THE UTILISATION OF BROWN COAL.

By P. G. W. Bayly, A.S.A.S.M.

Reprinted from the Proceedings of the Society of Chemical Industry of Victoria,
August—November, 1908.

VIII.—*The Utilisation of Brown Coal.*

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[Read 27th October, 1908.]

The consideration of the value of brown coal as an economic fuel is by no means new, and the present paper may therefore be regarded as an effort to direct attention to the enormous deposits in Victoria awaiting development. When it is realised to what an extent the material is utilised in Europe at the present time, and with what success, it certainly does seem amazing that as yet no definite steps have been taken to make use of the valuable asset. The extent of the deposits in Victoria shown on the attached map and proved by boring is almost beyond compute. They are of Tertiary age, and, generally speaking, are found in three main deposits :—

(1) *Morwell.*—Covering an area of about 800 square miles in the valley of the Latrobe.

(2) *Alberton.*—Almost directly south of the Morwell deposit. Area about 200 square miles.

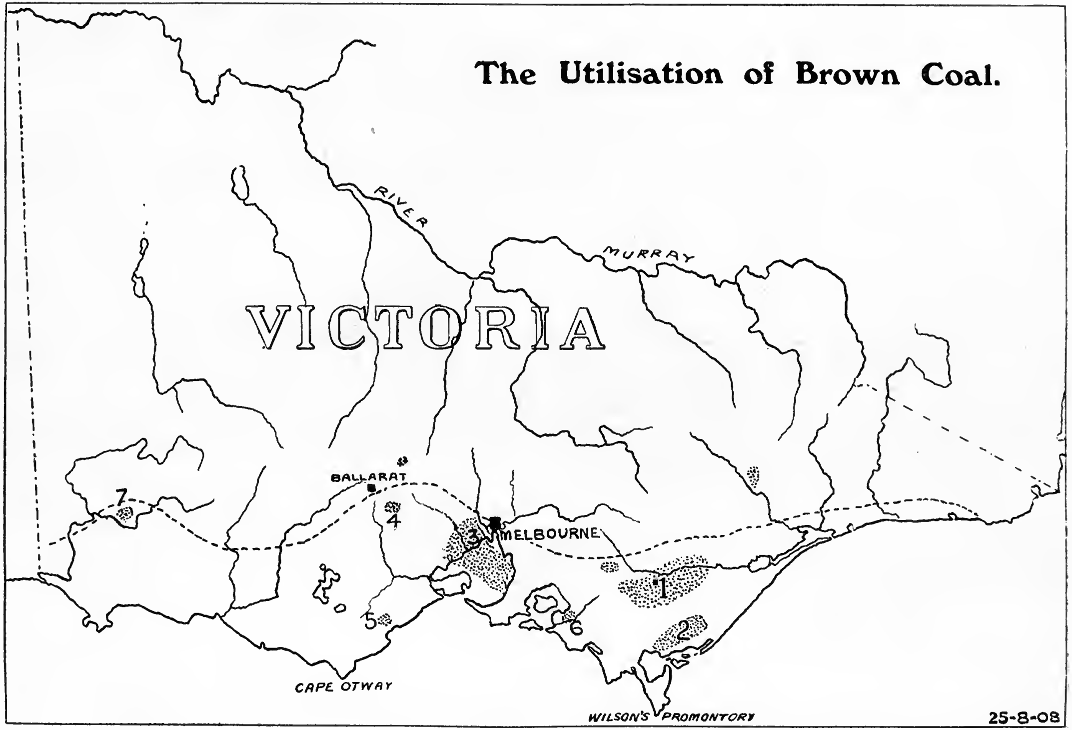
(3) *Altona Bay.*—Extending westward from Melbourne to Werribee. Total area, about 700 square miles, of which two-thirds is under the waters of Port Phillip Bay.

Other small deposits are at (4) Lal Lal, (5) Dean's Marsh, (6) Bass River, and (7) Coleraine.

The dark shading shows the estimated extent of the larger bodies of brown coal in Victoria. Practically the whole of Port Phillip Bay is underlain by the beds, which are all found south of the dotted line indicating the approximate north boundary of the Tertiary formations.

One bore (Fig. 1) at Morwell, in a depth of 1000 feet, passed through a total thickness of 808 feet of brown coal—principally

The Utilisation of Brown Coal.



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MORWELL BORE FIG 1.

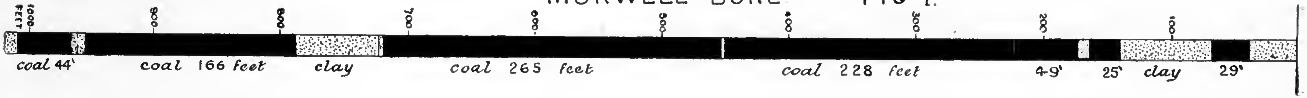

FIG. 2.

GIPPSLAND RAILWAY BORES.

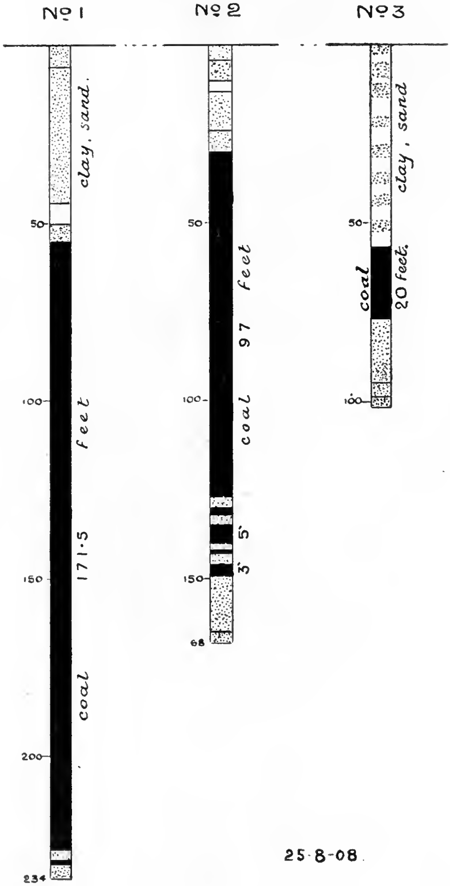

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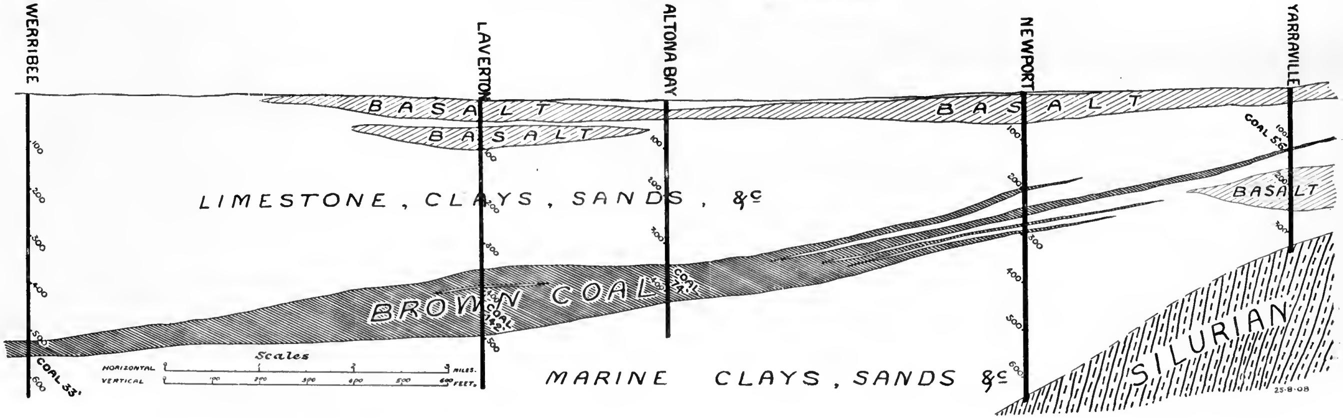
FIG. 3.

ALTONA BAY BORES



in three tremendous beds of 266, 227 and 166 feet respectively. In another locality (Fig. 2) on the Gippsland Railway Co., thicknesses of 97 feet and 171 feet have been bored through. These beds are not at any great depth, in fact, at Morwell the brown coal outcrops on the surface, and can be quarried out. At Altona Bay (Fig. 3) the bore struck a seam of 74 feet at a depth of 348 feet. At Laverton the thicknesss is 142 feet, at a depth of 356 feet. With such figures as these before one, it seems remarkable that no economic use has been made of the material. It is not that it is unknown. Some thousands of tons have been raised and sent to Melbourne. Everyone knows in a vague manner that Gippsland has brown coal deposits, and that years ago an attempt was made to use it. But so far no definite and actual use has been made of this vast asset. It may therefore be advantageous to discuss the reasons why it has so far failed, and to suggest possible sources of utilisation.

The broad definition of fuel, according to Percy, is applied to "substances which may be burned by means of atmospheric air, with sufficient rapidity to evolve heat capable of being applied to economic purposes."

TABLE I.—FUELS.

A—NATURAL FUEL.

1. Wood
2. Peat or turf
3. Lignite or brown coal
4. Coal—Bituminous
    - (*a*) Soft bituminous
    - (*b*) Hard bituminous
    - (*c*) Semi anthracite
5. Anthracite
6. Liquid fuel
7. Natural gas

B—PREPARED FUEL.

8. Briquettes (patent fuel)
9. Coke and charcoal
10. Water and fuel gas

C—WASTE RESIDUES.

11. Bagasse (sugarcane refuse)
12. Sawdust
13. Spent tan
14. Coffee and rice husks, etc.

Under proper conditions any kind of combustible matter may be regarded as having some value. This will be, for economic purposes, relative to the value of black coal as a standard fuel, but the great improvement in modern gas engines, especially in the last few years, has given a new conception to the practical value of fuels. The United States Geological Survey experiments at St. Louis showed that the power efficiency of certain coals used in the gas producer plant was from 2.4 to 3 times their efficiency when burned in a steam-boiler plant.

The principle followed is always guided by Percy's definition, and hence "any substance capable of exothermic oxidation with sufficient rapidity to leave an available balance of energy after the leakage of energy surrounding the point of combustion (e.g., radiation, convection and conduction) have been supplied," can be regarded as a fuel.

Brown coal occupies a position in calorific value below bituminous coal and above peat and turf. From the following table it will be observed that the composition changes by the increase of carbon contents and the decrease of hydrogen and oxygen :—

TABLE II.

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.
Wood - - -	50	6	42	2
Peat - - -	60	6	34	—
Brown Coal - -	66	5.5	28.5	—
Bituminous Coal -	78	5	17	—
Anthracite - -	96	2.7	1.3	—

Brown coal itself may be classified on the same lines, showing varieties merging into peat at one end and bituminous coal at the other.

TABLE III.

	Carbon.	Hydrogen.	Oxygen.
1. Ligneous Brown Coal (Lignite) showing fibrous fracture and woody structure -	62	6	32
2. Earthy Brown Coal - - - - -	65	6	27
3. Brown Coal proper (conchoidal) - -	70	5	25

(N.B.—The oxygen may be regarded as being combined with hydrogen as water.)

From the analyses which are given in Tables V. to VIII. it will be seen that the Victorian varieties fall between the second and third classes. The Dean's Marsh is the best of these, but the deposit is small.

CALORIFIC POWER OF FUEL.

Within broad limits the heating power of various fuels may be summed up as follows. The materials have been calculated as ash and water free :—

TABLE IV.

	British Thermal Units.
Peat - - -	5,000 to 9,000
Brown Coal -	9,000 ,, 12,600
Bituminous Coal -	14,400 ,, 16,200
Anthracite - -	16,500 ., 17,100
Petroleum - -	20,000

OCCURRENCE OF BROWN COAL.

In *New South Wales* beds have been found up to 30 ft. in thickness—the quality is, however, poor, and the ash is high.

In *South Australia* large deposits of lignite are available at Leigh's Creek, and a seam has recently been discovered at Noarlunga, about 30 miles from Adelaide. This latter deposit is being investigated now for commercial purposes.

In *New Zealand* very large deposits are being worked, seams up to 30 ft. being available. The total output of brown coal in 1906 amounted to 467,000 tons.

This material is largely used for household purposes throughout New Zealand, and where a better class of coal is not available, is used for steam-raising with very fair results. Mixed with 20 per cent. of bituminous coal, it forms a good steaming fuel.

In *Queensland* the deposits are not of great value, being a long way from industrial centres and of poor value.

In *Victoria* the deposits, both in size and quality, are of much more importance than those in the other Australian States. A detailed list of the bores and description of these deposits has been prepared by the Mines Department.

In *Germany*, the centre of the lignite basin is on the Rhine. Lignite is, besides peat, the most important fuel in Germany. 48,000,000 tons of lignite (brown coal) were produced in 1905, and, in addition, 5,000,000 tons were imported from Bohemia. Of this total about 10,000,000 tons were briquetted. The heating value varies from 3000 to 6800 B.T.U. per lb., the moisture contents averaging about 45 per cent.

The process of briquetting the new material consists of grinding it to a fine powder, and heating the same in a double walled cylinder by means of steam till the moisture content is reduced to 15 or 17 per cent. It is pressed while still hot at 21,000 to 29,000 lbs. per square inch, generally without any binding agent being added.

In *Cologne* the beds are 260 to 400 feet thick, and are worked by open cut. The coal here is all briquetted.

In *Saxony* the brown coal occurs in beds, 60 to 70 feet thick, and is worked by open cut.

In many districts the brown coal is used in the raw state without drying or briquetting, and without any attempt being made to recover by-products. It is used in the railways for heavy. slow freight trains.

In the *United States* an extensive series of tests has been made by the Geological Survey on the Dakota lignite. These have been entirely satisfactory, both for steam-raising and briquetting.

ANALYSIS.

The following analyses of Victorian brown coal have been made, principally at the Mines Department laboratory :—They show that the Victorian material is of very superior quality compared with that of other States, and certainly with that compared with that of other States Table V., and certainly with that which finds common use in Germany at the present time. The advantages consist of lower moisture and ash content, and higher carbonaceous matter.

TABLE V.

Locality.	Water.	Ash.	Volatile Matter.	Fixed Carbon.
Morwell	35	3·5	—	—
Laverton	45	3·5	—	—
Altona Bay	30	5	—	—
N. Zealand (South Island)	23.1	6.2	31.6	39·1
Germany	45	9	—	—
Noarlunga, S.A.	35·3	13	26.5	15·2
Port Fairy (peat)	62.6	8.5	17·3	11.6

Samples of the Morwell coal have contained as low as 1 per cent. of ash. This coal is, generally speaking, lower in ash than the others. In the experiments which are to be quoted, the work was done on a large sample of 5 tons, which was received from the Great Morwell Mine. It was true earthy brown coal, breaking with a conchoidal fracture, and was taken from the open cut working at the mine. The analysis is as follows :—

TABLE VI.—MORWELL COAL.

Ultimate Analysis.	Moisture Free.	Moisture and Ash Free.
Carbon	65.80	68.29
Hydrogen	4·78	4·95
Nitrogen	·75	—

Proximate Analysis.	Raw.	Air-dried.	Moisture Free.
Water	35·08	20.0	—
Volatile Matter	29·24	36.0	45·1
Fixed Carbon	33·28	41.0	51.2
Ash	2.40	3·0	3·7
	100.00	100.0	100.0
Sulphur	0.9		

Calorific Value.	Water.	British Thermal Units.	Theoretical Evap. Power in lbs. of Water at 212° F.
Raw	20.16 p.c.	8,228	8.53
Briquetted	18.5 p.c.	9,081	9·41
Briquetted	13·9 p.c.	9,540	9.88

TABLE VII.

ULTIMATE ANALYSES OF VARIOUS BROWN COALS.

Samples dried at 100°*C. and ash free.*

Coal.	C.	H.	O.	N.	Total.	Specific Gravity.	Ash.	Water in Original Samples.
Narracan	67.90	4.74	26.30	0.37	99.31	1.12	7.93	39.5%
Laverton	67.60	4.86	26.00	0.57	99.93	1.10	5.00	45.0
Dean's Marsh	73.70	4.76	20.33	1.02	99.81	1.21	4.51	20.1
Altona Bay	67.90	4.60	26.80	0.70	100.00	—	7.50	45.0
Morwell (H. C. Jenkins)	66.05	4.35	28.50	0.81	99.71	1.02	1.06	28.1
Jas. Stirling	66.07	5.01	24.00	1.30	—	—	3.45	41.2
(1908)	68.29	4.95	—	—	—	—	3.70	35.08
Bohemia	74.00	6.00	20.0		—	—	—	—
German	66.00	5.52	—	—	—	—	9.05	—

The ultimate analysis given here may be taken as representing fairly the composition of the different Victorian coals.

It may be taken that with suitable air drying facilities the coal will reduce in moisture to about 18 or 20 per cent., and that if further dried by artificial heat it will recover moisture to about this amount.

DISTILLATION EXPERIMENTS.

Experiments were made to determine the recoverable by-products from different types of brown coal. A cast-iron retort was used, holding about 3 lbs., and the coal introduced in the wet state. A large mercury retort was found to be well adapted for the purpose. The temperature was gradually brought up to about 1000 degrees C. The neck of the retort consisted of a 1½ in. pipe, and this was water cooled. The products of combustion were passed through a series of vessels to recover condensable tar, etc., and through a succession of acid wash bottles to retain the ammonia. A Wright gas meter enabled the actual amount of gas, as well as the rate of production, to be measured, and readings were taken every ten minutes. The gas was collected in a large gas-holder devised out of oil drums. A mercury gauge introduced in front of the gas meter enabled the pressure state of the train to be watched, and this was regulated by the waste tap from the gas-holder. The excess of gas was burned in a bunsen or in a Welsbach mantle. In one series of experiments (Morwell) it was observed that the issuing gas was slightly cloudy, so a scrubber of damp sawdust was introduced between the mercury gauge and meter. This had the effect of entirely removing the cloudiness, and the issuing gas was then quite invisible and free from the objectionable smell noticed before the scrubber was introduced. It was necessary to learn by experience, and many changes and adaptations were made before satisfactory results were obtained.

As a rule the amount of coal used was 2½ lbs. of raw material, undried and rough crushed. The heating was gradual, and a record kept of the rate of production of gas. Each experiment was generally complete in three hours, when the gas flow ceased.

TABLE VIII.—SUMMATION OF DISTILLATION RESULTS.

Proximate Analyses—	MORWELL	NEERIM
	Per Cent.	Per Cent.
Water	27.16	34.95
Volatile matter	36.40	30.64
Fixed carbon	34.35	17.23
Ash	2.09	17.18
	100.00	100.00
Products from 1 ton raw Coal—		
1. Ammonium sulphate—		
Nitrogen present	0.546 p.c.	0.406 p.c.
Equivalent to $(NH_4)_2SO_4$ theoretical	57.66 lbs.	42.87 lbs.
$(NH_4)_2SO_4$ actually obtained	23 ”	15.5 ”
Percentage recovery	39.97 p.c.	36.17 p.c.

Amount obtainable if 60% was recovered	34.5 lbs.	25.7 lbs.
Value at £12 per ton	3s. 8d.	2s. 9d.
2. Tar	7.7 gall. 70 lbs.	10 gall. 82.5 lbs.
3. Gas	10,000 to 12,000 cub. ft.	6700 cub. ft.
Calorific value per c. ft.	450 B.T.U.	450 B.T.U.
4. Carbonaceous residue	820 lbs.	770 lbs.
Containing Ash	6.35 p.c.	High Ash

(1) *Ammonia Recovery.*—The ammonia was found to be nearly all in the first condenser vessel, which contained all the water from the coal, and a little tar and light hydrocarbons.

The water was removed from the tar by a separating funnel, and the ammonia determined by redistillation with sodium hydroxide, and absorption in hydrochloric acid (decinormal).

The distillate was nesslerized.

The acid washes were also treated, and a little more ammonia recovered.

As a rule, about 85 per cent. of total ammonia was obtained in the first condensed water.

No determination was made of any possible ammonia in the tarry portion.

The value of ammonia sulphate is about £12 to £14 per ton, and there is a ready and unlimited market, both locally and in the East.

(2) *Tarry Matter.*—This was obtained in the down pipe from the retort. It was weighed and measured, and its specific gravity determined.

It was then treated by fractional distillation at varying temperatures up to 370 C., and the oils ranging from very light to thick clear grease of the consistency of vaseline were collected and their specific gravity determined.

Samples were shown of the crude oils obtained.

(3) *Gas Produced.*—The gas was sampled and analyses made, as indicated in Table IX. The overflow gas was burned in a bunsen or Welsbach burner.

The gas produced by distillation is non-illuminating, but it is of high value for combustion purposes. When burned in an incandescent mantle, it gave a fine white light, which could be used for illuminating purposes if required. Its actual photometric power was not determined, as this is of minor importance.

A plant is already in operation in Victoria for gas production from peat, and both for heating and illuminating purposes it has proved most successful.

From the figures given in this table the calorific value of the gas may be compared with other recognised producer gases, of which analyses are given to show approximately their composition. Of course the different types of producer gas are diluted with the nitrogen in the air, used in combustion, and the quantity produced would be much larger per ton of coal burned.

(4) *Coke Residue.*—The carbonaceous residue was weighed and examined for coking properties, which were generally lacking.

A proximate analysis was made of each to determine the amount of volatile matter remaining.

(5) *Ammonia Results*—The theoretical amount of ammonium sulphate which should be produced from any given sample may be calculated from the percentage of nitrogen present.

In large recovery works at present in successful operation in England, the percentage recovery is about 60-80 per cent. of total nitrogen contained in the raw material.

There is no reason why this percentage should not be obtained under proper conditions of work. The value of the Victorian coal as far as this product is concerned is set out in Table VIII.

The actual amount of ammonium sulphate recovered in the distillation of Morwell coal amounted to 23 lbs. per ton of wet coal. This result is not satisfactory and is probably due to incorrect heating. Each 1 per cent. of nitrogen in the coal is equivalent theoretically to 106 lbs. of $(NH_4)_2SO_4$ per ton.

Table IX.

Analyses of Gas produced by distillation of Brown Coal compared with standard producer and other gases.

	Brown Coal Gas			Coal Gas	Dowson Gas	Mond Gas
	Narracan	Dean's Marsh	Morwell			
Hydrocarbon vapours -	5.0	4.9	—	—	—	—
Carbon dioxide (CO_2) -	8.5	1.2	16.0	—	6.6	15.0
Carbon monoxide (CO) -	26.9	23.2	35.0	7.5	25.1	12.0
Methane (CH_4) - -	10.0	13.4	10.0	39.5	0.3	2.0
Ethylene (C_2H_4) - -	1.7	1.1	—	3.8	0.3	—
Hydrogen (H) - -	47.9	56.2	38.0	46.0	18.7	28.0
Nitrogen (N) - - -	—	—	—	0.5	49.0	43.0
	100.0	100.0	99.0	97.3	100.0	100.0
Heat value—B.T.U. per cub. foot - - -	454	494	364	683	163	162

BRIQUETTING EXPERIMENTS.

Many statements have been made to the effect that Victorian brown coal is entirely unsuitable for briquetting, unless a proportion of agglutinant, such as pitch, is used, and the additional cost of this makes the cost prohibitive. I cannot agree with this objection, as I have found that under proper conditions a firm, hard briquette can be produced.

In my experiments in this direction the coal was tested under different conditions before the best results were obtained. The principal variation of experiment had regard to:—

1. Size of material.
2. Percentage of moisture present.
3. Heating of material before pressing.

It was eventually found that the best results were obtained by rough crushing the coal to bean size, reducing the water content to 10 to 15 per cent., and applying pressure after heating to about 70 deg. C. A pressure of 82 tons per sq. in. was obtained by the hydraulic press at the Newport Workshops, kindly placed at my disposal by the Railway Department. The mould and dies were made of mild steel, and the briquettes produced weighed about ½ lb. each. No agglutinant was used in pressing. The coal had been dried quickly to the particular temperature to be tried, and was then packed in tight boxes until required. It was heated in a closed tray on a forge alongside the press, and a measured amount poured into the mould and pressed.

The object of these experiments was to determine whether or no the material had sufficient binding power under proper conditions to produce a stable briquette. No agglutinating material at all was used, but the experiment of applying a cheap waterproofing to the briquette, to prevent disintegration by exposure, was tried. This has been successfully done in some tests made in America.

If a cheap, industrial by-product were available, it might be added with advantage, but from results of the present tests, no such agglutinant appears necessary. I have in preparation an experiment whereby clay will be added, in order to render the ash heavier, and less liable to blow about. This is one of the minor difficulties observed in the use of Morwell coal. The very low ash (Table VII.) of this material would enable even 5 per cent. of clay to be added without serious detriment. This would tend to make the ash more of a clinker.

A large number of the more successful briquettes were sent away to the Franco-British Exhibition, together with about two tons of raw brown coal, and attracted much attention. The briquettes now exhibited were made in February, 1908, and have been exposed to air in a room ever since. They appear to show no serious sign of disintegration, and are fairly sound. When placed in an ordinary grate fire the briquettes burned away readily, but they are not strong enough to stand any poking. A German manufacturer of briquettes has expressed the opinion that both in suitabilty for manufacture, heating value, and for distillation purposes the Morwell brown coal is much superior to any that is operated on in Germany. Some very fine specimens of briquettes, made in Germany from the Morwell coal, were exhibited at the meeting. They are of excellent quality.

The question of briquetting Morwell coal was gone into in 1892 by the Austral Otis Company, which erected a plant for £6000 at Morwell capable of producing 30 tons per day of 10 hours. About 4000 tons of briquettes were sold in Melbourne at from 20/- to 25/- per ton. The factory was run for some time by the company for whom the works had been erected, but the financial strain of 1893 made it necessary to close down. Sufficient work was done, however, to show that under proper conditions the briquetting is a sound commercial proposition.

Briquetting Cost.

The first consideration is the material itself. At the plant erected by the Austral Otis Co. the raw material was tipped into the hoppers at 2/- per ton. I have no doubt at all that on a large scale of working, with modern excavators, the material could be trucked at 1/- per ton. In this view I am supported by experienced mining engineers.

TABLE X.

Cost of producing 10 tons of briquettes having a calorific value of 9500 to 10,000 B.T.U.:—

Raw coal required, 10 x 2½ = 25 tons, at 1/-	£1	5	0
Cost of briquetting, at 6/6	3	5	0
Freight to Melbourne, at ½d. per mile	1	17	6
Cost of 10 tons of briquettes in Melbourne	£6	7	6
Cost per ton in Melbourne	0	12	9
Interest, at 10 per cent.	0	0	9
	£0	13	6
Delivery charges per ton	0	1	6
Total cost delivered	£0	15	0

A leading German firm estimates cost of plant as follows :—

Table XI.—Expenses.

Capacity	1 Press	2 Presses	3 Presses
Per annum Raw Coal	43,000 tons	86,000 tons	129,000 tons
,, Briquette	15,000 ,,	30,000 ,,	45,000 ,,
Per week - -	300 ,,	600 ,,	900 ,,
Cost per ton - -	6/-	6/-	5/9
Plant - - -	£22,000	£35,000	£47,000

From other information received the sums appear to be rather excessive. A plant capable of producing 165 tons per day, per year of 300 days (50,000 tons), should cost about £20,000. The plant erected by the Otis Co. cost £6000. It produced 30 tons briquettes per day of 10 hours, per year of 300 days, working full 24 hours—21,600 tons.

Burning Raw Brown Coal in Ordinary Household Grate.

A test was made of the suitability of brown coal for use as a fuel in an ordinary grate. The coal was burned daily for a week, and the amount used compared with Newcastle coal used under similar conditions.

Table XII.

	Hours burning	Total Coal used	Coal used per hour of fire	Ash per cent.	Contained moisture
Brown Coal -	57½	218lbs.	4.6lbs.	2.23 p.c.	35 p.c.
Black Coal -	55½	122 ,,	2.2 ,,	7.59 ,,	

Its use in this direction would be only possible if it could be sold in Melbourne at half the cost of black coal, as it would not possess the advantages of the briquetted coal.

Tests Made on Brown Coal by Melbourne Tramway Company in 1890.

These were made on a large scale, and the report stated that it was a good steaming coal, burning with no smoke, and that the tubes were much cleaner than when using black coal. On the other hand the ash was very light, and gave much trouble to keep the bars clean.

The comparative values recorded were:—

Newcastle, 1 ton = Brown Coal, 2.4 tons.

It was admitted that the sample of brown coal used was very inferior, and not a fair quality, and that with a better arrangement of fire bars the results would have been more satisfactory.

Tests made by Austral Otis Company for Messrs. C. Newbery and R. A. F. Murray.

The brown coal used was of the following composition:—

Water - - - -	25.98
Volatile Hydro-Carbons -	31.02
Fixed Carbon - - -	40.65
Ash - - - -	2.35
	100.00

The evaporative power was found to be:—

1 lb. A.A. coal evaporated 8.9 lbs. water.

1 lb. Brown Coal evaporated 6.21 lbs. water.

The general conclusion arrived at was that:—

2 tons A.A. coal = 3 tons Brown Coal.

Direct Burning of Peat.

At Aurich, in Germany, an electric power installation, with a capacity of 5000 kilowatts, is run by burning peat under steam boilers, to run steam engines. By means of a special adjunct to the boilers the peat is used, containing 90 to 95 per cent. of water. It is dried, briquetted, and automatically discharged into the furnace. It is equivalent to using coal at 6/- per ton.

The peat is raised by special "grab" arrangements (the Hone Grab).

Drying.

Ekenburg found that peat containing 90 per cent. water, when heated to 150 deg. C., decomposes, the slimy hydrocelluloses being partly carbonised. In this state it readily parts ith its water to 35 per cent. by simply squeezing it.

UTILISATION IN GAS PRODUCERS.

Whatever source of profit there may be in briquetting or distillation, the main use which will be made of our great brown coal beds is by means of the modern gas producer. The theory of this furnace is direct combustion of carbonaceous fuel and the utilisation of the gaseous product as a heating agent.

Ordinary combustion gives :—

$$2C + O_2 = 2CO. \qquad (1)$$

This is accompanied by an evolution of 30 per cent. of the heat of carbon reacted on. This loss is obviated by introducing a steam jet, which causes the reactions :—

$$C + 2H_2O = CO_2 + 2H_2 \qquad (2)$$

$$C + H_2O = CO + H_2 \qquad (3)$$

producing a cooling effect. The heat required for these reactions is obtained from the reaction (1). The combination of these effects gives the composition of gas produced as follows :—

TABLE XIII.

	(1) and (2).	(1) and (3).
Carbonic monoxide	22.6	38.0
Carbon dioxide	10.7	—
Hydrogen	21.4	14.1
Nitrogen	45.3	47.9
	100.0	100.0
Calorific value B.T.U. per cubic foot	151.5	176

The efficiency of a producer may be taken as about 75 per cent. As a utiliser of the calorific power in a fuel the ordinary steam boiler is very wasteful, and modern types of boilers have been constructed to increase the efficiency.

The introduction of producer gas and various types of gas engines has made this improvement necessary, but even so the results of comparative tests show remarkable superiority of efficiency of the gas producer over the steam boiler. This has been demonstrated in a striking manner by the U.S. Geological Survey.[1] The tests were made under entirely similar conditions, and they show that with any fuel whatever, whether bituminous coal or low grade fuel, peat, brown coal or by-products, the power derived from gas producers is 2.4 to 3 times that obtained under steam boilers using the same fuel. Added to this, the producer makes possible the utilisation of fuels which it would be difficult, if not impossible, to use by direct burning under the boiler.

The brown coal of Victoria may be regarded as eminently suitable for use in the gas producer, and the experiments have shown that the by-product recovery will be a potent factor in its successful use.

I have records of two recent trials of Victorian brown coal for suction gas plants :—

1. In the first case the plant used consisted of 36 h.p. Hornsby suction gas plant, 28 h.p. Hornsby Stockport gas engine, 24 h.p. Siemens dynamo, with water resistance in circuit. The duration of the run was 3½ hours. Coal used per b.h.p. hour, 3 lbs. The producer was one in constant use for ordinary coal or coke consumption, and had not been adapted in any way for the brown coal. As a consequence the fuel did not burn to the best advantage, and a certain amount was wasted in the grate. A more serious trouble was in the tar present in the gas. After running 3½ hours this had produced a heavy deposit in the gas valve and pipe near the engine, and also in the reservoir. Only the regular scrubber used for ordinary coal was in the system, and the tests showed that this was insufficient. The gas yielded was entirely suitable for use in the gas engine apart from the trouble indicated, and the amount produced was large.

2. In another test on similar coal, the plant was improved by the addition of a second coke scrubber, a tar extractor (working on the principle of a cream separator), and a sawdust scrubber.

The tar extractor was driven from a countershaft connected with the engine, which was in this case a Crossley 34 h.p. The engine drove a 20 h.p. dynamo. After a trial run, in which adjustment of the delivery pipe from the tar extraction was necessary, the plant ran with every satisfaction for several hours. The valves and cylinders were found to be perfectly clean; a little tar was obtained from the coke scrubber, but none from the sawdust. Coal used per i.h.p., 3 lbs. The coal used in both these trials was very damp. No modification had been made in the producers, which could have been improved by introducing a wider hopper and a rocking type of grate arranged over a water seal, so that the fire bars could be kept always clean.

The advantage of suction plants is that the small installation will work quite as economically as the larger, and much more so than a steam plant for similar power. By the use of lignite briquettes in Germany a consumption of only 1.76 lb. per kilowatt hour is guaranteed.

As far as the pressure producer is concerned, the most modern type for utilisation of lignite appears to be the double zone type, of which the Deutz has given excellent results. In this the first products of combustion pass again through a lower zone of incandescent fuel. The efficiency is 75 per cent. in full load, and the gas produced remarkably even in composition, about 250 B.T.U. per cubic foot. An 80 h.p. plant, using Bohemian lignite of 9200 B.T.U., consumed in test 1.19 lb. per horse-power hour, at a cost of .06d. per horse-power hour.

TABLE XIV.

The composition of the gas is given as:—

Carbon dioxide (CO_2) - - -	6.4
Carbon monoxide (CO) - - -	22.0
Methane (CH_4) - - - -	1.6
Ethylene (C_2H_4) - - - -	0.7
Oxygen (O) - - - - -	0.8
Hydrogen (H) - - - -	9.6
Nitrogen (N) - - - -	58.9
	100.0

In this type of producer it is regarded as the best practice to entirely destroy the paraffins, tar and oils, and, to burn them in the producer proper without regard to by-products.

This, however, is a matter for experience to decide, as the actual value of recovered by-products must always determine whether it is warranted by the increased cost of plant and the decreased calorific value of the gas.

The following calculation has been made of the value of Morwell coal when used in the producer, without reference to by-products:—

TABLE XV.

	Water.	Calorific Power.
(a) Morwell at ...	27.16 p.c.	8228 B.T.U.
(b) Morwell, air-dried	20.00 p.c.	9000 B.T.U.

will produce—

(a) 0.73 b.h.p. per hour per lb. coal burned.
(b) 0.80 b.h.p. per hour per lb. coal burned.

Assuming efficiency of producer 75 per cent., of gas engine 30 per cent.—

Electrical power production:—

(a) 2.01 lbs. coal per unit, at, say, 2/- per ton.
(b) 1.84 lbs. coal per unit, at, say, 2/2 per ton.

Cost of fuel:—

(a) .0215d. per unit of power produced.
(b) .0214d. per unit of power produced.

Or. at 5/6 per ton (2/- mining, 3/6 freight), .059d. per unit in Melbourne at a generating station. This plan has to be compared with the transmission of power at high voltage from generators at the mine. Bituminous coal, 13,000 B.T.U., at 12/- per ton, would cost .082d. per unit. The cost of winning the raw brown coal has been taken at 2/-, but it has been shown that in a large way of working this can be considerably reduced,

Power production, then, is best obtained by gasification of the coal. Sufficient evidence has, I think, been brought forward to show that the brown coal is entirely suitable. The utilisation of this power is directly connected with electrical energy, and this leads to the question of location of the dynamos. To bring the raw fuel to Melbourne loads it with the freight charge of, say, ½d. per ton per mile; or 3/9 per ton. On the other hand is the expense of transmission at high potential, which I will not do more than mention. Suffice it to say that transmission of power at a high voltage of from 30,000 to 40,000 volts with suitable transformers is in successful operation in different parts of the world. In Germany power is transmitted from Lauffen to Frankfurt, 106 miles, at a pressure of 30,000 volts.

SUMMARY.

The whole problem and scheme may be thus stated :—

Gippsland Coal.

1. The coal can be mined in the open cut at a rate which should not exceed 1/- per ton.
2. The amount is practically unlimited.
3. The calorific value improves with depth.
4. The distance from Melbourne is 80 to 90 miles.
5. Suggested means of utilisation :—
    (a) Briquetting on the mine for household use in Melbourne.
    (b) Distillation, producing—
        (1) Rich gas—Calorific power 450 B.T.U. per cubic foot.
            Carbonic oxide, 25 per cent.
            Hydrogen, 50 per cent.
            Methane, 10 per cent.
        (2) Ammonium sulphate.
        (3) Acetic acid.
        (4) Methyl alcohol.
        (5) Tarry products—light and heavy oils, paraffin, pitch, greases, dyes, deodorants, etc.
        (6) Carbonaceous residue.
    (c) Producer gas—with or without by-products. Gas calorific power, 140 B.T.U., and the utilisation in gas engines for electrical purposes.

Port Phillip Bay Coal.

A shaft at Altona Bay showed a bed of 65 ft. at a depth of 335 ft. The advantage which this deposit would have, being within 12 miles of Melbourne and near to deep water, is more than counterbalanced by the greater cost of production, due to necessary mining and its inferior quality. The cost of production would be about 5/- per ton.

The Morwell deposit has the balance of evidence in its favour as an economical source of fuel supply.

DISCUSSION.

Mr. J. Gibson, the President, in inviting those present to take part in the discussion, said that if Victoria is to retain its place in the industrial world, it is essential that manufactures should secure a cheaper power. What we have to find out is whether it is possible to economically utilise the brown coal resources. Mr. Gibson stated that his firm had carried out experiments in this direction. For several years their boilers were fired with small coal containing about 20 per cent. moisture, and the consumption, as compared with ordinary black coal, was as two to one. The South Australian brown coal had also been tried, first as it came from the mine, with about 40 per cent. of moisture, and it simply put the fires out. Then it was tried by mixing with bituminous coal, and the result was that as much bituminous coal was used as if there had been no brown coal at all. Another experiment was made by grinding in a Cyclone pulveriser and firing the furnaces as is done with black coal, but the result was not very successful, whilst at the same time extremely dangerous, being very liable to spontaneous combustion. In Germany, where brown coal is used, it is not burnt in grates, but on the hearth.

Mr. F. E. A. Stone referred to experiments which he helped to carry out some fourteen years ago in connection with the use of brown coal for locomotives, and which proved an absolute failure. In his opinion it was out of the question to use brown coal, except as it comes from the mine, containing 35 per cent.

of moisture. Mr. Bayly referred to air drying, but it would require an enormous area of drying sheds, and the extra handling would add considerably to the cost. The efficiency of brown coal is very low. His experience of mixing it with black coal was identical with the chairman's. Briquettes were tried on the locomotives with the bars set very much closer than is usual for black coal, but as soon as they got hot they fell to pieces, and the consumption was enormous.

Mr. Jacobs said that he visited Europe last year and investigated the brown coal industry. He considered that it would pay to instal a briquetting plant in Victoria, and considered that a capital of £50,000 would be required.

Mr. G. D. Meudell said that the output of brown coal in Germany for 1907 was 62,000,000 tons and briquettes 14,000,000 tons. Although brown coal is not used for passenger locomotives it is used all over central Europe for slow freight trains. In Victoria brown coal has had to contend against the officials who have reported on it. Mr. Bayly, however, has taken a firm stand in favour of the commercial and economic usefulness of these deposits.

Mr. W. N. Pratt looked at the subject from the commercial aspect. He said that if brown coal cannot be produced at a price to make it a marketable commodity, all the analyses would have to be relegated to the laboratory. Mr. Bayly stated it could be mined at Morwell for 1/- per ton if produced at the rate of 500 tons per day, but this is above the possible consumption, at any rate for household purposes. By reducing the output to 50,000 tons per annum the cost would probably be at least 1/6 per ton; freight will not be lower than 3/9 (½d. per ton per mile). It cannot be handled in the city and suburbs for less than 1/- per ton. By briquetting the coal you will lose 6d. per ton by the reduction in weight. Cost of machinery will be equal to 1/- per ton. Briquetting will cost 3/- per ton, and management 3d. This brings cost of briquettes up to 11/- per ton. One ton of good black coal is equal to two tons of brown coal, and costs in proportion less. In Germany there is a population of 50,000,000, and the cost of labour low, so that conditions are very different to what obtains in Victoria.

Mr. Evans, in referring to Mr. Bayly's suggestion to add clay to the briquettes to make the ash heavier, said that in South Wales it was customary to mix the anthracite culm with clay, and it produced a very nice fuel, but the ash was light.

Mr. Bayly, in replying, said that brown coal has an economic value, and we must find it out. He pointed out that Mr. Jas. Stirling, formerly Government geologist, had been an enthusiastic advocate of our brown coal resources, and had written exhaustive reports on the subject.

BIBLIOGRAPHY OF BROWN COAL.

1891— (1) Report on Coal.
By Royal Commission. Victorian Government.
1892— (2) The Brown Coal Industry in Germany.
By J. Cosmo Newbery.
(3) Report on Coal and Coal Tests Board.
By Royal Commission. Victorian Government.
1893— (4) Notes on Victorian Brown Coal Beds.
By Jas. Stirling. Aust. Inst. Min. Eng.
1900— (5) Utilization of Brown Coal Power by Electrical Means.
By H. C. Jenkins, A.R.S.M., Vict. Govt. Metallurgist.
(6) Destructive Distillation of Brown Coal.
Ex "Mineral Industry," New York.
1901— (7) Report on Narracan and Dean's Marsh.
By H. C. Jenkins.
(8) Notes on Brown Coal Industry in Germany and Austria.
By Jas. Stirling.
1902— (9) Report on Utilization of Brown Coal.
By H. C. Jenkins.
(10) The Tertiary Brown Coal and Liginite Beds of Victoria.
By Jas. Stirling. "Journal of British Society of Mining Students."
1903—(11) Report on Coal Supplies.
By Royal Commission. British Government.

(12) "Steam."
By Babcock & Willcox Ltd.
(13) Briquettes and Patent Fuel.
By Björling.
1907—(14) The Analysis of New Zealand Coals.
By J. S. Maclaurin, D.Sc., F.R.S. Reports to N. Z. Government.
(15) Peat: Its Use and Manufacture.
By Björling & Gissing. Rebman Ltd., London.
1908—(16) Gas Power.
By Junge.
(17) Report on Electric Power Production in Victoria.
By Chas. H. Merz. Victorian Government.

For full Bibliography of Records of Boring, Departmental Reports, and all published information concerning Brown Coal in Victoria, see :—

1907—(18) A Contribution to the Bibliography of the Economic Geology of Victoria.
Records of the Geological Survey of Victoria, Vol. II., Part 3.