 by the Bulli Coke Coy. Limited, and have subsequently been acquired by The Bulli Colliery Coke Works, Ltd., the city office being situated in Tattersall's Hotel Buildings, Pitt-street, Sydney.

The ovens are adjacent to the Illawarra Railway Line, 1 mile from the colliery, to which they are connected by a private line of railway. Port Kembla is distant 14 miles, and Sydney 41 miles, and coke is shipped in about equal quantities from either port.

Only slack coal is used, and is obtained from the Bulli Colliery, where both No. 1 or the Bulli Seam and No. 2 or the Four Feet Seam are being worked, and a blend of coal from both is occasionally coked with very satisfactory results.

When the works were inspected, slack from No. 1 seam only was being used, so that a sample of coke made from the mix was not obtainable.

Analyses of coal from both No. 1 and No. 2 seams, as published in the Coal Resources of New South Wales* are as follows :—

PROXIMATE Analyses of Samples of Coal from Bulli Colliery.

Name of Colliery, Locality, &c.	Section of Seam.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	lb. of water converted into steam by 1 lb. of the coal.	Remarks.
Bulli Colliery, Bulli. Four-feet Seam.—Sample taken in Salisbury's cut-through.	Roof, sandstone. ft. in. Coal .... 1 3 Band .... 0 1 Coal .... 2 8 Splint 0 8 4 8	1·07	21·46	65·71	11·76	0·413	1·432	77·47	12·7	Coke, slightly swollen, firm, dull lustre; ash: light grey, granular.
Bulli No. 4 Tunnel Colliery, Bulli. Four-feet Seam.—Sample from face of Mordue's bord.	Roof, sandstone. ft. in. Coal .... 2 0½ Band .... 0 1 Coal .... 1 8½ Splint ..... 0 6 4 4 Floor, shale.	0·42	22·67	63·72	13·19	0·384	1·422	76·91	12·2	Band picked out; coke: slightly swollen, firm and lustrous; ash : grey, granular.
Bulli Colliery, Bulli. Top or Bulli Seam.—Sample taken at working face of a pillar, No. 1 heading, Robinson's district.	Roof, shale. ft. in. Coal .... 7 9= Splint 0 3 8 0	0·97	24·23	61·90	12·90	0·424	1·429	74·80	12·6	Coke : well swollen, firm and lustrous; ash : light grey, granular.
Bulli Colliery. Top or Bulli Seam.—Sample taken from near face of right back heading, Western district, just through troubled country.	Roof, shale. ft. in. Spar .... 0 4 Coal .... 6 0= 6 4	0·57	24·30	64·61	10·52	0·369	1·400	75·13	13·0	Coke: fairly swollen, firm and lustrous; ash : reddish tinge, granular.

The slack used is not washed, but passed through a Carr disintegrator direct, from which it is raised to the main storage bin by a mechanical elevator. It is conveyed from the bin to the ovens in canisters running on two sets of rails, and discharged into two ports set in the crown of the oven, gravity and hand power only being used.

The duff as charged to the ovens was analysed in the Departmental Laboratory with the following result :—

No. $\frac{594}{16}$. " Duff " coal as charged to ovens, Bulli Coke Works.

Proximate Analysis.

Hygroscopic moisture	0·49	
Volatile matter..	24·43	
Fixed carbon	61·31	Coke = 75·08 per cent.
Ash..	13·77	
	100·00	

Sulphur in coal—0·343 per cent.

Ash—Light-buff coloured, granular.

* E. F. Pittman Sydney, 1912.

Bulli Coke Works.

The ovens, of the Welsh type, and fifty-four in number in two sets of fifteen and thirty-nine each, are about 21 feet long, and tapering from 4 ft. 6 in. to 4 feet in width. The original height of the ovens was 4 feet, but this is gradually being raised to 5 ft. 6 in. as opportunity offers, or repairs are necessary. The flue system is horizontal, the generated gasses being conveyed in a vertical flue at the ram end into the floor flues, and thence into the main discharge passage leading to the stacks, of which there are two, one at either end of the sets of ovens.

The time for burning is divided into two periods of forty-eight and seventy-two hours respectively, the charge for the former being 4 tons 12 cwt. of slack, yielding 3 tons 10 cwt. of coke, and for the latter 6 tons of slack, yielding 4 tons of coke.

After the coking process is completed, the doors of the ovens are raised and the charge pushed out by a ram, hydraulic power being used for both purposes. The coke is quenched on the landing platform, the necessary water being sprayed from a hose, and supplied from two dams with a considerable catchment, having a total capacity of one and a half million gallons.

It is estimated that the loss from breeze, ash, &c., is about two per cent., but this varies considerably, and is dependent upon the quality of the coal, atmospheric conditions during burning, and thorough quenching at the time the charge is just ripe.

The generated gasses are allowed to go to waste, and the general layout of the works appears somewhat unfavourable for economic handling.

The bricks used in the construction of the ovens are Pendlebury and Sons' dry-pressed ordinary, with fire brick lining. It is found that the life of the ovens varies enormously, some having been constantly in use for twenty years without even repairs.

The principal consumers of the coke produced are the Broken Hill Proprietary Coy., Port Pirie, and San Francisco (U.S.A.) firms. 31,704 tons of slack coal were used during 1915, for a yield of 22,872 tons of coke, or equivalent to 72·1 coke percentage, whilst an average of twenty-five men are employed at the works.

An average sample of coke was obtained here on the 24th February, 1916, and analysed with the following result:—

No. $\frac{592}{16}$. Coke from Bulli Coke Works.

Proximate Analysis.

Hygroscopic moisture	0·46
Volatile matter	1·40
Fixed carbon	80·08
Ash	17·64
Sulphur	0·42
	100·00

Specific gravity—1·880.

Ash—Light-buff coloured, semi-flocculent.

Coke—Dark grey in colour, dense and hard; pieces of shaly material visible in the coke; should stand the weight of a heavy burden in a smeltinrg funace, and not readily broken on handling.

The ash contents of this coke had the following chemical composition :—

No. $\frac{600}{16}$. Ashes from Bulli coke. Analysis by H. P. White.

Chemical Composition.

Moisture at 100° C.	0·09
Silica (SiO_2)	49·70
Alumina (Al_2O_3)	31·82
Ferric oxide (Fe_2O_3)	4·20
Ferrous oxide (FeO)	0·23
Manganous oxide (MnO)	0·01
Lime (CaO)	5·82
Magnesia (MgO)	1·38
Barium oxide (BaO)	0·48
Strontium oxide (SrO)	*present
Soda (Na_2O)	0·57
Potash (K_2O)	1·36
Lithia (Li_2O)	*present
Titanium oxide (TiO_2)	1·45
Phosphoric anhydride (P_2O_5)	0·68
Vanadic oxide (V_2O_3)	0·01
Sulphur Trioxide (SO_3)	1·79
Chromium Sesquioxide (Cr_2O_3)	abs.
Carbon	0·58
	100·17

* Spectroscopic reaction only.

On 12th April, 1916, a further average sample of coke was taken, and analysed with the following result :—

Second sampling of Bulli coke—

Proximate Analysis.

	1.	2.
Hygroscopic moisture	0·17	
Volatile matter	0·69	
Fixed carbon	80·76	
Ash	18·02	18·03
Sulphur	0·36	
	100·00	

Specific gravity—1·906.

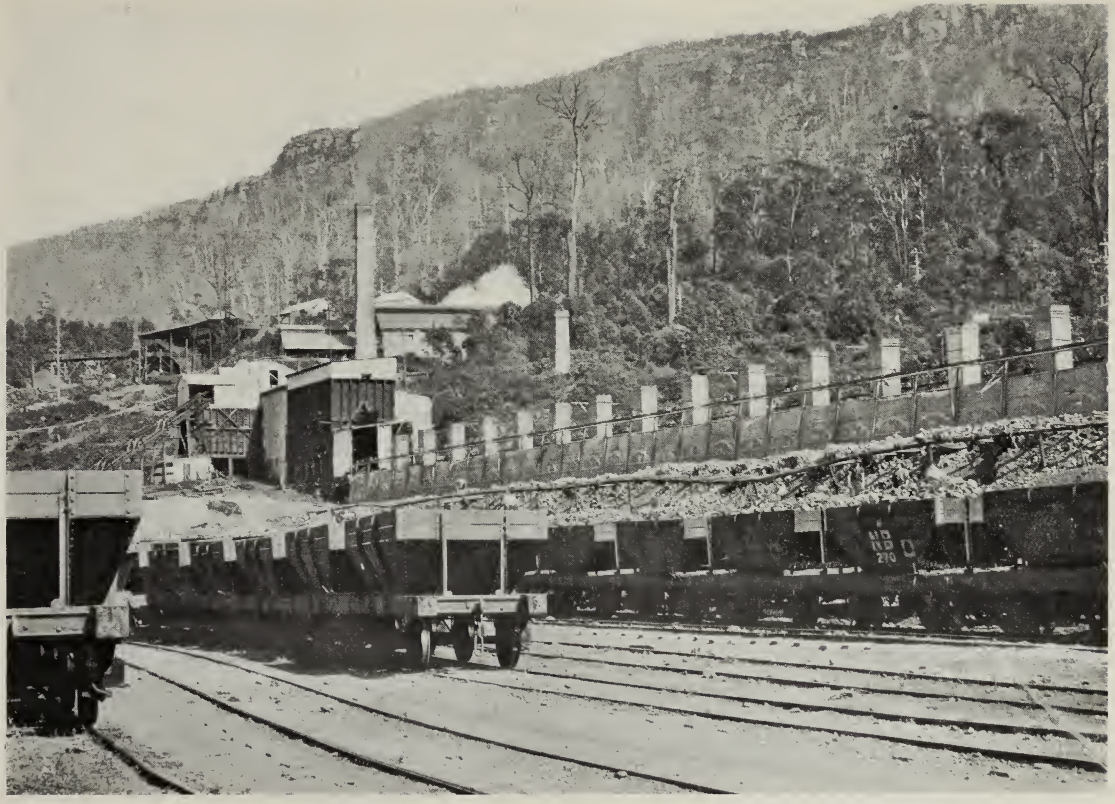
Ash—Light-buff coloured, semi-flocculent.

The sample when received was very damp and was air dried before the analysis was made.

No. 7.

North Bulli.

The coke ovens of this company were erected in 1906, and at the present time are under the superintendence of Mr. Miller, the colliery manager. The head office of the company is at 4 O'Connell-street, Sydney, and the works are situated at Coledale, a station on the Illawarra railway line, 38 miles from Sydney, and 17 miles from Port Kembla. The coal used is mainly obtained from the Bulli seam as worked at the North Bulli colliery, distant between 200 and 300 yards from the ovens.



North Bulli Co.'s Ovens, Coledale.

Analyses of coal from this colliery, as published in "The Coal Resources of New South Wales" are as follow* :—

ame of Colliery, Locality, &c.	Section of Seam.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	lb. of water converted into steam by 1 lb. of the coal.	Remarks.
th Bulli Colliery. olédale. Bulli eam.—Sample om a face of first ght cross-cut off o. 17, left heading elow the down-row (150 feet) ult.	Roof, shale. ft. in. Spar .... 0 3 Coal.......... 5 0= 5 3 Floor, shale.	0·83	22·79	63·97	12·41	0·519	1·403	76·38	12·7	Coke : fairly swollen, firm and lustrous; ash: light grey in colour, semi-granular.
th Bulli Colliery, oledale. Bulli eam—Sample om face of 7th ft. off No. 18 ght heading.	Roof, sandstone. ft. in. Spar ...... 0 2 Coal .... 3 11½= Splint ..... 0 1½ 4 3 Floor, shale.	0·43	24·22	62·98	12·37	0·398	1·415	75·35	12·4	Coke : slightly swollen, firm and lustrous; ash : light grey, granular.

It is probable that the slack coal used at the coke works contains a slightly higher ash percentage, but the comapny has not seen fit to establish a coal-washing plant.

The coal is transported by a mechanical conveyor to the Carr disintegrator; a reserve storage pit also being used for receiving slack from other collieries when it is necessary to purchase extra supplies; this also being raised to the disintegrator by a mechanical conveyor.

From the disintegrator the duff, as the ground coal is called, is mechanically conveyed to a storage bin, from which it is removed to the ovens by electrically-operated motors travelling on parallel sets of rails, and moving two canisters of duff at a time to each charging port, of which there are two per oven. These latter are of the rectangular Beehive type, and are provided with a single vertical flue leading to a chimney stack about 9 feet high, one stack serving every two ovens.

The ovens are built in two sets of fifty-two and fifty-four respectively, with a continuous overhead connection for charging. The dimensions of the former are 20 feet long, 6 feet 2 inches high to the crown of the arch, and 7 feet wide at one end, tapering to 6 feet 8 inches at the other, whilst the latter are 19 feet long, the remaining dimenions being the same.

The periods of burning are forty-eight and seventy-four hours, the charge for the former being 6 tons of duff, and the latter from 8 to 9 tons. After the coking process is completed the doors of the ovens are raised by hydraulic power and the charge pushed out by a steam-driven ram.

The coke is partially quenched on the landing stage with a sprayer designed by Mr. Miller, which is moved along an overhead wire-rope to the necessary position, and consists of a horizontally-suspended pipe-length with radiating

* E. F. Pittman, Sydney, 1912.

apertures extending the width of the charge, and connected by a length of hose to the main service-pipe. Further quenching is done by a hose on the coke bench, and it is estimated that the wastage in a charge after withdrawal approximates 3 per cent., but this is of necessity variable.

No use is made of the generated gasses, and at the time the works were inspected production was apparently greater than removal facilities, with the result that charges were pushed out on top of one another, ash and breeze accumulated, whilst the moisture percentage must have been high in the lower layers of coke.

The daily output is from 185 to 190 tons from thirty-seven ovens, and the number of men employed, fifty. The bricks for the ovens are supplied by the Illawarra Brick Company and Pendlebury and Sons, both ordinary dry-pressed and fire-bricks being used. The water supply is obtained from a surface catchment dam, with the Illawarra service supply to draw on in case of shortage.

The coke produced during 1915 was about 50,000 tons, approximately 70,000 tons of slack coal being used, or about 71 per cent. of coke.

A sample of coke was procured from these works on 24th February, 1916, and analysed with the following result:—

No. $\frac{591}{16}$. Coke, North Bulli Coke Works.

Proximate Analysis.

Hygroscopic moisture	0·59
Volatile matter	1·18
Fixed carbon	80·59
Ash	17·23
Sulphur	0·41
	100·00

Specific gravity—1·847.

Ash—Buff coloured, semi-flocculent.

Coke—Dark grey in colour, dense, and hard, with very rough surface. Should stand the weight of a heavy burden in a smelting furnace, and is not readily broken in handling.

The chemical composition of the ash contents was as follows:—

No. $\frac{599}{16}$. Ashes from North Bulli Coke. Analysis by W. G. Stone.

Chemical Composition.

Moisture at 100° C.	0·06
Silica (SiO_2)	50·00
Alumina (Al_2O_3)	25·70
Ferric oxide (Fe_2O_3)	10·60
Ferrous oxide (FeO)	0·45
Manganous oxide (MnO)	0·12
Lime (CaO)	5·02
Magnesia (MgO)	2·47
Barium oxide (BaO)	0·10
Strontium oxide (SrO)	*present
Soda (Na_2O)	0·57
Potash (K_2O)	1·49
Lithia (Li_2O)	*present
Titanium oxide (TiO_2)	1·20
Phosphoric anhydride (P_2O_5)	0·13
Vanadic oxide (V_2O_3)	0·01
Sulphur trioxide (SO_3)	1·91
Chromium sesquioxide (Cr_2O_3)	†trace
Carbon	0·40
	100·23

* Spectroscopic reaction. † Less than 0·01 per cent.

South Clifton Coke Works (Northern bench of Ovens).

No. 8.

South Clifton Coal and Coke Company.

The coking plant of this Company was established sixteen years ago (1900), and is situated alongside the colliery shaft, adjacent to the Illawarra Railway line at South Clifton, 36 miles from Sydney, and 16 miles from Port Kembla. The city offices are located at No. 89, A.M.P. Chambers, Pitt-street, Sydney, under the general management of Mr. C. F. Mallett.

Only slack coal is used, and is obtained from the Bulli Seam at the South Clifton pit workings. Analyses of this coal, as published in "The Coal Resources of New South Wales,"* are as follow :—

me of Colliery, Locality, &c.	Section of Seam.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	Lb. of water converted into steam by 1 lb. of the coal.	Remarks.
ı Clifton Col-·y. Bulli Seam. Sample from face No. 10 heading first ri ht flat, No. 8 rope road.	Roof, shale. ft. in. Coal.......... 5 7 Floor, shale.	0·69	22·02	65·61	11·68	0·466	1·384	77·29	12·8	Coke, slightly swollen, firm and lustrous; ash, light grey in colour, semi-granular.

The whole of the slack coal is passed through a Carr disintegrator below the colliery screens, the method of handling both the slack and duff being a mechanical overhead conveyor system, discharging from either side. The ovens are of the old-fashioned Beehive type, built of brick and rubble stone work, 66 in number, and of the following dimensions :—12 feet in diameter and 7 feet 6 inches high. They are arranged in benches of 24 and 42 ovens, situated on either side of the colliery, the ovens being placed back to back in each bench. The burning is divided into 72 and 96 hour periods, the duff charge for the former being 4 tons and for the latter 5 tons.

Internal quenching is adopted, the water supply being obtained from surface catchment. After quenching the coke is withdrawn by hand, about 10 per cent. of the product being bagged and the remainder loaded into railway trucks for transport.

It is estimated that the loss from breeze and ash approximates 2 per cent., or about 1¾ cwt. per oven, and is composed largely of ash.

The generated gases are allowed to go to waste, and although mechanical charging is adopted, the type of ovens in use do not lend themselves to economic handling.

Both Hurstville and the Illawarra Brick Co.'s bricks are used in the ovens, and the coke is shipped at Sydney Harbour and Port Kembla in about equal quantities.

The output of coke for 1915 was 16,300 tons, obtained from 21,725 tons of slack, and 30 men were employed at the works.

* E. F. Pittman, Sydney, 1912.

An average sample of coke was taken at these works on the 25th of February, 1916, and analysed, with the following result:—

No. $\frac{593}{16}$. Coke from South Clifton Colliery Coke Works.

Proximate Analysis.

Hygroscopic moisture	0·81
Volatile hydrocarbons	1·10
Fixed carbon	82·49
Ash	15·30
Sulphur	0·30
	100·00

Specific gravity.—1·832.

Ash.—Buff coloured, semi-flocculent.

Coke.—Dark grey in colour, dense, hard and compact; should stand readily handling without breaking, and the weight of a heavy burden in a smelting furnace.

The ash contents of this coke has the following composition:—

No. $\frac{601}{16}$. Ashes from Coke, Clifton Colliery. Analysis by W. G. Stone

Chemical Composition.

Moisture at 100° C.	0·06
Silica (SiO_2)	49·18
Alumina (Al_2O_3)	27·80
Ferric oxide (Fe_2O_3)	9·55
Ferrous oxide (FeO)	0·31
Manganous oxide (MnO)	0·08
Lime (CaO)	5·40
Magnesia (MgO)	2·55
Barium oxide (BaO)	0·22
Strontium oxide (SrO)	*present
Soda (Na_2O)	0·51
Potash (K_2O)	1·04
Lithia (Li_2O)	*present
Titanium oxide (TiO_2)	1·30
Phosphoric anhydride (P_2O_5)	0·39
Vanadic oxide (V_2O_3)	0·01
Sulphur trioxide (SO_3)	1·79
Chromium sesquioxide (Cr_2O_3)	abs.
	100·19

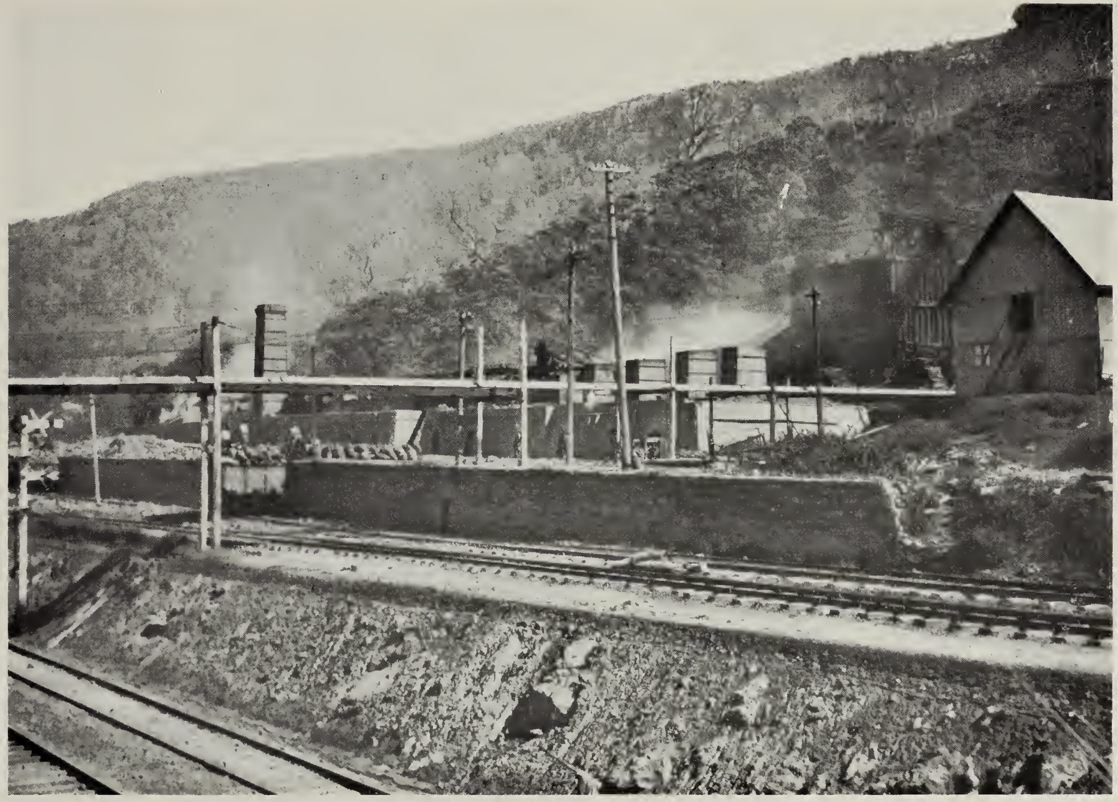
* Spectroscopic reaction only.

No. 9.

The Illawarra Coke Company, Limited.

This Company commenced operations towards the end of 1913, the first coke being drawn in December, 1914, so that the plant is yet in its infancy. Many of the latest improvements in coke works are being adopted, but are still in a more or less experimental stage.

It may be said that such has already been passed through in other countries, and that an experienced expert, after inspection of the world's principal coking plants, should have been in a position to erect suitable plant at once.



South Clifton Coke Works (Southern bench of Ovens).

† 07323

This is no doubt true up to a certain point, but it must be remembered that an entirely new set of local conditions present themselves, which can only be met by corresponding innovations or adjustments, and the Company is to be congratulated on its efforts to raise the standard of coking plants in New South Wales.

Under these circumstances it is not possible to state what will be the ultimate methods of treatment found most suitable, but it is evident that the aims of the Company are centred upon adopting the most economic modern appliances, best suited to local conditions and coke requirements.

The city offices of the Company are situated at 4, Bridge-street, Sydney, and the works at Coal Cliff, adjacent to the Illawarra Railway line and Coal Cliff Colliery.

They are 34 miles distant from Sydney by rail, and 18 miles from Port Kembla, at both of which ports the coke is shipped, but mainly from the former.

Only slack coal is used, the supply being obtained almost entirely from the Coal Cliff Colliery. An elaborate conveyor-belt system 300 feet long, with automatic coal weighing attachment, and capable of handling 100 tons of slack per hour, transfers the coal from the colliery hoppers to the Coke Company's bins. It is there screened, the fines being fed into the "duff" hopper direct, whilst the coarser portion is first passed through a Carr disintegrator. With the exception of the oven door lifter which is worked by hydraulic power, all the mechanical arrangements are operated by electricity supplied by the colliery plant.

The ovens, of which there are 50, are of the improved patent Beehive type, with the following dimensions:—length 32 feet, width 9 feet 3 inches, tapering to 9 feet, and height 7 feet 6 inches. Each oven has four overhead charge ports, and one stack is provided for every two ovens, whilst the two canisters for conveying the duff from the store bin to the oven are fitted with a double discharge, and carry sufficient for a full oven-charge.

Analyses of average samples of coal from the Coal Cliff Colliery, as published in "The Coal Resources of New South Wales," are as follows*:—

Locality.	Section of Seam.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	Calorific value.	Remarks.
Coal Cliff Colliery. Top or Bulli Seam.—Sample taken in pump heading, West district (Jetty).	Roof, sandstone. ft. in. Spar .... 0 1 Coal.......... 5 6= 5 7	0·57	22·93	62·55	13·95	0·328	1·391	76·50	13·4	Coke, slightly swollen, firm and lustrous; ash, light grey, granular.
Coal Cliff Colliery. Bulli Seam.—Sample taken in right back heading, west drive over stone drift (shaft).	Roof, sandstone. ft. in. Spar .... 0 3 Coal.......... 5 1= 5 4	0·85	22·00	65·37	11·78	0·341	1·394	77·15	13·4	Coke, fairly swollen, firm and lustrous; ash, light grey, granular.

* E. F. Pittman, 1912.

A washing plant is not considered necessary by the Company, and a sample of the duff as fed into the ovens was recently analysed in the Departmental Laboratory with the following result, the sample having been taken on 28th March, 1916 :—

No. $\frac{958}{16}$. "Duff" Coal. Illawarra Coke Co., Coal Cliff.

Proximate Analysis.

Hygroscopic moisture	0·71	
Volatile matter	23·73	
Fixed carbon	63·39	Coke—
Ash	12·17	75·56 per cent.
	100·00	

Sulphur in coal.—0·398 per cent.

Ash.—Light grey in colour, semi-flocculent.

The hours of burning are arranged in 72 and 96 hour periods, the charge for the former being 16 tons, and for the latter about 20 tons 6 cwt. It is estimated that the recovery is about 69 per cent., and the output per oven 25 tons of coke per week.

After the coking process is completed, the doors of the oven are raised by the hydraulic lifter, and the coke pushed out by a double-racked Buchanan ram, worked by electricity. The quenching is done on the landing stage by a locally designed cage sprayer, suspended on an overhead rail and provided with solid iron sides to prevent the charge spreading, whilst six overhead perforated pipes with two separate water-feeds pour a considerable volume of water on to the coke as it passes through the cage. The ram pushes the charge right across the landing stage, and it slides into a travelling hopper for removal to mechanical conveyors. As it slides into these it is again sprayed, and then passed over screens to railway waggons, or to another elevator for dumping on the reserve supply heap.

The Company is provided with a number of specially constructed waggons for use on the Government railways, which carry a full load of from 8½ to 9 tons of coke without hand packing.

No estimate has yet been formed of the loss in the form of breeze or burnt coke, but the writer's inspections of the works led to the belief that such was comparatively small.

The generated gases are not used, for apparently it suits the Company better to obtain the necessary power from the Coal Cliff Colliery plant, and to adopt a type of oven best suited to their coke requirements.

As already stated, this plant is not yet in full working order, and considerable broken time has resulted owing to constructional work, so that it is impossible to give an output extending continuously through any given period.

The present maximum weekly output would be about 1,250 tons, but for the week's run ending 1st April, 1916, 1,295 tons of coke were produced from about 1,850 tons of coal, or an average of about 70 per cent. Practically the whole of the output is absorbed by the smelters at the Mount Morgan Mining Co., Queensland, to whose works the coke is conveyed by rail, so that considerable handling is necessary before the coke reaches its destination.

The Illawarra Coke Co., Coalcliff.

The bricks used at the coke works are obtained from both Hurstville and the Illawarra Brick Company, the former type being found best suited for oven floor work.

The Company employ about twenty men, every effort apparently being made to adopt mechanical appliances which will reduce the number of hands required to a minimum.

The necessary water is obtained by gravity from a dam with a capacity of twelve million gallons, and an excellent catchment, so that provision has been made for even very droughty conditions.

On the 28th of March, 1916, these works were visited, and a thoroughly representative sample was taken by one of the writers, which on being analysed in the Departmental Laboratory, gave the following result :—

Locality and Official Number.	Specific Gravity.	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Remarks.
Illawarra Coke Company, 956–16.	1·847	0·48	1·40	82·62	15·05	0·45	Ash, buff coloured, semi-flocculent.

Assay results for the past six months—from 25th September, 1915, to 18th March, 1916—furnished by the Company, gave the mean ash contents as 15·70 per cent. The maximum amount found being 16·5 per cent.; the minimum, 15 per cent.

A sample of "Black ends" obtained was found to contain 13·07 per cent. of ash, 0·32 per cent. of sulphur, and 1·29 per cent. of hygroscopie moisture. The composition of the contained ash in the coke is as follows :—

No. $\frac{957}{16}$. Ashes from Illawarra Coke, Coal Cliff. Analysis by W. A. Greig.

Chemical Composition.

Moisture at 100° C.	Nil.
Silica (SiO_2)	46·50
Alumina (Al_2O_3)	28·63
Ferric oxide (Fe_2O_3)	7·30
Ferrous oxide (FeO)	0·36
Manganous oxide (MnO)	0·05
Lime (CaO)	10·22
Magnesia (MgO)	0·30
Barium oxide (BaO)	0·16
Strontium oxide (SrO)	absent
Soda (Na_2O)	0·42
Potash (K_2O)	0·76
Lithia (Li_2O)	*present
Titanium oxide (TiO_2)	1·00
Phosphoric anhydride (P_2O_5)	0·79
Vanadic oxide (V_2O_3)	0·03
Sulphur trioxide (SO_3)	3·37
Chromium sesquioxide (Cr_2O_3)	†trace
	99·89

* Spectroscopic reaction only. † Less than 0.01 per cent.

Northern District Coke Works.

No. 10.

The Broken Hill Proprietary Steel Works, Newcastle.

This Company has erected a modern by-product coking plant in connection with their steel works at Port Waratah, Newcastle, the ovens being first used in June, 1915. They are connected to the State Railway System, and have deep-water shipping facilities, but the whole of the coke output is used in connection with the Steel Works. In fact, as pointed out elsewhere in this publication (page 62), the Company is compelled to purchase coke from outside sources.

The coal used is obtained from several collieries working on the Borehole Seam, and at the time the works were inspected, the Company supplied the following analysis of crushed coal as charged to the ovens during January and February, 1916, together with analyses of the ash.

Duff.

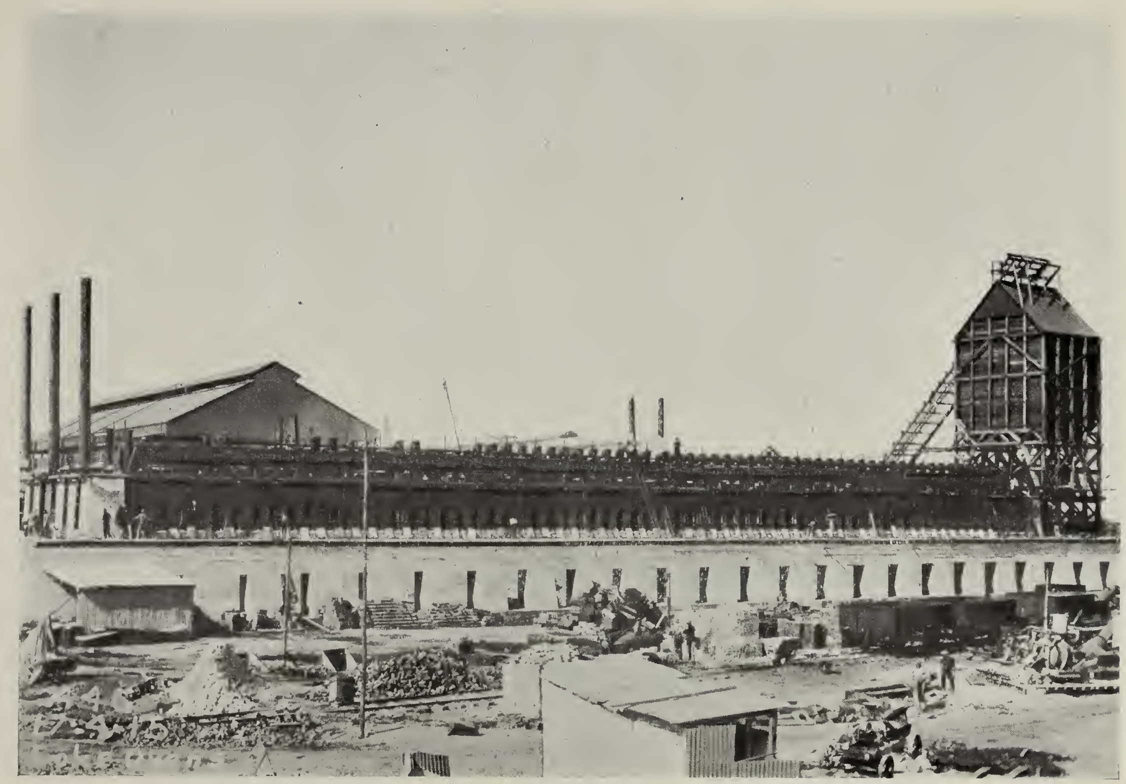
Fixed Carbon.	Volatile Hydro-carbons.	Ash.	Sulphur.	Date of Sampling.
56·47	31·43	12·1	·72	24 January, 1916.
55·93	31·56	12·5	·80	31 ,, ,,
55·77	32·20	12·0	·51	7 February, ,,
54·94	32·74	12·3	·58	14 ,, ,,
55·30	32·84	11·9	·50	21 ,, ,,

Ash.

Silica.	Ferric Oxide.	Alumina.	Lime.	Magnesia.	Manganese.	Phosphoric anhydride.	Iron.	Phosphorus.	Date.
46·0	18·0	30·5	3·4	...	trace	1·33	12·6	0·58	24 January, 1916.
44·0	15·4	34·6	2·9	0·36	·40	1·68	10·8	0·73	31 ,, ,,
48·8	14·3	33·1	2·2	Nil.	·37	1·10	10·0	0·48	7 February ,,
46·5	18·1	30·1	3·3	Nil.	·19	1·08	12·6	0·47	14 ,, ,,
44·6	17·9	32·5	3·3	trace	·14	1·29	12·4	0·57	21 ,, ,,

Both slack and large coal are used, the former being fed direct to a Carr disintegrator crushing 70 per cent. through twenty meshes to the inch, but the latter is first passed through toothed rolls. The crushed coal is then elevated to an overhead bin, and fed into a charging machine with four hoppers, registering with the oven-charging holes.

The ovens are of the most modern type, built after the Semet-Solvay Recuperative pattern, and sixty-six in number. The dimensions are 36 feet long, 8 feet high, and 1 ft. 6 in. wide, and they are built of imported Belgian and English fire-bricks, a percentage of the Illawarra Brick Company's product also being used.



By-product Coke Ovens, Broken Hill Proprietary Co.'s Steel Works, Newcastle.

The charge per oven is 7·9 tons of crushed coal, the burning period twenty-four hours, and the loss from breeze (small coke) and burnt coke is 2½ per cent. By-products are recovered, the generated gases being used for lighting and heating, and the tar sold to a separate company for further treatment. A complete plant for the preparation of sulphate of ammonia has been installed, and is producing a salt of excellent quality.

An analysis of the gas, supplied by the management through the courtesy of Mr. J. H. F. Hill, Coke Oven Superintendent, is as follows:—

ANALYSIS OF GAS.

Carbon dioxide.	Hydro-carbons.	Oxygen.	Carbon monoxide.	Methane.	Hydrogen.	Nitrogen.	Sulphuretted hydrogen.
2·8	4·0	0·5	7·7	32·6	49·0	2·8	0·3

British Thermal Units per cubic foot of gas, 602.
8 gallons of tar per ton of coal.
Average daily gas production 6,000,000 cubic feet.

After coking is completed, the charge is pushed out by an electrically operated ram, through a Darby quencher, and subsequently sprayed on the coke bench to complete the quenching, the water supply being obtained from the Hunter River District Service.

The total output is absorbed by the Steel Works, and the quality, as indicated by the following analyses made by the Company's chemist, although somewhat high in ash, and inclined to be brittle under pressure, would appear to be admirably adapted for requirements.

WEEKLY BULK ANALYSES OF COKE.

Volatile matter.	Ash.	Sulphur.	Date.
·48	16·5	·46	20 March, 1916.
·52	17·8	·46	27 ,, ,,
·38	16·1	·43	3 April, ,,
·57	17·8	·39	10 ,, ,,
·56	17·0	·39	17 ,, ,,
·33	18·0	·40	24 ,, ,,

Apart from the Australian Coking and By-products Company's Works at Islington, not now working, these are the first by-product ovens in the State, and it is probable that the success or otherwise of this process as applied to the New South Wales coals will be a great object lesson to coke producers throughout the State.

The percentage of coke ranges from 61·78 in the earlier outputs to 73·9 in more recent production, and this compares very favourably with other coke producers in the State.

One hundred and thirty-five men are employed at the Coke Works, and the output for six months ending 1st December, 1915, was 43,968 tons of coke produced from 71,160 tons of coal, while from the latter date to 3rd May, 1916, 48,496 tons of coke have been produced from 72,698 tons of coal.

A sample of the coke produced in these ovens was obtained on the 25th March, 1916, and gave the following result on being analysed in the Departmental Laboratory :—

No. 691/16. Coke. Broken Hill Proprietary Steel Works, Newcastle. Slack obtained from Seaham, Burwood and Lambton Collieries, Newcastle.

Proximate Analysis.

Hygroscopic moisture	1·38
Volatile matter	0·79
Fixed carbon	81·04
Ash	16·42
Sulphur	0·37
	100·00

Specific gravity.—1·809.
Ash.—Reddish tinge, semi-flocculent.
Coke.—Dark grey in colour, firm, light, and not readily broken on handling.

A complete analysis of the ash contents in this sample gave the following results :—

No. 750/16. Ashes, Broken Hill Proprietary Steel Works, Newcastle.
Analysis by J. C. H. Mingaye.

Chemical Composition.

Moisture at 100° C.	absent
Silica (SiO_2)	54·02
Alumina (Al_2O_3)	32·63
Ferric oxide (Fe_2O_3)	7·50
Ferrous oxide (FeO)	0·36
Manganese oxide (MnO)	0·46
Lime (CaO)	0·92
Magnesia (MgO)	0·68
Barium oxide (BaO)	0·02
Strontian oxide (SrO)	*present
Soda (Na_2O)	0·85
Potash (K_2O)	1·16
Lithia (Li_2O)	*present
Titanium oxide (TiO_2)	0·85
Phosphoric anhydride (P_2O_5)	0·56
Vanadic oxide (V_2O_3)	†trace
Sulphur trioxide (SO_3)	0·24
Chromium sesquioxide (Cr_2O_3)	†trace
Carbon	trace
	100·25

* Spectroscopic reaction only. † Under 0·01 per cent.

There is a considerable difference in both the coke and ash analyses made in the Departmental Laboratory as compared with those made by the Company's chemist, but this might very well happen with samples taken on different dates when coal from several collieries is being used in varying proportions.

Through the courtesy of Mr. J. H. F. Hill, Superintendent of Coke Works at the Broken Hill Proprietary Company's Steel Works, under authority from the Company, the following information is available.

By-product Coke Ovens, Broken Hill Proprietary Co.'s Steel Works, Newcastle.

Ovens.—The ovens are of the Semet-Solvay Recuperative type. This oven is characterised by a lining for the ovens independent of the walls, a system of construction which ensures quick repairs and an equality of temperature through the large reservoir of heat carried in the main walls. It is possible to repair one of these ovens while those on each side are working as usual. The horizontal flues are visible for their whole length and regulation is thus rendered easy and certain, and an even temperature maintained throughout their length. The construction is everywhere substantial, and a long life for the ovens is thus obtained, with low maintenance charges. The oven flues are lined with special bricks of small size, which give much less trouble with contraction and expansion than the large blocks formerly in use —moreover repairs are much facilitated and cheaper. Quick coking is one of the results of this construction—the actual time now occupied being twenty-two hours. The gas from the ovens rises through the ascension pipe, and dips into the hydraulic (water sealed) main. Thence to the water-tube condensers, where it is cooled to such a degree as to deposit most of its moisture and tar together with the naphthaline, which is immediately taken up by the tar. About half of the ammonia is absorbed by the liquor of condensation. The benzol passes on unabsorbed, together with the remainder of the ammonia, and a certain residue of tar in the form of tar-fog. This latter, after passing the exhauster, is forced through the tar extractor—of the Pelouze and Audouin type—the feature of which is that the tarry gas is divided into a large number of small jets by passing through a perforated plate, these jets being then caused to impinge on a blank plate, whereupon the tar sticks and runs down while the gas passes on.

The gas next passes to the saturator. This is an enclosed vessel partially filled with weak sulphuric acid through which the gas now bubbles, the ammonia combining with the sulphuric acid with the formation of sulphate, which as the solution becomes saturated crystallises out and is removed with an ejector into a draining table, and thence to a centrifugal drier, after which it is conveyed to the storehouse. The ammonia liquor having been separated by gravity from the tar passes to stills where the ammonia is driven off with live steam, the fixed ammonia being set free by the addition to the liquor of milk of lime. The still gas joins the rest of the gas on its way to the saturator.

In this process, as will be seen, no absorption is required of the ammonia vapours in water. The ammonia scrubbers hitherto used are dispensed with, together with all their tanks, pipes and pumps, and the effluent liquor, sometimes a source of so much anxiety, is reduced in quantity by one half. This is known as the semi-direct process and is becoming increasingly popular.

The light oils still remain in the gas. They are known commercially as benzol, toluol and solvent naphtha, and consist of benzene, toluene and higher homologues in varying proportions. The removal of the light oils is effected by scrubbing the gas with creosote oil in scrubbers of various designs. The creosote takes up about 4 per cent. of its weight of benzol, and the benzolized oil is next distilled with live steam, whereupon the light oils distil over and are purified by washing with strong sulphuric acid and water, and neutralized with caustic soda. The washed oil is then fractionated into crude fractions, which are subsequently rectified into the pure products by another distillation for each product.

Benzol plants are, of course, required for the preparation of explosives, but apart from that are at present prices a lucrative investment.

No. 11.

Purified Coal and Coke Co., Wallsend.

This company's works were established in 1877, but have been enlarged and brought more up-to-date as opportunity offered. They are situated at Wallsend, and connected to the Government railway system at Waratah Junction by the Wallsend Colliery Company's private line, some 4 miles in length, whilst the Newcastle-Wallsend tram-line passes within a quarter of a mile of the works. The head office of the company is located at the corner of Bolton and Scott streets, Newcastle, and the management is in the hands of Mr. H. G. Langwell, with Mr. A. E. Taylor as engineer and works superintendent.

The coal used is from the Borehole seam, as worked at Wallsend Colliery, an analysis of which is published in "The Coal Resources of New South Wales"* as follows :—

Name of Colliery, Locality, &c.	Section of Seam.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	lb. of water converted into steam by 1 lb. of the coal.	Remarks.
Wallsend Colliery, Wallsend Borehole Seam.—Sample from the back heading, Modder River district, No. 1 split.	Roof shale. ft. in. Kerosene shale...... 0 3 Coal .... 0 5 Band ...... 0 0¾ Coal .... 0 2½ Band ...... 0 0½ Coal .... 1 6 Band ...... 0 0¾ Coal .... 1 4¼ Jerry ...... 1 6 5 4¾ Floor, sandstone.	1·04	35·27	53·40	10·29	0·488	1·376	63·69	12·4	Bands picked o…; coke: slig… swollen, f… and lustrous; ash: buff-coloured, se… granular.

Under normal conditions slack coal only is used, but at the present time, owing to depression in the coal trade, due to export restriction, about two-thirds large coal is used.

After having been screened at the colliery and delivered in hopper-waggons to the coke works, the slack is mechanically conveyed to the washery direct, whilst the large is first passed through a Gates rock breaker and fed to rolls.

It then joins the slack, and all is passed through a washery consisting of four pulsating vats, the washed coal passing over lips into a system of troughs with a mechanical restrainer consisting of an endless belt fitted with copper paddles, revolving in the opposite direction to the flow of coal-laden water. A large proportion of the water drains off through the bottom of these troughs, so that on reaching the third one an accellerator is used, similar in design to the restrainers, but the copper paddles act as scrapers, revolving in the direction of the discharge. As the water passes through the bottom of the troughs it removes a portion of the coal sludge, and this is fed back into the slack hopper, to again pass through the previous process. This does away

* E. F. Pittman, Sydney, 1912.

Wallsend Purified Coal and Coke Co.'s Ovens, Wallsend.

with any loss of coal, but would appear to increase the quantity of material passing through the disintegrator and washery to an unnecessary extent. The arrangement adopted at Mount Lyell Coke Works (see page 29), with regard to saving the coal-dust, would appear to have points in its favour if suitable to local conditions.

The slack coal used contains a proportion of what might be termed colliery refuse, and naturally a much higher ash percentage is present than in the large coal. This is considerably reduced by the washing process, as evidenced by the two following analyses :—

Analysis of slack coal as fed to the washery 16·1693.

Proximate analysis.

Hygroscopic moisture	1·92	
Volatile hydrocarbons	35·58	
Fixed carbon	48·81	Coke—62·5 %
Ash	13·69	
	100·00	

Ash—Dark-grey in colour, semi-granular.
Coke—Well swollen, firm and lustrous.
Sulphur in coal—0·549.

Analysis of prepared washed coal as fed to the coke ovens—

Proximate Analysis.

Hygroscopic moisture	1·94	
Volatile matter	35·90	
Fixed carbon	52·24	Coke—62·16 %
Ash	9·92	
	100·00	

Ash—Dark-grey in colour, semi-granular.
Coke—Well swollen, firm and lustrous.
Sulphur in coal—0·439.

In actual practice it is estimated by the management that the ash percentage is reduced by 10. At the time the sample was taken a large proportion of large coal was being used, hence the discrepancy.

From the washery the coal is fed to the disintegrator and passes through into the canisters ready for charging, the time occupied in the whole process being about three minutes, and the moisture left in the duff amounts to approximately 9 per cent.

The ovens are of the Beehive pattern, and seventy-six in number, arranged back to back, with the following dimensions : 11 feet in diameter, and 7 ft. 3 in. high to the crown of the arch. The duff charge weighs about 7 tons, and is filled from the top by means of canisters moved on rails by gravity when full, the empties being returned to the hoppers by a steam-worked endless rope, with a self-detaching clip arrangement.

The ovens are burnt in eighty-hour periods, at a maximum temperature of 1,500° F., and the air supply is provided by a system of horizontal flues, which cause it to pass completely round the coking bench before admission to the oven, a temperature of about 800° F. being thus reached before coming into use.

The coke return is estimated at 48 per cent. and after internal quenching it is withdrawn by hand, about 15 per cent. being bagged, 55 per cent. despatched by rail *ex* Newcastle, the remainder being loaded at that port for interstate shipment.

The bricks used in the ovens are locally made, no firebricks being utilised, as it is considered that the slight increase in the life of an oven when the latter type are used does not justify the increased cost. The co-efficient of expansion is somewhat high in the local brick, and they are fairly refractory, the life of the oven dome being estimated at fifteen years, and the barrel lasts about five years, but running repairs are carried out about every six months.

The necessary power is provided from an automatic feed, 200 horse-power Babcock and Wilcox boiler, whilst the water supply is obtained from a local dam or the Hunter River Water Supply service.

Forty-five men are employed at the works, and during the year 1915, 21,144 tons of coke were made from 44,000 tons of coal gross.

An analysis of the coke made in the laboratory of the Department of Mines from a sample procured on the 1st of March, 1916, gave the following result, whilst the chemical composition of the ash contents is indicated in the succeeding analysis.

No. $\frac{692}{16}$. Coke, Wallsend Purified Coal and Coke Co.

Proximate Analysis.

Hygroscopic moisture	1·16
Volatile matter	0·74
Fixed carbon	84·36
Ash	13·34
Sulphur	0·40
	100·00

Specific gravity.—1·754.
Ash.—Reddish tinge, semi-flocculent.

No. $\frac{749}{16}$. Ashes, Wallsend Purified Coal and Coke Co. Analysis by H. P. White.

Chemical Composition.

Moisture at 100° C.	absent
Silica (SiO_2)	57·24
Alumina (Al_2O_3)	24·81
Ferric oxide (Fe_2O_3)	11·20
Ferrous oxide (FeO)	0·27
Manganous oxide (MnO)	0·18
Lime (CaO)	2·52
Magnesia (MgO)	0·49
Barium oxide (BaO)	0·07
Strontium oxide (SrO)	†present
Soda (Na_2O)	0·56
Potash (K_2O)	1·03
Lithia (Li_2O)	†present
Titanium oxide (TiO_2)	0·95
Phosphoric anhydride (P_2O_5)	0·70
Vanadic oxide (V_2O_3)	0·02
Sulphur Trioxide (SO_3)	0·26
Chromium Sesquioxide (Cr_2O_3)	absent
	100·30

† Spectroscopic reaction only.

Wallsend Furified Coal and Coke Co.'s Ovens, Wallsend.

For special purposes a coke is made from a mixture of Jesmond coal and Mount Pleasant coal (Borehole seam and Bulli seam), and a sample of this coke was analysed with the following result :—

No. $\frac{954}{16}$. Wallsend Purified Coal and Coke Co. Mixture of Bulli and Jesmond Coal.

Proximate Analysis.

Hygroscopic moisture	0·69
Volatile matter	0·99
Fixed carbon	85·76
Ash	12·15
Sulphur	0·41
	100·00

Specific gravity—1·793.
Ash—Slight reddish tinge, flocculent.

The ash contents of this coal were analysed with the following result :—

No. $\frac{955}{16}$. Ashes, Wallsend Purified Coal and Coke Co. Coke made from Bulli and Borehole (Jesmond) coals. Analysis by H. P. White.

Chemical Composition.

Moisture at 100° C.	nil
Silica (SiO_2)	52·56
Alumina (Al_2O_3)	28·65
Ferric oxide (Fe_2O_3)	11·30
Ferrous oxide (FeO)	0·27
Manganous oxide (MnO)	0·08
Lime (CaO)	2·78
Magnesia (MgO)	0·16
Barium oxide (BaO)	0·21
Strontium oxide (SrO)	absent
Soda (Na_2O)	0·71
Potash (K_2O)	0·82
Lithia (Li_2O)	*present
Titanium oxide (TiO_2)	1·30
Phosphoric anhydride (P_2O_5)	0·99
Vanadic oxide (V_2O_3)	0·02
Sulphur trioxide (SO_3)	0·35
Chromium sesquioxide (Cr_2O_3)	absent
Carbon	......
	100·20

* Spectroscopic reaction only.

No. 12.

The Co-operative Colliery and Coke Works, Plattsburg.

No authentic record was obtainable of the year in which this Company was established, but it would appear to have been during 1875 or 1876.

The works are situated at Plattsburg—or Wallsend, as the village is now called—about half a mile from the Wallsend Company's railway, to which it is connected by a siding. The Sydney representative is Mr. W. Laidley, with offices at 7 O'Connell-street, and the Works Superintendent, Mr. Barr.

The colliery and coke works adjoin, and the coal used is won from the Borehole seam, which analysed as follows from this colliery:—*

Name of Colliery, Locality, &c.	Section of Seam.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	lb. of water converted into steam by 1 lb. of the coal.	Remarks.
Co-operative Colliery, Plattsburg. Borehole seam.—Sample from face of a pillar, Keira narrow bords, No. 2 tunnel.	Roof, coal and shale bands. ft. in. Coal.......... 1 9 Stone band 0 1 Splint coal 0 2 Coal.......... 1 8 Stone band 0 1 Coal.......... 2 4 Coal and shale bands ... 1 0 7 · 1 Sandstone floor.	1·84	36·10	55·90	6·01	0·576	1·314	62·00	13·2	Bands picked o...; coke: fa... swollen, ... and lustr...; ash: buff-coloured, se...granular.
Co-operative Colliery, Plattsburg.—Sample from face of a pillar in Reay's district, No. 1 tunnel.	Roof, coal and shale bands. ft. in. Coal .... 1 11 Stone band 0 0½ Coal .... 1 8 Stone band 0 0½ Coal .... 4 0 7 8 Floor, sandstone.	1·71	36·60	56·22	5·47	0·535	1·317	61·69	13·2	Bands picked o...; coke: fa... swollen, ... and lustr...; ash: buff-coloured, se...granular.

Here, again, both large and slack coal are being used at the present time, but washing has not been found necessary in view of the low ash percentage in the coal.

The nature of this coal enables a marketable coke to be made without undergoing a disintegration process, and large coal is sometimes used in the ovens, but the greater portion is first passed through a Carr disintegrator.

The ovens, sixty-seven in number, are of the old Beehive type, six pairs are built back to back, the remainder forming three sides of a rectangle, the central space being used as a coke bench. They range in size from 10 to 11 feet in diameter, and from 6 feet 7 inches to 10 feet from the floor to the crown of the dome. The six pairs have overhead feed ports, and are encased in dressed stone, whilst the remainder are built entirely of locally-made bricks, and shovel-filled from the door, the coal being wheeled by hand from the screens or disintegrator to the ovens.

The charge varies in weight from 4 to 6 tons, according to the size of the ovens, and the period of burning is three days throughout, whilst internal quenching is, of necessity, adopted owing to the type of oven, the Hunter River Water Supply Service being used.

It is estimated that the coke yield is 55 per cent., and the loss after withdrawal under 1 per cent. Twenty per cent. of the coke is bagged for interstate shipment, and the remainder distributed to the various consumers through the Government Railway system.

* E. F. Pittman, "The Coal Resources of New South Wales, Sydney, 1912.

Co-operative Coal and Coke Co.'s Plant, Wallsend.

Co-operative Coal and Coke Co.'s Ovens, Wallsend.

Only forty-four ovens are now in use, fourteen men being employed, and the output for 1915 was 7,161 tons of coke, produced from 13,020 tons of coal, or 54·92 per cent.

An average sample of coke was obtained from these works on the 1st March, 1916, and analysed with the following result in the Departmental Laboratory: —

No. $\frac{695}{16}$ Coke, Co-operative Coke Works, Plattsburg.

Proximate Analysis.

Hygroscopic moisture	1·67
Volatile matter	1·02
Fixed carbon	84·98
Ash	11·99
Sulphur	0·34
	100·00

Specific gravity—1·724.
Ash—Buff coloured, flocculent.
Coke—Light-grey in colour, firm, light, and not readily broken on handling.

An analsyis of the ash from this coke gave the following result :—

No. $\frac{751}{16}$ Ashes, Co-operative Coke Works, Plattsburg. Analysis by H. P. White.

Chemical Composition.

Moisture at 100° C.	nil
Silica (SiO_2)	56·96
Alumina (Al_2O_3)	30·65
Ferric oxide (Fe_2O_3)	7·05
Ferrous oxide (FeO)	0·14
Manganous oxide (MnO)	0·20
Lime (CaO)	0·82
Magnesia (MgO)	0·61
Barium oxide (BaO)	0·09
Strontium oxide (SrO)	absent
Soda (Na_2O)	0·69
Potash (K_2O)	1·01
Lithia (Li_2O)	*present
Titanium oxide (TiO_2)	1·45
Phosphoric anhydride (P_2O_5)	0·34
Vanadic oxide (V_2O_3)	0·02
Sulphur trioxide (SO_3)	0·09
Chromium sesquioxide (Cr_2O_3)	absent
Carbon	trace
	100·12

* Spectroscopic reaction only.

No. 13.

The Australian Coking and By-Products Company, Limited.

This Company's plant is situated at Islington, adjacent to the port of Newcastle, and was erected during 1912–13, with the object of manufacturing coke and saving the by-products. The works only ran five months when operations were suspended, and at the present time they are lying idle. It is somewhat difficult to realise the cause of this cessation of work, but after a personal inspection, one of the writers (L.F.H.) came to the conclusion that the faulty nature of the fire-bricks used in the oven construction were largely responsible.

The representative of the Company, Mr. W. Charnley, kindly supplied the following particulars with regard to the plant:—

"The coal is delivered into a pit from hoppers; conveyed by means of an elevator to top of washery; tipped on to screens, which grade it into three sizes; thence to washery boxes, which are on the jig principle, the dirt settling down is conveyed away by means of an elevator. The washed coal is carried away by shoots to a large settling basin. It is then lifted by means of an elevator, having perforated buckets to allow the water to drain away, to a storage bunker. The coal is discharged from underneath this bunker on to a belt, which carries it to two Carr disintegrators. These discharge the crushed coal on to a conveyor belt, which takes it to a bunker over coal charging machine, situate at end of ovens. This machine is a combined charger and ram, and runs on lines along the whole battery of forty-eight ovens. When coke is sufficiently burnt the machine is brought up to the particular oven, oven doors are raised, and the coke is pushed out on to platform in front of ovens. The ram is then drawn out of oven and fresh charge pushed in, doors lowered and luted. The ovens are of the well-known Coppee type, having vertical flues. Gases are drawn off through mains by means of exhausters to coolers and scrubbers which condense them into ammonia liquor and tar. Ammonia liquor is heated up to a gas, passed through milk of lime to saturator containing sulphuric acid, forming sulphate of ammonia. Surplus gases are returned to ovens. Plant capable of dealing with 240 tons coal per day; has three Lancashire boilers each 30 feet by 9 feet, of which two are heated by surplus heat from ovens. These raise steam for electric, washery, and sulphate plants."

No analysis of the coke produced was obtainable, but as Borehole seam coal was used, and a washery provided, results should have been satisfactory if the ovens were suitable.

No. 14.

The Rix's Creek Coke Works.

These works were established some fifteen years ago, but there is an older bench of ovens not now in use, and adjacent to the former main haulage tunnel of the colliery.* The Great Cobar Copper Company now own the colliery and coke ovens, and Mr. G. Youll, formerly Manager for the company, is working them on tribute.

They are situated on Rix's Creek, about 4 miles from Singleton, and are connected to the main Northern Railway line at Rix's Creek platform by a private line about 1 mile long. The distance from Newcastle, the nearest shipping port, is 52 miles by rail, where the entire output is now being used by the Broken Hill Proprietary steel works.

The necessary coal is obtained from Rix's Creek colliery, adjacent to the ovens, but the exact horizon of the seam being worked has not hitherto been definitely determined. A brief geological examination of the neighbourhood by one of the authors inclines him strongly to the belief that it is identical with the Borehole seam of the Newcastle district, for not only is the coal admirably adapted for coking—a distinctive feature of that seam, as opposed

* "Geology of the Hunter River Coal Measures," by T. W. Edgeworth David. Memoirs Geol. Survey of New South Wales. Geology, No. 4. Sydney, 1907, p. 68.

Rix's Creek Coke Works.

to other Newcastle coal horizons—but the number of included bands correspond closely, and it is the same relative height above the top of the upper marine series. An analysis of the Rix's Creek coal, as published in "The Coal Resources of New South Wales"* is as follows :—

Name of Colliery, Locality, &c.	Section of Seam.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	lb. of water converted into steam by 1 lb. of the coal.	Remarks.
New Park Colliery, Rix's Creek, Singleton.—Sample from No. 3 tunnel	Roof, coal and bands, 2 feet. ft. in. Band ...... 0 4½ Coal .... 1 0 Band ...... 0 2½ Coal .... 1 0 Band ...... 0 2¾ Coal .... 0 4¼ Band ...... 0 0¼ Coal .... 0 7 Band ...... 0 0¾ Coal .... 0 2 Band ...... 0 2 Coal .... 0 8 Band ...... 0 9 Coal .... 1 1½ 6 8¾ Floor, coal and bands.	2·60	38·12	51·21	7·77	0·574	1·275	58·98	12·7	Bands picked out; coke: slightly swollen, firm and lustrous; Ash: Buff-coloured, semi-granular.

At the present time the total output of the colliery is used at the coke works, the full run of the mine being charged direct into the ovens, without either washing or disintegration. Although the miners are supposed to hand-pick the coal, only the more prominent bands are rejected, with the result that a high percentage of dirt is fed to the ovens with the coal. Much iron pyrites is also present, occurring principally on the joint-faces, so that there is ample room for improving the charge by washing.

The ovens, 12 feet in diameter and 6 feet high to the crown of the dome, are of the old-fashioned Beehive type, twenty-six in number, and built back to back in one stone-faced bench, with Waratah sandstock brick lining. The periods of burning are seventy-two and ninety-six hours respectively, the weight of the charge, which is fed by manual labour from hoppers into a port in the crown of the oven, being 5 tons in each case, and yielding 58 per cent. of coke.

Internal quenching is adopted, and is more or less confined to the upper surface or face only, and the imperfectly-quenched coke is withdrawn by hand and wheeled into the coke bench, ready for loading into railway trucks. It is apparent that the quenching is far from adequate, for the coke is very often dully glowing when landed on the bench, and increased loss in ash from burnt coke results. Moreover, the coke has a natural tendency to "finger," with the result that the percentage of "breeze" is high.

* "The Coal Resources of New South Wales," by E. F. Pittman, A.R.S.M., Government Geologist and Under Secretary for Mines, Sydney, 1912.

The maximum weekly output would be 150 tons, but the present average is only 110 tons; eight men being employed.

Analyses of the coke and ash contents, as determined in the Departmental Laboratory, are as follows, the sample having been obtained on the 9th of March, 1916:—

No. $\frac{752}{16}$. Coke, Rix Creek Coke Works.

Proximate Analysis.

Hygroscopic moisture	0·44
Volatile matter	0·60
Fixed carbon	86·98
Ash	11·54
Sulphur	0·44
	100·00

Specific gravity—1·745.

Ash—Slight reddish tinge, flocculent.

No. $\frac{753}{16}$. Ashes, Rix Creek Coke Works. Analysis by W. G. Stone.

Chemical Composition.

Moisture at 100° C.	0·06
Silica (SiO_2)	53·70
Alumina (Al_2O_3)	28·72
Ferric oxide (Fe_2O_3)	8·30
Ferrous oxide (FeO)	0·27
Manganous oxide (MnO)	0·10
Lime (CaO)	2·76
Magnesia (MgO)	1·40
Barium oxide (BaO)	0·10
Strontium oxide (SrO)	†present
Soda (Na_2O)	0·69
Potash (K_2O)	0·68
Lithia (Li_2O)	†present
Titanium oxide (TiO_2)	1·70
Phosphoric anhydride (P_2O_5)	1·57
Vanadic oxide (V_2O_5)	0·15
Sulphur trioxide (SO_3)	0·11
Chromium sesquioxide (Cr_2O_3)	*trace
	100·31

* Less than 0·01 per cent. † Spectroscopic reaction,

No. 15.

The Ashford Coal Co., Limited.

This company was formed to work an area of coal-bearing land between Inverell and the Queensland border, the geological age of which appears to be the same as the Greta Coal Measures.*

* E. F. Pittman, "Mineral Resources of New South Wales," Sydney, 1901, p. 314.

Rix's Creek Coke Ovens.

G. and C. Hoskins' Coking Plant, Lithgow.

Owing to the isolated position of this area very little coal or coke have so far been produced, and the works are now shut down, but Mr. Pittman* has expressed the opinion that "the future extension of the railways will doubtless result in the working of this area."

The published official analysis of the coal is as follows :—

Hygroscopic moisture	0·71
Volatile hydrocarbons	22·90
Fixed carbon	68·96
Ash	7·43
	100·00

Specific gravity—1·348.
Sulphur—0·412.
Calorific value—13·83 lb. of water converted into steam.

As already stated, both the colliery and coke works are now closed down, but the following information was supplied by Mr. Edgar Hall, Secretary to the Company, and Manager of the Silver Spur Mining Co., No Liability, Queensland :—

> Run-of-Mine coal was used for coking, no disintegrating plant being available, but the workings were confined to the soft seams of coal, which are high in ash." There are six Beehive ovens, 12 feet in diameter and 7 feet 6 inches high inside, the weight of the charge being 6 tons, the burning period forty-eight hours, and the output 2 tons per oven per diem.

The ovens are built of Illawarra fire-bricks and bricks made of fire-clay from Ashford, with regard to which Mr. Hall makes the following statement :—

> The fire-clay accompanying the coal is of very high quality. The bricks made from it were the best fire-clay bricks we ever used, and were next in quality to the Bauxite bricks we import from France.

With regard to the coke produced, Mr. Hall has supplied the following information :—

> The coke made was used in a 100-ton head blast-furnace at Silverspur, and gave excellent results, bearing a heavy burden and a tall column, and producing a high heat.

Western District Coke Works.

No. 16.

The Lithgow Iron Works (G. and C. Hoskins).

The proprietors of these works have a coking plant in connection with their blast furnaces, such having been established during 1912. The coke ovens are about 1 mile distant from Eskbank, a railway station on the Main Western line, 95 miles from Sydney, and the Sydney offices are located in the Equitable Buildings, George-street.

The coal used is obtained from the Lithgow seam, as worked at the Oakey Park colliery, distant about 1½ miles from the ovens, and alongside the Government railway. A most noticeable feature with regard to coal from

* Pittman, "Mineral Resources of New South Wales," Sydney, p. 3 5.

this seam is that whilst the Oakey Park product is admirably adapted for coking, coal from the same seam in adjoining collieries possesses very inferior coking properties, or is entirely unsuited to coking.

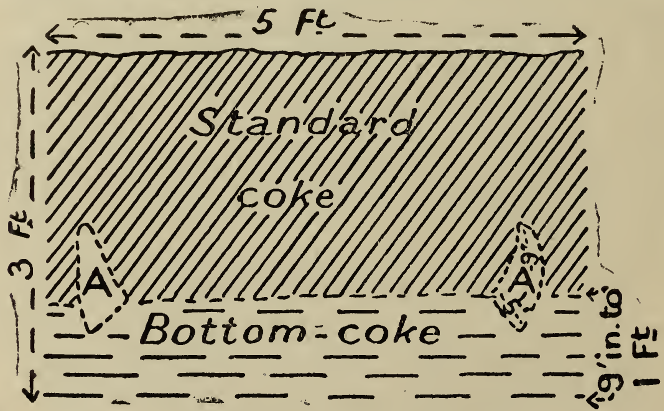
At the present time both large and small coal is purchased from this colliery, and analyses of the coal, as published in "The Coal Resources of New South Wales," are given on page 69.*

The coal is delivered at the coke works in hopper-waggons, and fed to a breaker consisting of a horizontal toothed roll, revolving between heavy but not rigid steel aprons. This reduces the coal to a maximum diameter of about 2½ inches, and it is then raised by a tray elevator to the Carr disintegrator. At the time the works were visited the disintegration process was being dispensed with, and the roughly-crushed coal was raised directly to the storage bins by means of a scraper elevator, the object being to ascertain if the larger coal would yield a coke more suitable to requirements.

The ovens are of the Belgian type, seventy-eight in number, with bottom flues only, but an additional fifteen were being erected with both side and bottom flues. They are built on the rectangular Beehive pattern, with a low angled gable roof, and the following dimensions :—Length, 30 feet; width, 5 feet; and 5 feet high to the ridge. The ovens are charged from canisters into two ports, arranged so as to distribute the coal on either side of the port, the weight of coal fed to each oven being about 10 tons, and the burning period fifty hours.

The main bench of ovens are built of local bricks, which would appear to be both hard and refractory, but the fifteen in course of erection are being built with Waterloo fire-bricks.

A somewhat curious phenomenon occurs in the ovens in use at the time the works were inspected, which is best explained by the following sketch :—



A. A. Uncaked carbonised material.

The uncaked carbonised material is useless by reason of its tendency to "pack," in the blast furnace, through inability to bear the weight of the charge, and its presence in each oven is not easy of explanation.

One of the writers (L.F.H.) suggests that the trouble is due to an increased ash percentage in the charge within the zone effected, for it is well known that an increase in the ash contents will often prevent caking.

* E. F. Pittman, Sydney, 1912.

G. and C. Hoskins' Coke Ovens, Lithgcw.

The increase would be brought about by the following process :—

The duff is charged from four port holes in the crown of the oven, with a maximum drop of 5 feet. The first hopper or two charged falls more or less flat on the floor, but each succeeding hopper of duff creates a batter, down which the duff falls until reaching an angle of repose, and the shaly material, having a greater specific gravity, naturally gravitates to the oven sides, but reaches the angle of repose before touching the wall.

This process goes on until the full charge has been fed in, when it is levelled off by means of a scraper worked by hand.

The central portion of the total thickness is practically undisturbed, with a natural concentration of dirtier coal, but the lower portion was not subject to this concentration action, whilst the upper has been more or less remixed. Hence a zone occurs along either side of the charge which contains more than its due percentage of ash, thereby retarding or preventing coking.

The possibility of insufficient heat or oxygen presents itself, and in the hopes of remedying the evil, the new side-flue ovens are being erected.

The oven doors are raised by hydraulic power, the coke is discharged by a steam ram, after internal partial quenching, and is finally thoroughly watered on the coke bench, about 4 per cent. of waste resulting from breeze and ash.

The maximum weekly output is 1,250 tons, but it is difficult to arrive at the output for 1915, owing to broken time, &c.

The generated gasses are used in the oven flues only, but from the fifteen new ovens the gas will be utilised for generating steam for power purposes.

An analysis of the coke as made by the proprietors, own chemist during December, 1915, was as follows :—

Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Phosphorus.	Moisture.
1·1	80·1	17·6	·45	·013	1·2

The whole of the output is absorbed at the iron works, and thirty men are employed, but no figures are available as to the quantity of coal used and coke produced during 1915. Samples of coke were obtained from these ovens on the 15th March, 1916, and analysed with the following results :—

No. 790. Coke made from "Duff," Lithgow Steel Works (G. and C. Hoskins).
16.

Proximate Analysis.

Hygroscopic moisture	0·68
Volatile matter	1·18
Fixed carbon	80·03
Ash	17·42
Sulphur	0·64
	100·00

Ash—Dark-grey in colour, semi-flocculent.

Specific gravity—1·775.

No. $\frac{792}{16}$. Coke made from "run-of-mine coal," Lithgow Steel Works (G. and C. Hoskins).

Proximate Analysis.

Hygroscopic moisture	0·85
Volatile matter	1·00
Fixed carbon	79·79
Ash	17·77
Sulphur	0·59
	100·00

Ash—Dark-grey in colour, semi-flocculent.
Specific gravity.—1·796.

No. $\frac{790}{16}$. Ashes. Coke made from "Duff coal," Lithgow Iron Wokrs (G. and C. Hoskins) Analysis by W. G. Stone.

Chemical Composition.

Moisture at 100° C.	0·08
Silica (SiO_2)	54·60
Alumina (Al_2O_3)	31·99
Ferric oxide (Fe_2O_3)	7·25
Ferrous oxide (FeO)	0·13
Manganous oxide (MnO)	0·15
Lime (CaO)	0·60
Magnesia (MgO)	0·19
Barium oxide (BaO)	0·12
Strontium oxide (SrO)	†present
Soda (Na_2O)	0·39
Potash (K_2O)	2·68
Lithia (Li_2O)	†present
Titanium dioxide (TiO_2)	1·40
Phosphoric anhydride (P_2O_5)	0·38
Vanadic oxide (V_2O_3)	0·02
Sulphur trioxide (SO_3)	0·02
Chromium oxide (Cr_2O_3)	*trace
Carbon	0·22
	100·22

* Less than 0·1 per cent. † Spectroscopic reaction only.

No. 17.

The Oakey Park Coal and Coke Co.

This company has been producing coke for about twelve years, the first set of ovens being of the true Beehive pattern; but about ten years ago (1905–6) a bench of rectangular ovens was erected, and have been worked more or less continuously ever since. The city office of the company is at 83 Pitt-street, Sydney, and the works are situated about half a mile from the Government Railway at Oakey Park Junction, on the Main Western line, 92 miles from Sydney.

The necessary coking coal is obtained from the Lithgow seam, as worked in the company's own colliery adjoining the coke ovens, and as a rule slack only is used, although provision is made for breaking and grinding large coal when required.

Oakey Park Coal and Coke Co.'s Ovens, Oakey Park.

Analyses of coal from this colliery, as published in "The Coal Resources of New South Wales,"* are as follows :—

Name of Colliery, Locality, &c.	Section of Seam.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	lb. of water converted into steam by 1 lb. of the coal.	Remarks.
Oakey Park Colliery, Lithgow. Lithgow Seam.—Sample from No. 26 bord, to left of main heading, No. 2 district.	Roof, coal and bands. ft. in. Coal .... 2 6 Band ...... 0 0¼ Coal .... 2 8¼ Band ...... 0 0¼ Coal .... 0 4 5 7¼ Floor—coal and bands, 10 inches, then sandstone.	1·79	34·17	52·30	11·74	0·645	1·348	64·04	12·4	Bands picked out; coke: well swollen, firm and lustrous; ash: dark-grey, granular.
Oakey Park Colliery, Lithgow. Lithgow Seam.—Sample from Bennett's place, first right, No. 2 district.	Roof, coal and bands. ft. in. Coal .... 2 5½ Band ...... 0 0½ Coal .... 2 6 Band ...... 0 0½ Coal .... 0 4½ 5 5 Floor—coal and bands, 1 foot, then sandstone.	1·71	34·78	52·13	11·38	0·672	1·347	63·51	12·4	Bands picked out; coke: well swollen, firm, fair lustre; ash: grey, flocculent.

The disintegrator in use is of the Carr type, and is situated near the pit head, but one set of ovens (rectangular) is about 32 chains away from the colliery, and the skips of duff, which is treated in a dry state, are transported to the ovens by an endless rope haulage-way. The first bench of ovens used are of the ordinary Beehive pattern, and thirty-two in number; but about two years after commencing operations forty rectangular ovens of the Maclanahan type were erected. The Beehive ovens are built to two different dimensions, eight having a diameter of 12 feet and a height of 6 ft. 6 in. to the crown of the dome, whilst the remaining twenty-four have a diameter of 9 feet and are 6 feet high. The charge for the former is 10 tons, and for the latter 7 tons, seventy-two and ninety-six burning periods being alternately adopted in each case, the latter tiding the works over a Sunday shift.

An analysis of a sample of this coke, obtained on the 16th of March, 1916, is as follows :—

No. $\frac{788}{16}$. Coke made in Beehive ovens, Oakey Park.

Proximate Analysis.

Hygroscopic moisture	0·63
Volatile matter	0·76
Fixed carbon	77·36
Ash	20·54
Sulphur	0·71
	100·00

Ash—Dark-grey in colour, semi-flocculent.
Specific gravity—1·800.

* E. F. Pittman, Sydney, 1912.

The rectangular ovens are 30 feet long, 8 feet wide, and 5 ft. 11 in. high, with a curtain face at either end, affording an opening 3 feet high at one end and 2 ft. 9 in. at the other. These ovens carry a charge of 12 tons, and are also burnt for seventy-two and ninety-six hour periods, the charge being practically the same in either case.

The whole of the ovens are charged by overhead canisters, the Beehive from one and the rectangular from four ports, horse traction being used to move them from and to the main hopper. The rectangular ovens are provided with one flue on each side, and one stack to every two ovens; the doors are raised by hydraulic power, a steam ram being used for pushing out the charge, and external quenching adopted, the water supply being obtained from surface catchment, supplemented by the Lithgow Water Supply when necessary. Internal quenching and manual withdrawal are used in connection with the Beehive ovens, and it is estimated that the loss from breeze and burnt coke is between 3 and 4 per cent.

All the ovens are built with locally-made bricks, lined with a fire-brick, and have a lengthy life without even renewals.

Messrs. G. and C. Hoskins, of the Eskbank Iron Works, and the Great Cobar Copper Co., are the principal consumers. Twenty-five men are employed, and the output for 1915 was 16,007 tons of coke produced from 26,687 tons of coal, or an average yield of 59·97 per cent.

It should be pointed out that during the greater portion of this period the ovens were being considerably under-charged, thus reducing the coke percentage. Returns furnished by the management show that 62 per cent. of coke is about the average.

The coal used at the present time for the production of coke is all shovel-filled, thereby increasing the ash percentage.

This is evidenced by the coke analyses from G. and C. Hoskins' ovens, where screened coal from the Oakey Park Colliery is being used.

An analysis of the coke made from a sample procured on the 16th of March, 1916, gave the following result:—

No. $\frac{786}{16}$. Coke made in rectangular ovens, Oakey Park.

Proximate Analysis.

Hygroscopic moisture	1·69
Volatile matter	0·98
Fixed carbon	77·05
Ash	19·60
Sulphur	0·68
	100·00

Specific gravity—1·821.

Ash—Dark-grey in colour, semi-flocculent.

Cakey Park Coal and Coke Co.'s Beehive Ovens, Oakey Park.

The ash contents of this coke on analysis, gave the following chemical composition :—

No. 787/16. Ashes from coke made in rectangular ovens, Oakey Park Coke Works. Analysis by W. G. Stone.

Chemical Composition.

Moisture at 100° C.	0·05
Silica (SiO_2)	55·00
Alumina (Al_2O_3)	33·19
Ferric oxide (Fe_2O_3)	5·90
Ferrous oxide (FeO)	0·18
Manganous oxide (MnO)	0·18
Lime (CaO)	0·38
Magnesia (MgO)	0·44
Barium oxide (BaO)	0·08
Strontium oxide (SrO)	†present
Soda (Na_2O)	0·41
Potash (K_2O)	2·71
Lithia (Li_2O)	†present
Titanium oxide (TiO_2)	1·60
Phosphoric anhydride (P_2O_5)	0·25
Vanadic oxide (V_2O_3)	0·02
Sulphur trioxide (SO_3)	0·03
Chromium Sesquioxide (Cr_2O_3)	*trace
	100·42

* Less than 0·01 per cent. † Spectroscopic reaction.

On the 19th of April a sample of coke from the Beehive ovens was obtained from the Manager, who stated that it was representative of the coke from these ovens. An analysis of this sample is as follows :—

No. 1292/16. Picked sample from Oakey Park Coke Works. (Second sample).

Proximate Analysis.

Hygroscopic moisture	1·78
Volatile matter	0·82
Fixed carbon	77·83
Ash	18·87
Sulphur	0·70
	100·00

Specific gravity—1·791.

Ash—Grey in colour, loose.

No. 18.

The Australian Gas-light Company.

The coke resulting from the operations of this company, in common with other gas companies throughout the State, differs entirely from the product from other coke works.

Gas coke is essentially a by-product, resulting after the extraction in retort ovens of gas from coal high in volatile hydrocarbons.

Gas coke differs from metallurgical coke mainly in containing a much higher percentage of volatile matter, being more vesicular and friable, and not produced in large solid prisms or lumps. These factors all render it less suitable for metallurgical purposes, but more adapted for use where rapid ignition without forced draught is the essential factor.

The Australian Gas-light Company's main works are situated at Mortlake, on the Parramatta River, about 6 miles from the Sydney General Post Office as the crow flies, and they supply the whole of the metropolitan area and many of the adjacent suburbs with gas for lighting and heating.

The coal used is obtained from the Pelaw Main Colliery, near West Maitland, which is working the Greta seam of the Lower Coal Measures.

Analyses of this coal, as published in "The Coal Resources of New South Wales,"* are as follows :—

Name of Colliery, Locality, &c.	Section of Seam.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	Lb. of water converted into steam by 1 lb. of the coal.	Remarks.
Pelaw Main Colliery. Bottom Seam— Sample from No. 30 bord, 6 dip slant, No. 5 east district.	Conglomerate roof. ft. in. Coal ... 15 9 Sandstone Floor.	1·62	42·91	51·32	4·15	0·453	1·396	55·47	13·5	Coke, fairly swollen, firm, dull lustre; ash, buff-coloured, semi-granular.
Pelaw Main Colliery. Bottom Seam— Sample from No. 20 bord, 16 slant, No. 2 west.	Conglomerate roof. ft. in. Coal ... 15 2 Clay parting ... 0 0½ Coal ... 1 7 16 9½ Sandstone floor.	2·10	41·45	49·74	6·71	0·947	1·251	56·45	13·0	Coke, well swollen, firm and lustrous; ash, light reddish tinge, semi-granular.

Two types of retort ovens are in use, namely horizontal and vertical, the latter being on the continuous feed principle, operated mechanically throughout. There are 432 of the former and 112 of the latter, and additions to both are now being contemplated.

The coal is passed through a toothed wheel, which reduces it to a maximum diameter of 1½ inch. The horizontal ovens take a charge of 5 cwt., which is submitted to a six-hour distillation, and the vertical ovens are fed with from 2 tons to 3½ tons every twenty-four hours, the yield of coke in each case being estimated at 60 per cent.

The Company kindly supplied the following figures as regards coal consumption and coke produced for the year 1915 :—

Coal used	279,020 tons.
Coke produced	183,041 „

This gives a coke yield of 65·6 per cent.

About 40 per cent. of the coke produced is used at the Company's own works, and the remainder sold for household use, factories, foundries, bakers' ovens, producer-gas plants, gas engines, &c.

* E. F Pittman, Sydney, 1912, p. 73.

Analyses of the two cokes produced by this Company are as follows :—

No. $\frac{1095.}{16.}$ Made in horizontal ovens.

Proximate Analysis.

Hygroscopic moisture	3·82
Volatile matter	3·22
Fixed carbon	83·41
Ash	8·81
Sulphur	0·74
	100·00

Specific gravity—1·699.
Ash—Reddish tinge, semi-granular.

No. $\frac{1096.}{16.}$ Vertical ovens.

Proximate Analysis.

Hygroscopic moisture	1·21
Volatile matter	0·66
Fixed carbon	88·12
Ash	9·24
Sulphur	0·77
	100·00

Specific gravity—1·698.
Ash—Reddish tinge, semi-granular.

No. $\frac{1097.}{16.}$ Ashes. Australian Gas-light Co. Average from vertical and horizontal ovens. Coke made from Pelaw Main Coal. Analysis by H. P. White.

Chemical Composition.

Moisture at 100° C.	nil
Silica (SiO_2)	43·88
Alumina (Al_2O_3)	31·70
Ferric oxide (Fe_2O_3)	10·60
Ferrous oxide (FeO)	0·27
Manganous oxide (MnO)	0·02
Lime (CaO)	4·86
Magnesia (MgO)	1·96
Barium oxide (BaO)	0·32
Strontium oxide (SrO)	absent
Soda (Na_2O)	2·49
Potash (K_2O)	0·60
Lithia (Li_2O)	†present
Titanium oxide (TiO_2)	1·75
Phosphoric anhydride (P_2O_5)	1·05
Vanadic oxide (V_2O_3)	*trace
Sulphur Trioxide (SO_3)	0·26
Chromium oxide (Cr_2O_3)	absent
Carbon	*trace
	99·76

* Less than 0·01 per cent. † Spectroscopic reaction only.

THE SAVING OF BY-PRODUCTS IN COKE MANUFACTURE.

The erection of modern coke ovens with necessary appliances for the saving of the valuable by-products in our coal, and the extraction and working up of the various products, must ultimately come into use in Australia, and is a matter which requires serious consideration on the part of the coke manufacturers of New South Wales. With the gradual disappearance of the old prejudices against coke made in the by-product ovens, the modern process has now come into use and begun to assert itself. In 1898, in England 1·25 million tons of coal were carbonised in by-product coking ovens; in 1905, the quantity of coal so treated reached 3·31 millions; and in 1909, 7·5 million tons.

Evidence given before the "Royal Commission on Coal Supply in England," shows that the value of the by-products will not only pay for the working of such coke plants and provide a profit, but will also pay for the capital outlay within ten years. In the United States of America modern coking and by-product plants have been erected in many districts, and are extensively worked.

In Canada, in 1915, there were only two by-product coke-oven plants, yet these two plants were responsible for two-thirds of the total coke production of the Dominion. The Department of Mines, Canada, has published a valuable paper entitled "Products and By-products of Coal," by Edgar Stansfield, M.Sc., and F. E. Carter, B.Sc.,* in which they state—"It has already been pointed out that modern by-product recovery coke plants have recently been installed in certain places as a means of supplying city gas, but such installations are only possible where there is a good demand for metallurgical coke."

It is most probable that, in years to come, this matter will receive serious consideration at the hands of the gas works manufacturers, and their plant fitted with modern appliances for the saving of the by-products other than ammonia and tar; for with the rapid depletion of our coal supplies this will be rendered very necessary.

The wasteful loss of valuable material by the Beehive process of carbonising coal must sooner or later be considered, and the modern process introduced into the manufacture of coke, the whole question being a national one.

There has been a decided prejudice against the use of retort oven-coke, the coke from the Beehive ovens being more in demand for use in a blast furnace. This preference is now disappearing, and it is generally recognised that retort ovens can make as good a coke as Beehive ovens, and will give a higher result in coke on ordinary coking coals.

Beehive ovens are stated to burn about 10 per cent. of the coal itself, or if with a coal 75·0 per cent. yield of coke is obtained in a retort oven, probably only 65·0 per cent. would be obtained from a Beehive oven.

Germany owes largely to her modern methods of treatment of coal and coke the large amount of high explosives she has been able to use against the Allies in this War. The by-product coking plants which are favoured in England are the Otto-Helgenstock, Simon-Carves, Koppers, Semet-Solvay, Sixplex, Coppee, and Hussener.*

According to A. W. Belden :—"The yield of by-products is dependent on the working of the ovens, and can be regulated within certain limits at the option of the operator. The quality of the coke can be sacrificed for a better

* Metallurgical Coke. Bureau of Mines, U.S.A., p. 28

quality and increased yield of gas and by-products, or the latter can be sacrificed somewhat for better coke. The manipulation of the ovens depends in large degree upon which product is more desired. Ideal conditions are reached when a coke possessing the chemical and physical properties necessary for the purpose for which it is intended is produced, together with a maximum yield and quality of by-products."

In a by-product oven a true distillate of coal is obtained, the process being under control and can be regulated.

From the ovens the volatile matter passes through the uptake pipes, and is driven along from the ovens by means of exhausters, and *en route* to the exhausters passes along an hydraulic main laid along the top of the ovens to a chamber where it deposits tar and a small portion of the ammonia. The gas having deposited the greater part of its tar is then passed through air coolers, water coolers, scrubber, exhauster, and tar extractors, and ammonia washers, to gas holder. After the gas has been deprived of its tar and ammonia it is then treated by certain heavy creosote oils, which absorb from the gas the benzol contained in it, and benzols of various degrees of strength are manufactured therefrom.

The following is a typical analysis of the gas produced.

Hydrogen	50·0
Saturated hydrocarbons	34·0
Unsaturated hydrocarbons	4·0
Carbon monoxide	8·0
Carbon dioxide	2·0
Oxygen	......
Nitrogen	2·0
	100·0

Inflammable gas.—96·0 per cent.

Ammoniacal Liquor.

To the ammoniacal liqour from the ammonia washers, lime is added, and it is distilled, the ammonia (NH_3) being passed into sulphuric acid to form ammonium sulphate, or it is pumped into a condenser and saturated to form strong liquor, varying in NH_3 contents, but usually containing between 15 to 20 per cent. The quantity obtained depends on the nitrogen contents of the coal, but other factors, such as the shape of the retort ovens, temperature, &c., have an influence on the fraction of nitrogen which is evolved as ammonia.

Nitrogen may be present in coals to the extent of 1 or 2 per cent., but in gas works probably only about 14 per cent. of this is saved as ammonia in the gas, although the percentage may be increased by the addition of lime to the coal, or by passing steam through the retort during distillation.

In the dry distillation of coal about 2 per cent. of the nitrogen of the coal is evolved in the form of cyanide, and recovered.

$N.H_3$.—Yields per ton carbonised at Gas works from different coals ;—

Pelaw Main, Maitland	9 lb.
Newcastle	7½ ,,
Western district	4 ,,
Southern district	2½ ,,

The gas ammoniacal liquor, after concentration, is bought on the NH_3 content by the manufacturers of ammonia, where it is largely made into anhydrous ammonia, and used for refrigerating purposes, or is made into sulphate of ammonia.

Tar.—The composition of the tars varies with the apparatus employed, method of working, and class of coal used.

The following is a typical analysis of gas works tar :—

On distillation yields—

	per cent.
Water	2·20
Light oil	5·90
Middle oil	12·30
Heavy oil	12·00
Anthracine oil	16·00
Pitch	49·70

Specific gravity.—About 1·10.

The following amounts are stated to be obtained from the distillation of tar at ordinary gas works :—

From one ton of Tar distilled—

Ammoniacal liquor	3 gallons.
Crude naphtha	10 ,,
Light oils	4 ,,
Carbolic acid	1 ,,
Creosote	56 ,,
Anthracine cake	3 lb.
Pitch	13 cwt.

The light oils, which are from 3 to 6 per cent. of the original tar, contain :—

	per cent.
Phenols	5·[illegible]
Pyridines	1·0
Sulphur compounds	0·1
Neutral substances	1·0
Hydrocarbons	80·0

The middle oil, which constitutes 8–12 per cent. of the tar, contains :—

	per cent.
Phenols	10·0
Cresols	20·0
Napthalene	30·0
Residue—Heavy oil	4·0

In addition, the oil contains considerable amounts of pyridine and other bases.

The heavy oil—10 to 12 per cent. of the tar—a semi-liquid product—contains :—

	per cent.
Napthalene	30·0
Cresols and homologues	10·0
Pyridine bases	6·0
Hydrocarbons (?)	40·0

Crude Naphtha.—This is usually worked up into a standard strength, which yields 20 per cent. of benzol when distilled up to a temperature of 120° C.

This is sold to the dye-makers, who break it up into benzol, toluol, solvent naphtha, burning naphtha, and creosote.

The dyes are made from benzol and toluol. Solvent naphtha is used for dissolving indiarubber by mackintosh makers; burning naphtha for consumption in lamps, &c. ;—creosote for the preservation of timber, &c.

Light Oil.—About 20 per cent. quality distills over at 160° C. Sold to the refiners, who convert it into toluol, solvent and burning naptha, and creosote, for all of which products there is a growing demand.

Carbolic Acid.—By treatment of washing the crude naphtha, and light oils with a 10 per cent. caustic soda solution. The aqueous alkaline liquid is drawn off from the oil, and steam blown through, in order to volatilize any trace of napthalene or other hydrocarbon that it still contains.

The alkaline liquid is then neutralised by sulphuric or carbonic acid, and the precipitated oily layer of phenol drawn off and fractionally distilled in stills with zinc or silver condensing coils. The distillate is crystallized out in the cold, and separated from the still fluid cresols by a centrifugal machine; phenol is thus obtained almost chemically pure us a white solid. It is used principally for making picric, salicylic acids, &c.

The cresols, separated from the phenol, occur as a fluid mixture of the three isomers—these bodies are much used for disinfecting purposes.

Pitch.—Readily commands a sale for asphalt and for many other purposes. Large quantities of pitch are shipped to the collieries of Belgium and the north of France, and used for the manufacture of artificial fuel—briquette—the pitch acting as a binding material.

Briquettes.—If cheap tar, or pitch, is produced in sufficient quantity as one of the by-products in coke manufacture, and "Mond" system of gas production from bituminous coal, it could be utilised largely for briquetting the fine dust and coal which accumulates in large quantities in a colliery which yields a coal unsuitable for coking.

In certain centres there is a large amount of fine coke or breeze obtained from the coke ovens, which if briquetted would make excellent fuel.

To briquette the fine coal it is first washed in the ordinary way and dried, then mixed with 7 or 8 per cent. of tar and moulded into bricks by machinery.

The briquettes possess the following advantages:—They are less friable than coal lumps when properly made, and being of regular shape more readily stored.

For domestic use they have the advantage of not soiling the hands, and can be purchased by numbers, so that a check is kept on the weight supplied.

According to J. T. T. Braeme*:—"The World's production of this class of fuel is fully thirty million tons, of which nearly three-fourths are made in Germany; the output in Great Britain in 1910 was 1·6 million tons." It is pointed out that the briquetting of the fine coal dust will become a very important question as the supplies of the better class of coal become reduced.

Heavy Explosives.—1. Trinitro—phenol.
2. Trinitro—toluene.

Trinitro-phenol is used extensively for filling shells, and its salts have formed constituents of priming compositions, and of powders used as propellants. The honey-yellow colour of the molten acid suggests the name of "melinite" which it receives in France, while in other countries it is designated "lyddite," "pertite," "ecrasite," or "schimose" in Japan.

Trinitro-toluene.—This explosive is manufactured from pure toluene. It has sprung into prominence as a substitute for picric acid, chiefly owing to its freedom from acidic properties, its low melting, point and great stability,

Trinitro-toluene has been introduced into the French service under the name of "tolite." The Spanish Government call it "trilit," and it is also known as "trolyl," "trinol," &c.

By-product Treatment.—The first by-product plant for the making of coke and saving of their valuable by-products was erected in Newcastle (The Australian Coking and By-products Co.), but is not now working. A full description of this plant is given on page 61. The Broken Hill Proprietary Co's. works, erected at Newcastle, and fully described elsewhere in this paper,

* Fuel, solid, liquid, and gaseous.

may be said to be the successful pioneer of the by-product industry in New South Wales. This company deals with the making of metallurgical coke, ammonia, gas, tar, &c. The tar, for treatment and extraction of the valuable by-products contained therein, is taken over by De Meric, Limited, tar distillers. This firm have a works at Hamilton, and have lately erected an up-to-date plant adjoining The Broken Hill Proprietary Steel Works.

We are indebted to their chemist, Mr. John Paton, for information as to the work taken in hand at their works.

The tar is distilled and fractionated into light, middle, and heavy oils, distilling at a temperature of 100° C., 120° C., and 170° C. respectively.

From the light oil benzol, toluol, and solvent naphtha is made. It is further treated, and pyridine, xylol, benzol, and toluol obtained, the benzol and toluol being brought up to 90 per cent. strength.

From the middle oil, carbolic acid xtals, neutral oil, cresylic acid, and naphthalene are made; also it is proposed to manufacture disinfectants later on. The heavy oil by fractionation yields creosote, anthracene, dead oil (lubrication.) The tar will be carried into pitch, and from the pitch lamp black will be made.

Having visited the works of De Meric, Limited, we are of opinion that this Company deserve great credit for the manner in which they have started this industry in New South Wales, the work being of a complicated nature, and the by-products obtained of great value to the State—especially those products used in nitrating for the manufacture of high explosives.

Mr. William Corin, M.Inst. C.E., M.I.E.E., &c.,† strongly advocates the saving of the gas and by-products in the coking of coal, and points out that 304,800 tons of coke were manufactured in 1914 in New South Wales, of which 252,409 were made in the southern coal-fields, and that the large quantity of tar resulting would enable a supply to be furnished at low rates for improving the roads of the States. Speaking of the South Coast Coke Works, Mr. Corin—"estimates that in addition to the coke and by-products produced therefrom, that there would be available for gas no less than 140 million units, which, if the industry be regarded as a whole, and the by-products be sold at market rates, could be supplied for less than a farthing per unit delivered."

Blending of Coals for Coke Making and By-products Saving.—For the making of good metallurgical cokes by the by-product ovens, and to obtain a maximum result from the by-products, it probably will be found necessary to blend certain of our coals with others giving higher percentages of volatile matter, and so obtain a better class of coke suitable for metallurgical purposes.

The high-class coking coals in some districts are gradually being depleted and experiments will be necessary to blend, and so obtain the maximum coke and by-products contained in the coals by the modern treatment in by-product ovens.

According to A. W. Belden‡:—"The best results seem to be when coals are mixed in proportions that give about 25 per cent. of volatile matter in the mixture, and this practice is generally followed through the country where mixed coals are used."

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† Power Requirements and Resources of New South Wales.

‡ Metallurgical Coke Bureau of Mines, U.S.A., p. 24.

Other uses for by-products are as follows :—

*Timber Preservative.**—Creosote oil, one of the by-products in tar distillation, is largely used for the preservation of timber from decay or destruction by insect pests.

On the American continent the demand for creosote oil is much greater than the supply. In 1913 the United States consumed, for timber preservation, over ninety million gallons (Imp.) of the oil, and of this 62 per cent. was imported from Europe.

Between 60 per cent. and 70 per cent. of the total quantity of the oil consumed was used for the treatment of railway ties, some twenty-five million being thus treated. In Canada, nineteen million cross-ties are used annually, and only about 10 per cent. of these are creosoted, but even for this comparitively small number, Canada does not produce sufficient creosote oil. If all the tar produced in gas and coke-oven works in the country were distilled, the home supply of creosote oil would still be quite unequal to the demand, and tar distillers would therefore be certain of a sale for one of their most important products.

Road-making.—The state of our main roads in New South Wales would greatly be improved by the use of tar or pitch. Raw tar, or preferably dehydrated tar, is generally used, for either pouring on, or spraying the surface of the road, and in dry weather it tends to keep the surface free from dust, and in wet weather preserves the road material from the disintegrating effects of water.

The mean averages of the Northern, Southern, and Western coals are :—

Northern, calculated on about seventy-seven analyses, 35·09 per cent.
Southern, calculated on about twenty-one analyses ..... 23·10 ,,
Western, calculated on about thirteen analyses .... 31·49 ,,

The coals from the Maitland series give a much higher result in volatile matter.

The great waste of gas and loss of all by-products by the use of the Beehive ovens in the coking of fine coal for a metallurgical coke only, will have to be seriously considered in the erection of any future plants, and the question thoroughly gone into as to cost, suitability of our fine coals, separate or blended, for the making of metallurgical cokes, by-products extraction, and utilisation of the gas for power, or heat generation, &c.—the question being a national one.

The Broken Hill Proprietary Company (Iron and Steel Works), have kindly supplied the following information regarding bulk tests of South Bulli coal made in their by-product Coke ovens at Newcastle.

THE BROKEN HILL PROPRIETARY CO., LTD.

Iron and Steel Works.

The Coking Tests of South Bulli Coal made at the Broken Hill Proprietary Company's Ovens, Newcastle, 21st abd 28th April, 1916.

Two separate tests of one oven each, in different ovens.

SIZING TESTS.

Test No.	On 20.	On 30.	On 40.	On 50.	On 60.	On 100.	Through 100.
1	30·6	13·6	10·5	7·4	5·1	8·2	25·2
	......	......	......	......	......	......	....
Average	......	......	......	......	......	......	... .

* Products and By-products of Coal. Edgar Stansfield, M.Sc. and F. E. Carter, B.Sc.

Analysis of Coal.

Mosture 2·2 per cent.

Test No.	Volatile.	Fixed Carbon.	Ash.	Sulphur.
1	23·4	63·8	12·8	0·62
2	22·6	65·3	12·1	0·62
Average..................	23·0	64·55	12·45	0·62

Summary.

Test No.	Coal (Wet).	Per Cent. H_2O.	Coal (Dry).	Coke Large. (Wet).	Per cent. H_2O.	Coke (Dry).	Coke, Small (Wet).	Per cent. H_2O.	Coke, Small (Wet).	Breeze (Wet).	Per cent. H_2O.	Breeze. (Dry).
	tons.		tons.	tons.		tons.	tons.		ons.	tons.		tons.
1	7·278	2·2	7·118	5.354	0·35	5·335	0·071	15·0	0·063	0·093	19·6	0·0747
2	8·239	2·2	8·0008	6·080	0·50	6·0496	0·0728	11·0	0·0648	0·0888	17·6	0·0732
Average ...	7·7585	2·2	7·5594	5·717	0·425	5·6923	0·0719	13·0	0·0639	0·0909	18·6	0·07395

Yields.

Test No.	Coke (to Coal).	Total Breeze to (Total Coke).	Small Coke to (Total Coke).	Breeze to (Total Coke).	Total Yields.
1	74·95	2·47	1·1	1·37	76·84
2	75·61	2·23	1·04	1·19	77·33
Average	75·28	2·35	1·07	1·28	77·085

Note.—Small coke is coke passing through a fork with 1¼-inch spaces between prongs, but remaining on a ½-inch mesh of sieve. *Breeze* passes the ½-inch sieve.

Coking Time :—	Hours.	Minutes.
1	22	25
2	20	15

Analysis of Coke.

Test No.	Volatile.	Fixed Carbon.	Ash.	Sulphur.	Porosity.
	per cent.	per cent.	per cent.	per cent.	
1	0·5	84·4	15·1	0·869	Apparent sp. gr. 1·26.
2	0·65	84·85	14·5	0·820	Real sp. gr. 1·89.
Average ...	0·575	84·625	14·8	0·8445	Cell space by volume 32·1 per cent.

Gas Analysis.

Taken at equal intervals of time throughout the Tests.

Test No.	CO_2	CnHm	O_2	CO	CH_4	H_2	N_2	Grains per 100 cub. ft. NH_3	H_2S	CO.S. per cub. ft. (Light oils)	British Thermal Units.
1	1·7	8·4	0·4	6·7	33·2	47·6	1·5	214·3	Nil.	0·75	702
2	1·8	8·5	0·4	6·2	33·9	47·7	1·2	277·5	Trace.	0·80	710
1	1·8	3·0	0·3	7·0	33·0	51·4	2·8	276·4	Trace.	0·43	588
2	2·4	4·0	0·3	7·0	35·0	47·5	3·5	186·2	0·08	0·48	619
1	1·8	2·9	0·3	7·0	31·9	53·4	2·3	230·2	Strong trace.	0·35	581
2	2·0	2·8	0·4	6·1	31·6	53·0	4·1	173·2	Trace.	0·50	572
1	0·8	1·8	0·3	8·5	31·7	53·6	3·1	209·8	Strong trace.	0·40	559
2	1·4	2·0	0·2	6·2	28·8	57·2	3·8	133·7	Trace.	0·50	539 Average
1	0·8	0·3	0·2	8·4	31·8	53·3	5·0	150·1	0·03	0·37	503 1/587
2	0·6	0·6	0·0	6·4	20·9	63·0	8·3	177·2	0·04	0·40	446 2/577
Average	1·5	3·4	0·3	7·0	31·2	52·8	3·6	201·96	Trace.	0·5	582

One may safely count on coking in 20 hours with these ovens, and would produce per oven per week :—

$$6{\cdot}08 \times \frac{24}{20} \times 7 \text{ tons large coke}$$

$= 51{\cdot}07$ tons coke with 0·5 per cent. moisture.

The corresponding coal used would be $8{\cdot}24 \times \frac{24}{20} \times 7$

$= 69{\cdot}22$ tons with 2·2 per cent. moisture.

The figures given for the ammonia are undoubtedly low and this is due to condensation in the pipe leading from the oven to the absorbing apparatus. The coke superintendent is at present determining the amount of this condensation, and later on hopes to give a factor of which will correct the results.

In the second test, it will be noticed the oven was well filled up, and yet the time of coking was not increased.

The coke produced was inspected by Mr. Fleming, Manager of the Associated Smelters Coke Ovens at Bellambi, and by him pronounced to be equal, if not better, than the coke made by himself from the same coal in his non-recovery ovens, while the colour was a great deal better.

The by-products from Newcastle Coal (Borehole Seam) as supplied by the same company are as follows :—

1. Estimation of sulphate production per ton of coal, 30 lb.
2. Benzol product from per ton of coal, 3 gallons.
3. Tar, 8 gallons per ton in Semet-Solvay ovens. This will vary inversely with the heat employed.
4. Gas, 12,600 cubic feet per ton of coal (of 585 B.T.U. gross).

Table A.

Proximate Analyses of New South Wales Cokes.

District	Assay number (1916).	Locality.	Hygroscopic Moisture	Volatile Matter.	Fixed Carbons.	Ash.	Sulphur.	Specific gravity.	
Southern District.	473	Mount Lyell Coke Works, Port Kembla (made from washed coal).	0·73	1·14	81·87	15·95	0·31	1·812	Approximate average crushing strain per square inch, 3,900 lb.*
	389	Federal Coke Works, Wollongong ...	1·38	1·59	82·63	14·08	0·32	1·816	
	471	Mount Pleasant Coke Works (Messrs. Figtree and Sons), Wollongong.	0·82	1·24	82·42	15·19	0·33	1·843	
	1,094	,, ,, ,, ...	1·33	0·70	83·29	14·35	0·33	1·809	
	1,292	Corrimal–Balgownie Coke Works, Corrimal.	0·96	0·91	81·97	15·85	0·31	1·857	
	1433	,, ,, ,, ...	0·53	0·17	83·60	15·25	0·45	1·850	
	472	The Associated Smelters Coke Works, Bellambi.	0·49	0·73	82·40	15·99	0·39	1·851	
	592	The Bulli Coke Works, Bulli............	0·46	1·40	80·08	17·64	0·42	1·880	
	1,184	,, ,, ,, ...	0·17	0·69	80·76	18·02	0·36	1·906	
	591	The North Bulli Coke Works, Coledale.	0·59	1·18	80·59	17·23	0·41	1·847	
	593	South Clifton Coke Works, Scarborough.	0·81	1·10	82·49	15·30	0·30	1·832	
	956	The Illawarra Coke Works, Coal Cliff	0·48	1·40	82·62	15·05	0·45	1·847	
Northern District.	691	The Broken Hill Proprietary Co.'s Steel Works, Newcastle.	1·38	0·79	81·04	16·42	0·37	1·809	Approximate average crushing strain per square inch, 1,700 lb.*
	692	The Purified Coal and Coke Works, Wallsend.	1·16	0·74	84·36	13·34	0·40	1·754	
	954	,, ,, ,, (mixture of Jesmond and Mount Pleasant coal).	0·69	0·99	85·76	12·15	0·41	1·793	
	695	The Co-operative Colliery and Coke Works, Plattsburg.	1·67	1·02	84·98	11·99	0·34	1·724	
	752	The Rix's Creek Coke Works, Singleton.	0·44	0·60	86·98	11·54	0·44	1·745	
Western District.		G. and C. Hoskins' Steel Works, Lithgow—							Approximate average crushing strain per square inch, 2,100 lb.*
	790	"Duff"	0·68	1·18	80·08	17·42	0·64	1·775	
	792	"Run of Mine"	0·85	1·00	79·79	17·77	0·59	1·796	
		The Oakey Park Coal and Coke Co.'s Works, Oakey Park Junction—							
	786	Rectangular Ovens	1·60	0·98	77·05	19·60	0·68	1·821	
	788	Beehive Ovens	0·63	0·76	77·36	20·54	0·71	1·800	
	1,292	"Picked"	1·78	0·82	77·83	18·87	0·70	1·791	

* These tests were made at the Sydney Technical College, four 1-inch cubes being tested from each coke works. A maximum variation of 5,150 lb. was found between individual cubes from the same ovens, so that the test can only be accepted as roughly indicating the average crushing stress comparatively between the Northern, Southern, and Western cokes.

TABLE B.

TABULATED Statement of Analyses of Ashes from New South Wales Cokes.

NORTHERN DISTRICT.

No.	Coke Works and Locality.	Moisture (100° C.).	Silica (SiO_2).	Alumina (Al_2O_3).	Ferric Oxide (Fe_2O_3).	Ferrous Oxide (FeO).	Manganese Oxide (MnO).	Lime (CaO).	Magnesia (MgO).	Barium Oxide (BaO).	Strontium Oxide (SrO).	Soda (Na_2O).	Potash (K_2O)	Lithia (Li_2O).	Titanium Oxide (TiO_2).	Phosphoric Anhydride (P_2O_5).	Vanadic Oxide (V_2O_3)	Sulphur Tri-oxide (SO_3).	Chromium Oxide (Cr_2O_3).	Carbon.	Total.
749	Wallsend Purified Coal and Coke Co.	Nil.	57·24	24·81	11·20	0·27	0·18	2·52	0·49	0·07	*present	0·56	1·03	*present	0·95	0·70	0·02	0·26	absent	...	100·30
750	Broken Hill Prop. Steel Works, Newcastle.	Nil.	54·02	32·63	7·50	0·36	0·46	0·92	0·68	0·02	,,	0·85	1·16	,,	0·85	0·56	†trace	0·24	†trace	trace	100·25
751	Co-operative Coke Works, Plattsburg.	Nil.	56·96	30·65	7·05	0·14	0·20	0·82	0·61	0·09	absent	0·69	1·01	,,	1·45	0·34	0·02	0·09	absent	trace	100·12
753	Rix's Creek Coke Works...	0·06	53·70	28·72	8·30	0·27	0·10	2·76	1·40	0·10	*present	0·69	0·68	,,	1·70	1·57	0·15	0·11	†trace	...	100·31
955	Wallsend Purified Coal and Coke Co. (Coke made from Bulli and Borehole Coals—Jesmond.)	Nil.	52·56	28·65	11·30	0·27	0·08	2·78	0·16	0·21	absent	0·71	0·82	,,	1·30	0·99	0·02	0·35	absent	...	100·20
1097	Aust. Gaslight Co. (Peiaw Main Coal, Average from Vertical and Horizontal Ovens.	Nil.	43·88	31·70	10·60	0·27	0·02	4·86	1·96	0·32	,,	2·49	0·60	,,	1·75	1·05	†trace	0·26	absent	trace	99·76

* Spectroscopic reaction. † Less than 0·01 per cent.

TABLE B.

TABULATED Statement of Analysis of Ashes from New South Wales Cokes—*continued.*

SOUTHERN DISTRICT.

No.	Coke Works and Locality.	Moisture (100° C.).	Silica (SiO_2).	Alumina (Al_2O_3).	Ferric Oxide (Fe_2O_3).	Ferrous Oxide (FeO).	Manganese Oxide (MnO.)	Lime (CaO).	Magnesia (MgO).	Barium Oxide (BaO).	Strontium Oxide (SrO).	Soda (Na_2O).	Potash (K_2O).	Lithia (Li_2O).	Titanium Oxide (TiO_2).	Phosphoric Anhydride (P_2O_5).	Vanadic Oxide (V_2O_3).	Sulphur Tri-oxide (SO_3).	Chromium Oxide (Cr_2O_3).	Carbon.	Total.
595	Mount Lyell Coke Works...	0·07	54·11	33·46	4·75	0·23	†trace	1·92	0·53	0·30	*present	0·61	1·74	*present	1·45	0·50	0·01	0·55	absent	...	100·23
596	Federal Coke Works	0·05	52·94	34·49	4·10	0·45	0·04	2·32	0·68	0·40	,,	0·78	1·34	,,	1·35	0·64	0·02	0·76	†trace	...	100·36
597	Bellambi Coke Works	0·08	50·38	33·80	5·65	0·36	0·05	3·80	0·73	0·35	,,	0·60	1·13	,,	1·25	0·71	0·02	1·37	,,	...	100·28
598	Mount Pleasant Coke Works (Figtree and Sons)	0·07	50·94	32·01	3·30	0·27	0·01	5·72	0·45	0·48	,,	0·71	1·02	,,	1·65	0·69	†trace	2·34	absent	0·74	100·40
599	North Bulli Coke Works...	0·06	50·00	25·70	10·60	0·45	0·12	5·02	2·47	0·10	,,	0·57	1·49	,,	1·20	0·13	0·01	1·91	†trace	0·40	100·23
600	Bulli Coke Works	0·09	49·70	31·82	4·20	0·23	0·01	5·82	1·38	0·48	,,	0·57	1·36	,,	1·45	0·68	0·01	1·79	absent	0·58	100·17
601	Clifton Colliery Coke Works	0·06	49·18	27·80	9·55	0·31	0·08	5·40	2·55	0·22	,,	0·51	1·04	,,	1·30	0·39	0·01	1·79	absent	...	100·19
957	Illawarra Coke Co., Coal-cliff.	Nil.	46·50	28·63	7·30	0·36	0·05	10·22	0·30	0·16	absent	0·42	0·76	,,	1·00	0·79	0·03	3·37	†trace	...	99·89
1186	Corrimal-Balgownie Coke Works.	0·04	52·38	33·53	6·50	0·18	0·13	2·58	0·44	0·36	*present	0·61	1·17	,,	1·15	0·53	†trace	0·46	†trace	0·16	100·22
	Mean																				

WESTERN DISTRICT.

No.	Coke Works and Locality.	Moisture (100° C.).	Silica (SiO_2).	Alumina (Al_2O_3).	Ferric Oxide (Fe_2O_3).	Ferrous Oxide (FeO).	Manganese Oxide (MnO.)	Lime (CaO).	Magnesia (MgO).	Barium Oxide (BaO).	Strontium Oxide (SrO).	Soda (Na_2O).	Potash (K_2O).	Lithia (Li_2O).	Titanium Oxide (TiO_2).	Phosphoric Anhydride (P_2O_5).	Vanadic Oxide (V_2O_3).	Sulphur Tri-oxide (SO_3).	Chromium Oxide (Cr_2O_3).	Carbon.	Total.
787	Coke made in Rectangular Ovens, Oakey Park Coke Works.	0·05	55·00	33·19	5·90	0·18	0·18	0·38	0·44	0·08	*present	0·41	2·71	*present	1·60	0·25	0·02	0·03	†trace	...	100·42
790	Coke made from "Duff," Lithgow Iron Works' Coke Works (C. and G. Hoskins).	0·08	54·60	31·99	7·25	0·13	0·15	0·60	0·19	0·12	,,	0·39	2·68	,,	1·40	0·38	0·02	0·02	,,	0·22	100·22
	Mean																				

* Spectroscopic reaction. † Less than 0·01 per cent.

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