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Solid Fuel from the Technical and Commercial Standpoint.

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READ

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CHAIRMAN : MR. B. P. FIELDEN (Member of Council).

MY theme this evening is by no means new. It is merely a modest attempt to collect and compile a series of facts and data and to put forward certain crude and possibly impossible suggestions, which might at least interest chief engineers, and if I might be so bold and go so far, interest the consulting and the superintendent engineers also. It is, broadly, the application of the approximate analysis of coal, and the purchase of coal on a calorific basis for marine purposes, and so to introduce the subject, I purpose to briefly review the original constitution of coal.

The vegetable origin of coal is now almost an established fact, although certain authorities claim that varieties of bituminous coals have other origins. While this phase of the subject is undoubtedly interesting, it does not bear particularly upon the point at issue this evening. To a user the heat giving composition of a fuel is of much more importance.

Coal as it leaves the mouth of the pit broadly consists of com-
bustible substances, including the inflammable gases, together
with those of a non-inflammable nature, oxygen and nitrogen,
also mineral substances known as ash.   This ash is the result
of the minerals in the sap of the original plant together with
the material associated with its growth.

The combustibles can be enumerated as carbon, hydrogen,
and sulphur, with which are associated the oxygen and nit-
rogen.   Coal is therefore a complex mineral, the constituents
and properties of which vary very considerably.   Similar ulti-
mate analysis vary very considerably, and the varying constitu-
ents influence greatly their manner of burning.   The various
grades between wood and coal are illustrated in the samples
before you, and a fossil fern taken from a coal bed is submitted
as a type of the evidence as to the origin of coal.   (Here sam-
ples of peat, brown and black lignite, bituminian and anthra-
cite coals were shown, together with a fossil fern taken from a
coal measure).

Moisture which should have been included in the above can
be subdivided : that due to the hygroscopic nature of the coal
varying from one to four per cent, and that which is accidental,
or might I be correct in suggesting, in certain instances, added
intentionally.   High percentages of moisture are prejudical,
for obviously the most liberal would object to pay coal rates for
water, and sea water at that.   To this objection must be added
the extra weight and the loss of heat units required to evaporate
the moisture from the fuel.   In newly mined coal, however, it
is not unusual to meet with moisture to the extent of some 20
to 40 per cent.   This is eliminated by drying, but it is obvious
that in the interests of the owner, in the interests of the superin-
tendent in charge of the engineering department, and in the
interests of the chief engineer himself, some other check in the
direction of moisture is required than the eye of the chief him-
self, when coaling.

The mineral material, ash in the coal, is again another
source of trouble and loss, and one with which the marine engi-
neer who has to deal with foreign coals is too well acquainted
with, often to his sorrow.   Ash is not only valueless as a heat
producer, but it is associated with inefficient conditions only
too well known to those whose misfortune it has been to use
them.   The screening and wasting process tends to remove
large quantities, but an amount is practically inseparable from
the coal.   Thus ash, in more or less quantities is paid for at

coal rates, and gentlemen, it is not business to pay coal prices for paving stones.

Oxygen in a coal is, according to White, of America, about as objectionable, from a thermal standpoint as ash. He shows how that in two samples of coal with the same percentage of carbon, the one with high percentage of oxygen, and low ash, and the other with high ash and low oxygen percentage, the losses were about equal.

Nitrogen is of no thermal value. Associated with the coal it amounts to from one to two per cent. Some authorities, however, maintain that in some bituminous samples the percentage is much less.

Sulphur is considered by some to add to the thermal value of coal, but the amount is so small that, in this direction, it is usual to ignore it. In other directions, however, sulphur claims serious attention. It is found in quantities ranging from ·5 to 2·5 per cent. in the form of pyrites, and will, when heated under the ordinary condition of a furnace, yield sulphur dioxide, a very corrosive substance for copper pipes and the like. It is also said that the liberated sulphur from coal is absorbed by the fire bars, making the compound comparatively fusible, and this, no doubt, accounts for the trouble not infrequently experienced with certain classes of foreign coals such as the burning of the fire bars and metal bridges.

The classification of a coal is generally based upon the volatile hydrocarbons present. These hydrocarbons greatly influence its burning, its suitability for special purposes, and to a large extent the design of a fire grate. Flame is caused by their combustion, and smoke is the result when their combustion is incomplete.

A classification of carbonaceous coals according to the volatile matter contained is given as :—

Volatile matter up to		$8°/_{\circ}$	Anthracite.
,,	,,	3 to $16°/_{\circ}$	Carbonaceous.
,,	,,	16 to 26	Short Flaming Coals.
,,	,,	26 to $32°/_{\circ}$	Normal Bituminian.
,,	,,	32 and above $/_{\circ}$	Long Flaming Coals.

The commercial varieties of coal can be broadly classified under three heads: Lignites, bituminians, and anthracite. These can be again subdivided according to the whim of the merchant, but for our present purpose the three broad classes will suffice.

In *Lignite* there is the first geological stage between a peat and a true coal. The carbon has become metallised, it varies widely in character and composition, and it contains very high percentages of moisture, in some instances as high as 50 per cent. The value of volatile carbon to the fixed carbon is often one to one. The calorific value ranges about 10,000 B.T.U. (Samples of various types of lignite coals were here shown).

Bituminous coals are rich in hydrocarbons. In fact, about one-third of the heat units are in the hydrocarbons, consequently with this grade of coal a large number of heat units can be obtained from the fuel bed itself. It therefore follows, that the manner of the air admission to the furnace, the ratios of combustion space, and surface to fire grate area are features largely influencing the efficient combustion of a bituminous coal. For a high percentage of volatile matter is liable to wasting, owing to the escape of unburnt gases, while too low a value demands an excessive air supply. From available data it appears that a fuel which contains 15 to 20 per cent. of volatile matter often gives the most satisfactory results.

Anthracite coal (sample submitted) is very rich in free carbon. Its chief use is associated with the producer gas plant, but so far does not enter largely into the work of a marine engineer.

To those who go down to the sea in ships (engine rooms) is given the special privilege of a weird and wide knowledge of the world's coal varieties. Not as a rule the best of their varieties either, and in many cases their quality is by no means improved during its transit from the coal beds to the ship's bunker.

Lignite Coal.—The bulk of the coal used for marine purposes is of the lignite or bituminous class. The specific gravity of the average coal runs from 1·27 to ·45. The storage capacity depends to a great extent upon the specific gravity. The following data, according to Bream, is the storage capacity of the different coals as per admiralty data :—

<div style="margin-left:3em">

One ton of Welsh coal, 40 to 42 cub. ft.

One ton of Newcastle coal, 45 cub. ft.

One ton of Scots coal, 47 to 50 cub. ft.

</div>

The physical properties of coal can be ranged under the heads of density, cohesion, and calorific value. The combustible substances of the coal have been stated to be carbon, hydrogen, and the oxygen it contains, and when combustion is complete the flue gases should be composed of carbon dioxide, water vapour,

sulphur dioxide, together with nitrogen and free oxygen, the latter being due to an excessive air supply. In general terms practical combustion is a compromise between heat losses due to incomplete combustion, and losses due to heat units being carried away by the excess of the air supplied. This subject is so well explained in practically all engineering text books that it would be waste of time, and indeed, there is no need to dwell upon it here. A perusal of the following table would no doubt prove interesting as clearly showing the varying loss under conditions due to the formation of CO., and also to an excessive air supply.

TABLE I.—CARBONIC ACID PRODUCED BY EXCESSIVE FIRING.

TIME. H.M.	Pounds of Coal thrown on Grate. Pounds.	Carbonic Acid in Chimney Gases. Per cent. CO_2.	Carbonic Oxide in Chimney Gases. Per cent. CO.	Ratio of Carbon in Carbonic Oxide to Total Carbon. Per cent.	Pounds of Air per Pound of Coal. Pounds.	Pounds of Coal Burned each Half-Hour. Pounds.	Ratio of Loss by Carbonic Oxide to Full Power of Coal. Per cent.
6.15 a.m.	200	—	—	—	—	—	—
6.45	200	—	—	—	—	—	—
7.15	200	—	—	—	—	—	—
7.45	200	—	—	—	—	—	—
8.15	200	—	—	—	—	—	—
8 45	200	—	—	—	—	—	—
9.00	—	5·12	2·54	43 80	33·2	83·81	27·84
9.15	200						
9.30	—	5 55	2·99	45·85	29·5	93·75	29 14
9.45	200						
10.00	—	7·79	3 99	44·63	21·4	129 24	29·37
10.15	200						
10.30	—	7·70	4.61	48·47	20·1	137·60	30·81
10.45	200						
11.00	—	7·82	4 70	48·57	19·8	139·68	30 88
11.15	200						
11.30	—	8·01	4·81	48·55	19·3	143·30	30·86
12.00 m.	—	—	—	—	19·3	143·30	—
12.30 p.m.	—	15·21	0 25	2·52	19·3	143 30	1·60
12.45	200						
1.00	—	—	—	—	20 05	137·94	—
1.30	—	14·11	0·21	2·28	20·8	132·96	1·49
2.00	—	—	—	—	21·05	137·94	—
2.30	—	13·62	0·33	3·67	21·3	129·85	2 31
2.45	200						
3 00	—	14·50	0·48	4.95	19·4	142·56	3·14
3.30	—	13 18	0·29	3·39	22·0	125·34	2·12
3.45	200						
4.00	—	14·96	0·38	3·84	19·3	113·30	2 44
4.30	—	14·18	0·41	4·35	20·3	136·25	2·76
4.45	200						
5.00	—	13·01	0 41	4·72	22·0	125·34	3·00

Mean quantity of air .. .. 21·653
Mean of all but first two .. .. 20·36
Mean ratio of loss: first six, per cent. .. .. .. 29·65
Mean ratio of loss: last eight, per cent. .. .. .. 2·36

TABLE II.—LOSS OF EFFICIENCY DUE TO EXCESS OF AIR AND
TEMPERATURE OF ESCAPING GASES ABOVE TEMPERATURE.

TEMPERATURE OF ESCAPING GASES ABOVE ATMOSPHERE.

| Excess of Air in per cent. of that Chemically Registered. | 300 | 300 | 400 | 400 | 500 | 500 |
	Total B.T.U. in Gases.	Loss in per cent. of Total Heat Value of Coal.	Total B.T.U. in Gases.	Loss in per cent. of Total Heat Value of Coal.	Total B.T.U. in Gases.	Loss in per cent. of Total Heat Value of Coal.
0	695	5·9	928	7·9	1,160	9·9
50	1,016	8·7	1,354	11·5	1,693	14·4
75	1,176	10·0	1,568	13·3	1,959	16·7
100	1,336	11·4	1,781	15·2	2,226	19·0
125	1,495	12·7	1,994	17 0	2,492	21·2
150	1,655	14·1	2,207	18·8	2,759	23·5
175	1,815	15·5	2,420	20·6	3,205	25·8
200	1,975	16·8	2,633	22·4	3,291	28·0

It has been my endeavour to emphasise the fact that coal is a
substance varying in properties and qualities, and in these days
of recorded data and strict economy in engineering it is some-
what surprising that coal, our chief fuel, and main expenditure,
should have escaped the balance and the measure so long.   To
the marine engineer a more accurate knowledge of the fuel he is
burning would undoubtedly be an advantage.   This, combined
with a slight knowledge of practical funnel gas analysis, and
the simpler apparatus to perform these interesting experiments
and tests, would, I venture to assert, lead to better results than
are to be obtained in the ordinary run of things (dare I venture
to say) from the taking and studying of the indicator card.
Not that I wish to discourage the one, but to emphasise the
other.   To the marine engineer, therefore, the application of
coal analysis, and funnel gas testing, open up a wide field of
interesting and useful research.   For to the marine engineer
the engine room and stokehold are his research laboratory, the
place where his chief experience is to be gained, and the fascina-
tion is, the research work in an engine room is never ending,
never without interest and always instructive.

First the coal supply, the difficulty of handling and dealing
with it at different ports, opens up fields of thought, certainly
great possibilities of advantageous change, but for the present
let us confine our attention to the coal as delivered on board
ship.

The marine engineer can check the weight delivered, he can sometimes, *when present*, regulate the moisture added. Then, when the ship is coaled :—To the owners, a ton of coal is a ton of combustibles, in some instances, does not the owner pay for sea water and shingle at coal prices, and when the results achieved are not quite satisfactory, is there, under the present conditions, sufficient data to adjust the discrepancy? How is the marine engineer to gauge the happy medium between too much and too little air supply for a change of coal? In fact, what possibility has the chief engineer to justify results? For a true estimate of coal cannot be obtained from merely viewing. The addition of a snap analysis apparatus would, where CO_2 recorders are not fitted, be a step in the right direction as regards the air supply, and a system of sampling when coaling, and also during the voyage, with an approximate analysis of the samples, say, when reaching port, would possibly be a remedy for the other. The purchase of coal by its calorific value and the systematic approximate analysis of a fuel is finding high favour among large consumers ashore. The question is, can a satisfactory modified form be adopted in the marine world?

It is not necessary to be a highly skilled chemist to perform an approximate analysis, and with a view to substantiating this statement the following particulars are submitted. The principle consists in ascertaining the moisture, hydrocarbons, carbons, ash, sulphur, and calorific value. The apparatus required are :—

A fairly sensitive balance and weights. Fig. 1.
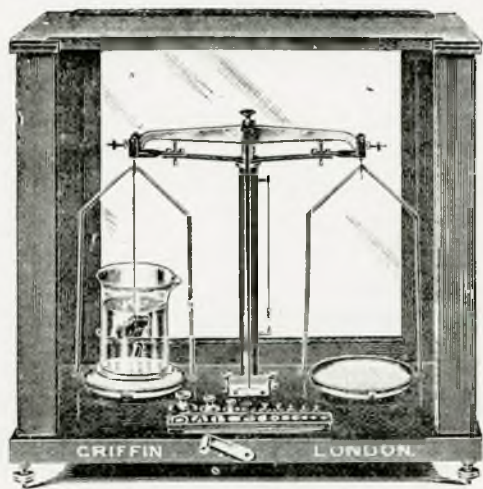
5586.

Fig. 1.

A desiccator for cooling the samples away from the action of the air.

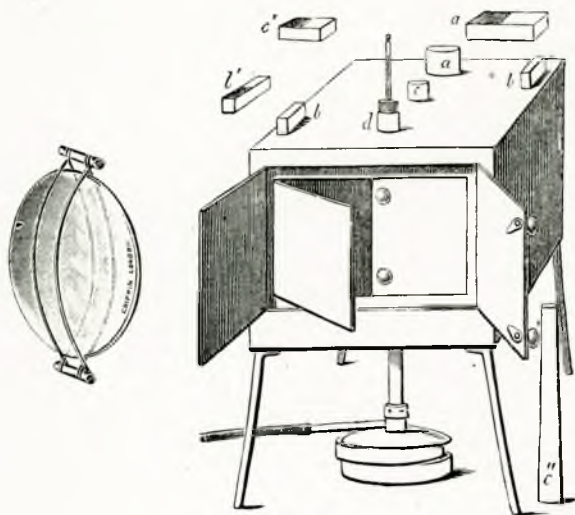Fig. 2. A drying oven, with watch glasses and thermometer.

Fig. 2.

A blow-pipe, with bellows, crucible and stand.
A suitable calorimeter.

The approximate analysis of coal.—The coal is sampled as described later and crushed by being passed through an ordinary coffee mill, which reduces it to a sufficiently fine powder. The coal is air-dried before testing. Two grammes of this sample are weighed into a pair of clock glasses and clamped together with a suitable clamp. This is placed in the drying oven, and is dried for ten minutes, taken out, allowed to cool under the desiccator, and weighed. A reduction will be the result. This process is repeated until there is an increase in weight, which indicates that the moisture is driven out, the increase of weight being due to the absorption of oxygen. The difference of weight gives an estimate of moisture. The amount is then expressed as a percentage in the usual way.

Volatile matter.—Two grammes of coal are weighed into (for preference) a platinum crucible, provided with a good fitting lid. This is heated for about seven minutes over a bunsen flame. Then further heated under a blow-pipe flame. The

whole is then cooled in the desiccator and weighed, and from these results the percentage of volatile matter is obtained. The coke residue consists of free carbon and ash.

Ash.—The coke residue is now burned either with a muffle furnace or by means of a blow-pipe flame. The process of cooling and weighing determines the complete combustion of the carbon. The difference of weight before and after the experiment gives the coke, or free carbons, while the residue is ash.

The estimate of sulphur is probably beyond one who has not had some experience at gravimetric analysis and had best be omitted, other than perhaps stating that when a bomb calorimeter is used the process is greatly simplified. A little distilled water is placed in the bomb and after ascertaining the calorific volume in the usual way the bomb is allowed to stand for about ten minutes, the sulphur is thus converted into a trioxide which is readily absorbed by the water, the whole of the bomb is rinsed in distilled water and the sulphuric acid thus formed is precipitated by barium chloride. The barium sulphide thus obtained is multiplied by ·1375, the corresponding weight of the sulphur, and this multiplied by 100 and divided by the weight of the fuel gives the percentage.

The calorific value is carried out by burning a known quantity of fuel in a confined space and surrounded by a known quantity of water. Then from the rise in temperature of the water the calorific value of the fuel can be obtained.

There are many and various types of calorimeters:—

(*a*) Those in which the oxygen is supplied in the form of a chemical compound, such as the Lewis Thompson and the Roland Wild Calorimeter.

(*b*) Calorimeters using oxygen gas at normal pressure, such as the Darling, the William Thompson, and others.

(*c*) The bomb type of calorimeter in which the fuel is burned under a pressure of several atmospheres.

The Lewis Thompson apparatus (Fig. 4) consists of a large glass cylinder consisting of 2,000 cc. of water, when filled to the mark, a copper cylinder or bell fitted with a pipe and tap as shewn, a small copper cylinder to hold the fuel, and a holder for the same. The method of operation is as follows: Two grammes of finely powdered coal (air dried) is mixed with 22 grammes of a suitable oxygen mixture such as potassium, three parts potassium nitrate to one part of potassium chlorate. This is well mixed and should present a uniform grey appearance.

The mixture is now placed in the small copper cylinder, which is fixed in the holder referred to, and ignited by means of a fuse. The whole is then quickly covered by the bell and immersed in the glass vessel containing water. Combustion is thus per-
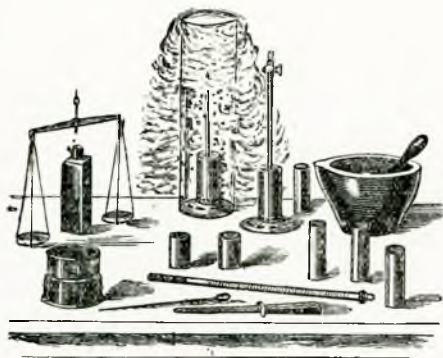

Fig. 4.

formed below water, and the heat liberated is taken up by the water. The final highest temperature reading is carefully noted and from this data the calorific value of the fuel is deducted.

$$\text{Calorific Value} = \frac{(20000 \times X)\ t}{2}$$

when X = water equivalent of the apparatus

when t = rise in temperature in degrees C.

The value X is best obtained by testing standard samples of fuel.

Roland Wild's Calorimeter.—This apparatus is of the sodium peroxide type, and consists of a combustion chamber suspended from the cover by a conduit, which is furnished with a valve. There is a well-made copper water vessel, inside an outer vessel, heavily nickelled, forming an air jacket, which effectually prevents absorption and radiation, thus rendering the rise in temperature of the water an absolutely true guide to the heat given off by the fuel. An agitating paddle or stirrer and a best quality sensitive thermometer, divided into $\frac{1}{10}$ths and easily read in $\frac{1}{20}$ths are also provided.
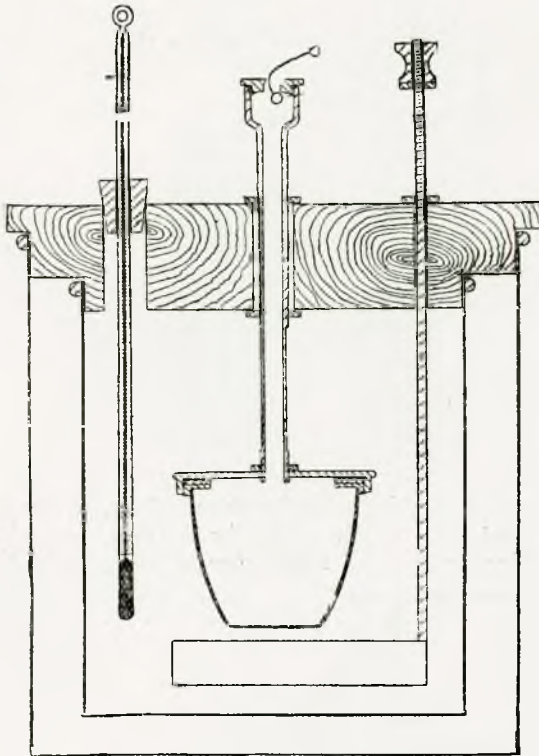
Fig. 5.

BRIEF INSTRUCTIONS.

(a)   Place stated amount of water in water vessel, and, of dried fuel, with proper amount of sodium peroxide into the crucible, which screw firmly home.

(b)   Stir water until temperature is constant, and note same.

(c)   Heat a piece of nickel wire to redness, drop same through valve opening and draw valve home, agitate water by stirrer. Note highest temperature.
The rise in temperature multiplied by 1000=calorific value in B.Th.U.'s of the coal.
The calorific value ÷ 967=evaporative power per lb. of the coal.
Example.—Water, 51°; rise, 13·15°.   Coal value, 13,150 B.Th.U.   Evap. Power per lb. 13·6 $\left(\frac{13150}{\cdot 967} \right)$.

In the *William Thompson* (Fig. 6) calorimeter accurate results can be obtained.   Radiation errors are largely prevented by placing the glass cylinder in a reflecting casing.   A careful perusal of the illustration (Fig. 6) will fully explain the principle.   It will be noted that the oxygen is supplied at normal pressure from a bottle, and that a series of baffles are provided to check the progress of escaping gases when passing through the water.   A wash bottle is also a useful addition be-

tween the oxygen and the calorimeter, the rate of flow of the
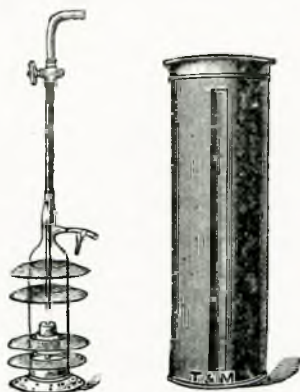gas being gauged by the bubbles passing through the water.

Fig. 6.

Far the most valuable, and also the most expensive apparatus
is the *bomb calorimeter* illustrated in the accompanying sketch
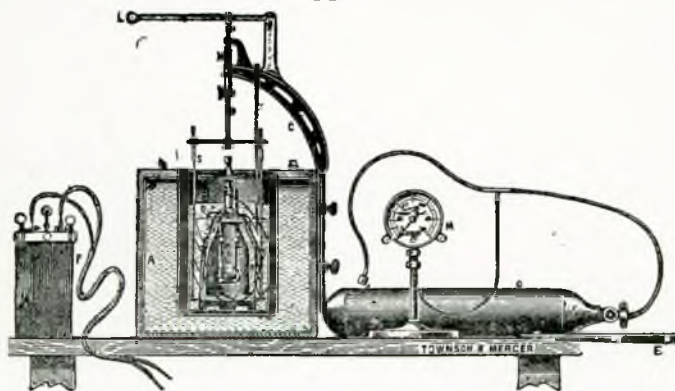(Fig. 7). The bomb, the apparatus where combustion takes

Fig. 7.

place, is of steel, lined with enamel to prevent corrosion. The
top is fitted with a cap, gas tight, and is provided with an inlet
for the oxygen and two electrical terminals to fire the charge.
The coal sample is made into a pellet and placed in a platinum
crucible in the bomb, the lid screwed on, the bomb charged with
high pressure oxygen from the bottle, and the whole immersed
in water similarly to the other systems. The charge is fired
with electricity and results in an explosion within the bomb.

The rise in temperature is noted, and the calorific value deducted from data obtained in the usual way.

There are also various elaborations such as circulation, which are shown in the accompanying sketch. For accurate work, corrections are made for sulphuric or nitric acid. One correction, however, which is worthy of note is that for radiation, as it applies to all calorimeters and is therefore of value.

I take the following from "Fuel," a very complete work on the subject by Bream : —

Radiation.—All systems of correction which are not purely arbitrary are based upon Newton's law, that the rate of radiation is in proportion to the difference of temperature between two bodies. This holds for all differences of temperature between the bodies, and this holds good for such temperatures as are involved in calorific work. The following example is also given by Brotne as an illustration.

CALORIFIC VALUE.

$$\text{Calorific Value} = \frac{(2000 \times X)\,t}{2}$$

Initial Temperature $t = 15 \cdot 52^\circ$
Correction for true rise in " t^2 "

Time after Firing in Minutes.	Thermometer Reading.	Mean Temperature per Minute.	Mean Difference.
1	17·37	16·445	0·925
2	17·94	17·655	2·135
2½	17·95	17·945	2·425
$(t)^2$ 3	17·95	17·945	2·425
4	17 9·45		
5	17·935		
10	17·860		

NORMAL RISE $= 17 \cdot 95 - 15 \cdot 52 = 2 \cdot 43^\circ F.$

Now @ Max. T. the heat *passing out of the Bomb* about $=$ Loss by Radiation.

Loss per Minute for last five Mins. $= \dfrac{17 \cdot 935 - 17 \cdot 860}{5} = 0 \cdot 015.$

Loss during 1st Min. $= \dfrac{0\;015 \times 0 \cdot 925}{2 \cdot 43} = 0 \cdot 06^\circ$

,,   ,, 2nd ,, $\dfrac{0 \cdot 015 \times 2 \cdot 135}{2 \cdot 43} = 0 \cdot 015^\circ$

,,   ,, 3rd ,, $\dfrac{0 \cdot 015 \times 2 \cdot 435}{2 \cdot 43} = 0\;015^\circ$

TOTAL LOSS   ..   .. $= 0 \cdot 034^\circ$

Corrected Rise in Temperature
$2 \cdot 43 \times 0 \cdot 034 = 2 \cdot 464^\circ$

Having now briefly described a form of a proximate analysis of coal which may be briefly performed on land, the question of obtaining a fairly average sample must now be considered. First, for a true average sample, care must be exercised to obtain a fair proportion of lump and slack. The usual practice ashore is to select from various parts of the heap about two or three cwt. This is thoroughly broken and divided into quarters, one being taken. This is again broken down to half inch, mixed, and one quarter taken. This continues until about a two pound sample remains, the size being about one quarter inch. The sample is then placed in an air-tight jar and sealed. If duplicate or triplicate samples are required they are drawn from the mass, and sealed in the same way, ready to be handed over to the analyst.

In marine work, probably a modification of this system could be suggested. Samples might be taken while coaling, sealed, and kept in a cool place. Other samples might be taken during the voyage, data associated with the sample might prove of value, and I venture to suggest that if such a system were adopted, changes in the process of manipulation of coal at the various foreign ports would quickly follow.

It is a well known fact that notwithstanding the developments of the gas plant and oil engine, steam is still the main power producer, and, judging from the improvements in steam generators and the steam turbine, it will still continue to be so. Side by side with the vast and wonderful improvements, it is not surprising that the greatest coal consumers of the world, the marine engineer, should be content to operate without some scientific control as to purchase and consumption.

It is surprising that at least a snap analysis apparatus to test the funnel gases is not fitted even to the well equipped liner, for it is a well established fact that operating without some scientific control is open to the inroad of losses, heavy and difficult to detect. On shore, the purchase of coal on its heat value is attracting considerable attention. It is no experiment, it operates satisfactorily. I have before stated that no owner wishes to pay coal prices for sea water, or paving stones, and it is probable that many a chief engineer would have a possible explanation for high coal consumption if such a course were adopted.

Obvious difficulties and local conditions govern the coal supplied, but by reducing the matter down to $\dfrac{\text{B.T.U. per ton}}{\text{Coal in pence per ton.}}$ brings the matter down to number of B.T.U. per penny, as a basis of calculation.

Contracts are now made by various Corporations, and also various Councils upon this basis. In these instances an average B.T.U. value is cited. The price per ton is increased in the same percentage as the increase of calorific value. Similarly, it is a fair business argument. Deduction is also made for an excess of mineral ash and smalls, and certain regulations governing the minimum quantity accepted are also stipulated. By such a system a commodity of a known value is marketed; it is fair to all; it only requires modifying and adapting to marine requirements. Might I draw an analogy. In imagination, I see a pumping system supplying fresh water to a cistern. The mechanism is perfect. There are countless records and indicators, and in that modern pump room, losses are reduced to a minimum. In imagination, I see associated with that perfect installation, leakage in the strong tanks, and indescribable losses of water due to waste and overflow. It is only an imaginary system, for such things could not be in these modern times of recorded data. In reality, I see a modern steamer. Its propelling machinery is perfect. There are feed heaters, super-heaters, most efficient and scientific laggings, in fact, everything that lends to economy is there. Associated with this modern mechanical masterpiece these are furnaces into whose great mouths are continually being poured, valuable and costly fuel.

What is wrong in this great chemical manufacture of CO_2, that the results obtained are so out of proportion to the costs and efforts put forth? Is the raw material up to standard? The chief engineer must supply his chief with data. The superintendent engineer must furnish his owners with such information upon which they can safely base their course of action. Therefore let us set about at once to supply this valuable and necessary data. How is it to be done? What means are provided to do so? None!

If this paper has aroused interest and attracted attention to the lack of scientific control associated with fuel in all its phases, on board the mercantile marine, it has, for the present, attained the object of the author.

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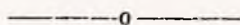
The CHAIRMAN: If there are any points on which members would like to question Mr. Battle, I should be very pleased if they would ask him now.

Mr. H. E. Newton: Perhaps Mr. Battle will tell us something about the effect of storing coal. There is no doubt that the storage of coal affects its calorific value, especially in hot climates, if large stocks are exposed in the open. Coal taken from such stocks as have been in store for a considerable time, is frequently of very inferior quality. In one case, a stock containing 80,000 tons of coal high in sulphur had practically burnt itself away in two or three years. Coal should be properly ventilated in the stocks to prevent spontaneous combustion. In loading coal cargoes, I believe a practical miner is generally engaged to attend to the proper method of stacking.

Mr. Battle: There is no doubt that the storage of coal affects its calorific value. Coal merchants generally find that it is not advisable to store coal in large quantities; 500 tons is generally the largest quantity stored; above this, spontaneous combustion is apt to occur. The calorific value of coal also is injured by storage.

In reply to a question on the testing of coal, Mr. Battle went on to say that one of the best methods of doing this was for the engineer to produce samples of the coal he had actually been burning. It had been suggested that samples should be taken during the voyage and sealed up, and this procedure would undoubtedly lead to an accumulation of data.

Mr. Newton: An electrical pyrometer fitted in the uptake would give a useful guide as to the proper chimney temperature and the state of the furnace fires. In cement works these are fitted at the tops of the high chimney shafts; the temperature there is important, as it influences the draught and the degree of heat in the kilns can be estimated from the chimney temperature.

Mr. Battle: My object has been to attract attention to the unscientific methods of manufacturing coal in the Mercantile Marine. I have not nearly exhausted the subject.

A Member: Coals appear to come in very much more mixed than they did before the introduction of the eight hours' shift.

Mr. Battle: Coal is bound to be mixed, and there is the connection of certain officials with certain foreign depots to be reckoned with, therefore I think it is necessary to have a systematic sampling during the voyage. It would not add to the work of the engineer; it simply means taking a good sample once a week or once a day, and it does not waste much fuel, a pound at a time being sufficient. .

The CHAIRMAN : It seems to me that one of the troubles in testing coal is that the samples are comparatively small and are taken from barges of different classes of coal which in turn may contain mixed coal and different results are obtained from supposedly the same class of coal at different times.

Mr. BATTLE : It seems to me that Mr. Fielden's point suggests the purchase of coal on an approximate calorific value and analysis, which would decidedly simplify matters and be at least on a business basis.

The CHAIRMAN : I do not know whether this is possible for the Company ; sometimes they are short of coal, and sometimes have to place orders weeks ahead.

Mr. BATTLE : Does not this also apply to such large buyers as the electric power station?

The CHAIRMAN : That depends on whether you have placed contracts well ahead.

Mr. BATTLE : If contracts have been placed well ahead the merchant has still got to supply the coal, and if he is paid according to value he will be careful as to quality. Certain merchants, of course, would object.

The CHAIRMAN : I should think that all foreign merchants would object.

Mr. BARTLETT : Regarding CO_2 recorders, they should prove as useful on board ship as in the power station. The recorder tells the engineer whether proper combustion is taking place or not, so that he can make the necessary adjustments by altering the air supply, or reducing the thickness of the fires, etc., to enable him to economise fuel. In some fire stations, the firemen are taught to take an intelligent interest in the matter, and those who get the best results, as shown by the recorder charts, are given a bonus. Of course the difficulty in the Mercantile Marine is to get thoroughly trained firemen, and the engineer often has to deal with a different set of men every two of three voyages.

Mr. BATTLE : It does not take much education to get a fireman to understand the CO_2 recording system ; if you can offer him some premium to keep within the limits, say of 120°, he would take more interest in his work, no doubt. Many engineers can testify to the eagerness of a good fireman to keep the steam steady on the gauge. The average shore fireman is not, in my experience, up to the standard of marine men, in fact, I

would go so far as to say that most electric power engineers would prefer a marine fireman.

Mr. BARTLETT: A good deal of trouble is sometimes experienced when using coals which contain sulphur, especially if the coal is delivered in a wet condition. I know of a large power station where the coal conveyor buckets, bunker plating, and coal chutes, were pitted and corroded in all directions, in a very short time, due to the action of the sulphur in the coal. The sulphur fumes given off from the chimneys also set up corrosion in the corrugated iron roofs of the station buildings. I do not know whether the same trouble has been experienced in ships' bunkers.

Mr. BATTLE: To the Marine Engineer, Mr. Bartlett's information is most interesting and will no doubt account for the more rapid corrosion of bunkers in certain conditions than in others. It is a well-known fact that sulphurous coal is very detrimental to boilers, and especially to fire bars; in fact, the sulphur in the coal is usually accountable for the collapse of fire bars when in heavy steam.

Mr. SHACKLETON: I should like to say one or two words. One thing has occurred to me which perhaps accounts for the better results in certain power stations, and that is that the great majority are equipped with mechanical stokers. Amongst the fuel there, Mr. Battle has shown us some peat. Of course, in the steamship world peat is useless; in the gas world it is not. Gas-plants are utilised, and are being utilised to fire boilers direct, and the boilers may be regulated to give their full capacity or a lower capacity as desired. I think such a plant and system has a future, to say nothing of the fact that there is no smoke whatever from the funnels. Apart from that, I think that Mr. Battle has gone into a very rich field and the talk has been a very interesting one.

The meeting closed with votes of thanks to Mr. Battle and the Chairman.

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The following table gives the composition and calorific value of a number of fuel oils as published by Messrs. Babcock & Wilcox in their book on water-tube marine boilers: —

KIND OF OIL.	Per cent. Carbon.	Per cent. Hydrogen.	Per cent. Sulphur.	Per cent. Oxygen.	Specific Gravity.	B.T.U. per lb.
California	85·04	11·52	2·45	·99*	—	17,871
California	81·52	11·51	·55	6·92*	—	18,667
Texas, Beaumont ..	84·6	10·9	1·63	2·87	·924	19,060
Texas, Beaumont ..	83·3	12·4	·50	3·83	·926	19,481
Texas, Beaumont ..	85·0	12·3	1·75	·92*	—	19,060
Texas, Beaumont ..	86·1	12·3	1·60	—	·942	20,152
Texas	87·15	12·33	0·32	—	·908	19,338
Texas	87·29	12·32	0·43	—	·910	19,659
Ohio	83·4	14·7	0·6	1·3	—	19,580
Pennsylvania	84·9	13·7	—	1·4	·886	19,210
West Virginia ..	84·3	14·1	—	1·6	.841	21,240
Russia, Baku	86·7	12·9	—	—	·884	20,691
Russia, Novorossick ..	84·9	11·6	—	3·46	—	19,452
Russia, Caucasus ..	86·6	12·3	—	1·10	·938	20,138
Mexican	85·1	11·5	2·1	1·3*	·87	19,289
Mexican	84·2	11·4	3·6	0·8*	·929	18,671
Mexican	83·0	11·0	4·3	1·7*	·97	18,182
Java	87·1	12·0	—	0·9	·923	21,163
Java	87·0	12·5	0·3	0·2	·894	19,247
Austria, Galicia ..	82·2	12·1	5·7	—	·870	18,416
Austria, Galicia ..	86·5	13·0	0·3	0·2	·855	19,532
Italy, Parma	84·0	13·4	1·8	—	·786	—
Borneo	85·7	11·0	—	3·31	—	19,240
Borneo	87·4	11·4	0·2	1·0	·936	18,769
Shale Oil (Broxburn) .	86·4	12·72	·38	·52*	·86	19,430

* Includes N.

Nearly all the above are natural oils. Shale oil, however, is a special distillate and comes almost entirely from Scotland, but, on account of the high cost, its use is practically limited to Naval vessels, and especially for the oil engines of submarine boats. The total output of shale last year was about 3,500,000 tons, but the average yield of crude oil per ton of shale distilled is only about 22 to 25 lbs., and, if it were not for the value of the by-products obtained, the cost of its production would be too high even for naval vessels. Its quality, however, is eminently suitable for burning as a fuel or for use in Diesel engines.