FRONTISPIECE. PLATE I.

Fuel Testing Station, Ottawa.

CANADA
DEPARTMENT OF MINES

MINES BRANCH

HON. ROBERT ROGERS, Minister; A. P. LOW, LL. D., Deputy Minister;
EUGENE HAANEL, PH. D., Director.

REPORT

ON THE

UTILIZATION OF PEAT FUEL

FOR THE

PRODUCTION OF POWER

Being a record of experiments conducted at the Fuel Testing Station, Ottawa, 1910-1911

BY

B. F. Haanel, B.Sc.,
Chief of Fuel Testing Division.

OTTAWA
GOVERNMENT PRINTING BUREAU
1912

No. 154.

21256—1½

LETTER OF TRANSMITTAL

DR. EUGENE HAANEL,
Director of Mines Branch,
Department of Mines,
Ottawa.

SIR,—I beg to submit, herewith, a report on the results of the investigation of the utilization of peat for the production of power, conducted at the Fuel Testing Station, Ottawa, 1910-11.

I have the honour to be,
Sir,
Your obedient servant,

(Signed) **B. F. Haanel.**

Ottawa, March 2, 1912.

4082

AUTHOR'S PREFACE.

With a view to ensuring an orderly arrangement of the resultant record of the experiments conducted with peat fuel, for the production of power through the medium of the gas producer, the following report has been divided into two parts:—

I. Description of the Körting producer gas plant, and cleaning system —as originally constructed and installed at the Fuel Testing Station, Ottawa; together with complete detailed records of the trials and tests conducted therewith;

II. Description of the alterations made to the producer plant by the makers; added to which are complete detailed records of the trials and tests conducted after the alterations had been made.

Valuable assistance was rendered by John Blizard, B.Sc., throughout the trials—particularly in the interpretation and working up of the results set forth in Part II; and by Edgar Stansfield, M.Sc., who had in charge the chemistry involved in the entire series of tests.

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PART I.

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REPORT

ON THE

UTILIZATION OF PEAT FUEL FOR THE PRODUCTION OF POWER: AN ECONOMIC INVESTIGATION

BY

B. F. Haanel, B.Sc.

PART I.

INTRODUCTION.

The numerous requests received at the Mines Branch for information concerning the economic utilization of peat in a producer-gas power plant, led to the preparation of the present report. The primary object in establishing a Fuel Testing Station at Ottawa was, to demonstrate that peat could be economically utilized as a fuel for power purposes in a producer-gas power plant. Since then, it has been decided to extend the scope of the investigations, namely, to include the testing—on a commercial scale and in a commercial gas producer—of the bituminous coals of the extreme eastern and western provinces, and of the lignites of Manitoba, Alberta, and Saskatchewan.

The producer-gas plant was installed at the Fuel Testing Station for testing the various kinds of fuels met with in Canada, in order to show, principally, the great saving in fuel which could be effected by its use. Some years ago it was scarcely safe for an engineer to recommend a producer-gas power plant as a substitute for steam power, on account of the unreliability of the former; but, to-day, the improvements, both in the design and method of operation—the result of many years of experimentation—have rendered this type of power plant thoroughly reliable. The ordinary steam power plant—ranging in capacity from 50 to 200 horsepower—consumes about 7 lbs. of coal per brake horse-power hour; assuming the coal to have a heating value of 12,500 British thermal units per lb. This statement, it must be understood, only relates to average small steam power installations. In larger and more elaborately designed steam power plants, as, for example, the power plant of the Interborough Rapid Transit Company, of New York, the consumption of fuel of the same heating value is in the neighbourhood of only 2 lbs. This fuel consumption—of probably the most economical steam power plant on the continent—affords a notable contrast to the fuel economy of a modern producer-gas power plant, viz., $1\frac{1}{4}$ to $1\frac{1}{2}$ lbs. of coal, of the above heating value per B.H.P. hour. Although far better economy than the above has been recorded for producer-gas power plants, the writer has chosen to use a conservative figure, which can be easily attained without the assistance of expert producer operators. This fuel economy, moreover, is realized with the small producer-gas plant as well as with the large; while the maximum efficiency of the steam plant is generally only attained with the largest and most elaborate installations. Cases can, of course, be cited of certain small steam plants, where the fuel economy—

for a steam plant—is remarkable. This, however, does not affect the above figure, of 7 lbs. of fuel per brake horse-power hour, which the writer believes is a fair average fuel consumption for the ordinary steam plants of from 50 to 200 horse-power capacity, met with throughout the country.

The absence of smoke and smoke-stack; simplicity of operation and design—especially in the smaller suction producer-gas power plants—and safety in operation, are a few advantages, apart from the great saving in fuel, which would recommend such a plant to power producers.

The great saving in fuel effected by the use of producer-gas power machinery will be most apparent in those places which are removed some distance from coal mines, and especially in the western Provinces possessing lignite deposits.

The above remarks apply especially to the central provinces, in which large areas are covered by peat bog; but which possess no coal or known lignite deposits of economic value. In these provinces, where all the coal used for industrial purposes is imported from some foreign source, the necessity for reducing the amount needlessly used is most urgent. Moreover, since the producer-gas power plant can efficiently utilize some of the cheapest and lowest grades of coal which are not suitable for steaming purposes, the saving in fuel bills, resulting from the use of these low-grade fuels, will be apparent to most power producers.

Before deciding upon the types of producers desirable to install at the Fuel Testing Station, a careful study of the question was made both in European countries and in the United States, and as a result, two producers, which were shown to be commercially successful, were purchased.

The slow development, in Canada, of this class of power plant, is partly due to lack of reliable information concerning the gas producer and gas engine, generally, and the type or design suitable for the special fuel it is desired to utilize—and particularly to the failure of some plants which were guaranteed to satisfactorily operate with fuels for which they were supposedly designed. While instances of this kind are not common, yet, a few failures are sufficient to cause manufacturers, power producers, and others, to lose confidence in everything pertaining to such a system.

By publishing the results of the investigation of the various fuels tested in the producers at the Fuel Testing Station, it is hoped that those power users who have been unfortunate in their selection of a gas producer and engine, and hence have lost confidence in the gas producer and gas engine as a reliable and economic method of producing power, will have their confidence restored, and their interest reawakened to the great possibilities of the producer-gas power plant as a means of producing cheaper energy than can now be obtained with the steam power plant.

Since this report may be read by many business men who are interested in the development of peat bogs as a source of fuel for the production of power, and who may not be possessed of the same degree of knowledge concerning the producer-gas power plant as they possess of steam power plants, especial care has been taken to describe, as minutely as possible, the apparatus entering into such a plant.

The erroneous notions which the writer has often heard expressed concerning the gas-engine have led to a more detailed description being given of both the theoretical principles governing its operation and the respective parts of which it is constructed, than is usual in government technical publications. With this practical object in view, illustrated descriptions of the gas-producer and gas-engine, and their auxiliary apparatus, have been inserted in the text—wherever deemed necessary.

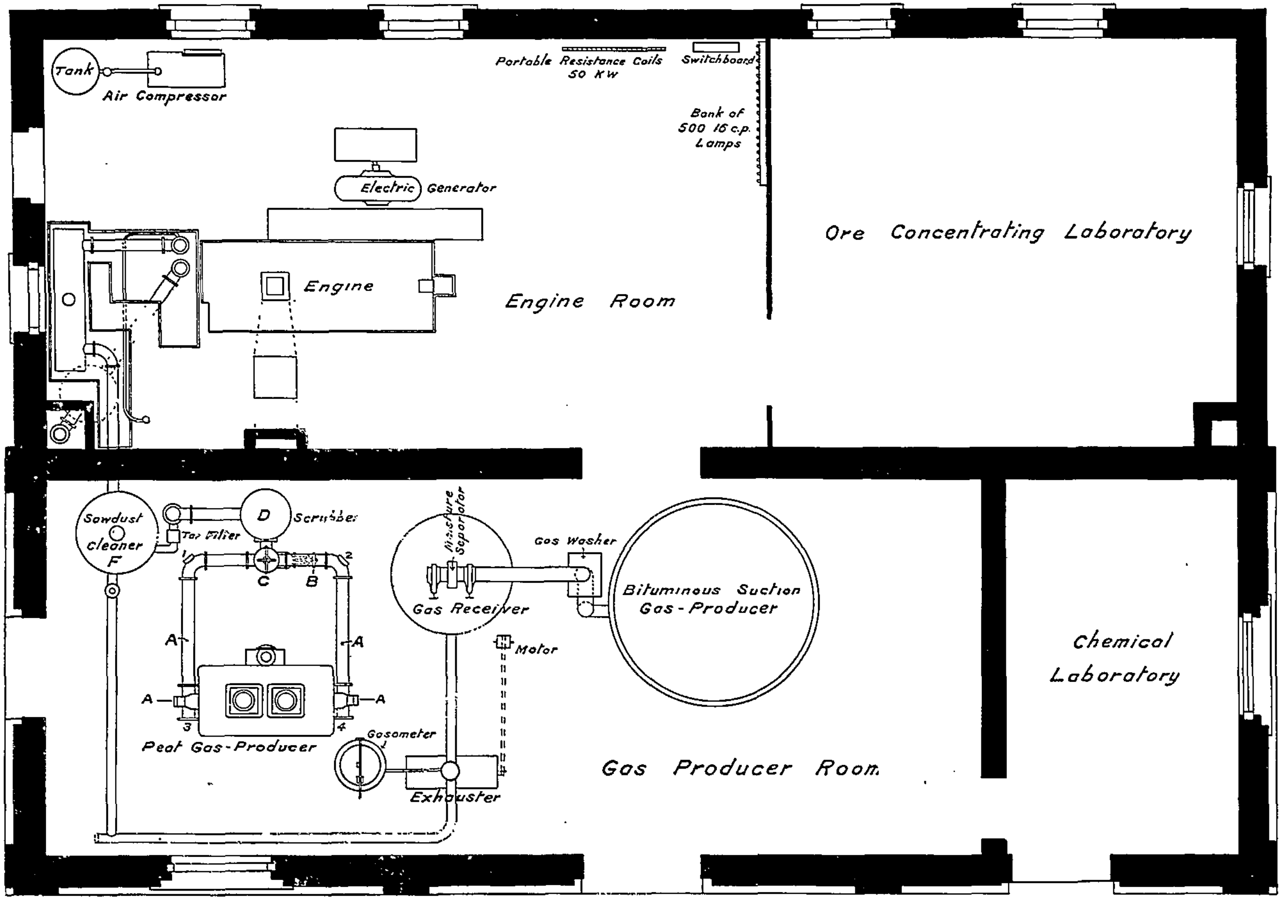


FIG., 1.—Ground floor plan of Testing Station.

GENERAL EQUIPMENT OF PLANT, AND ARRANGEMENT OF MACHINERY.

The Fuel Testing Station is equipped, at present, with a 60 H.P., double zone, Körting peat gas producer, with wet coke scrubber, tar filter, and dry scrubber; and a Westinghouse 100 H.P. bituminous, suction gas producer, complete, with exhauster, wet scrubber, gas receiver, and moisture separator, and a 60 H.P., 4 stroke cycle, single acting Körting gas engine. A small exhauster, driven by a 1 H.P. electric motor, is installed for starting the peat gas producer, and an air tank, with compressor driven by a 3 H.P. motor, supplies air under a pressure of nine atmospheres for starting the engine. A 50 K.W. direct current Westinghouse electric generator is directly connected to the engine.

For the purpose of absorbing the electrical energy generated when making a test, a 50 K.W. portable resistance, and a bank of 500 16 c.p., incandescent lamps are provided.

The electric generator is connected to a switchboard provided with a Weston ampere-meter and volt-meter, from which leads are taken to the resistance rack, to a 40 H.P. motor used for driving the concentrating machinery located in the same building, to the peat crushing motor, and to the lighting circuit.

A small crusher driven by a direct current motor is placed in the peat shed; where the peat blocks, as they arrive from the bog, are crushed to the size most suitable for the producer.

The chemical laboratory is located at one end of the producer floor, and is provided with the necessary apparatus for making complete gas analyses, fuel analyses, and determinations of the calorific value of fuels.

The calorific value of the producer gas is determined by means of a Junker's continuous calorimeter, which is placed in the engine room, close to the gas main. This calorimeter is provided with a small exhauster, driven by a $\frac{1}{10}$ H.P. motor, which delivers gas at constant pressure to the calorimeter. The general arrangement of the machinery, testing apparatus, and chemical laboratory, is clearly shown on Fig. 1, and hence requires no further explanation.

THEORY OF PRODUCER-GAS.

Before describing the peat gas producer and its operations, a short account will be given of the principles underlying the process of generating producer-gas, for the benefit of those possessing meagre technical knowledge on this subject.

By "producer-gas," is generally meant gas formed by the partial combustion of fuel in a suitable apparatus. The term "partial combustion," when used in connexion with producer work, may be defined as the incomplete oxidation of the combustible components of the fuel resulting in its complete gasification; and since some of the combustible components of the gas evolved are not fully oxidized, while others are not oxidized at all, the oxidation of the gases may be carried to completion by burning in a gas engine or furnace.

Producer-gas is entirely different from "town-gas": which is formed by the distillation of bituminous coal in a closed retort. In the case of town-gas, only the volatile matter of the coal is gasified; a residue of coke being left in the retort. The heat required for distillation is applied externally to the retort, and is furnished by the complete combustion of coal, coke, or gas.

A gas producer is an apparatus for converting a solid fuel into a combustible gas: usually a mixture in varying proportions, of carbon monoxide, hydrogen, gaseous hydrocarbons, oxygen, carbon dioxide, and nitrogen. The carbon monoxide, hydrogen, and gaseous hydrocarbons, constitute the combustible components of the gas; whereas carbon dioxide and nitrogen are diluent gases which lower the temperatures of their products of combustion.

Producer-gas can be formed from a large variety of fuels—in fact, any fuel which is carbonaceous—such as anthracite, bituminous coals, lignite, peat, wood, and oil.

Producer-gas is generally made by drawing or forcing air through a deep bed of incandescent fuel, in a closed producer. The air, before entering the producer, may contain no more moisture than happens to be in the atmosphere at the time, or may be mixed with steam, or water vapour. When air is drawn through a deep bed of incandescent fuel, in a closed producer, the fuel is gradually consumed, and the gas generated is drawn off, through pipes, to engines, or other apparatus.

Since carbon is the most important constituent of the fuels commonly used for making producer-gas, the action of air alone on pure carbon will be considered for the purpose of explaining the process. A gas made from charcoal in the above-mentioned manner, closely approximates to this; but, for the purpose of making the explanation as simple as possible, it will be assumed that pure carbon is the fuel to be used. The fact that four-fifths of the volume of the atmosphere consists of nitrogen: which acts as a diluent of the gas formed, and consequently affects the temperature attained, and, to a certain extent, modifies the reactions, will not be taken into consideration; since the quantities of heat evolved are in no way affected. If the producer has a shallow fire, instead of the deep bed of fuel referred to above, through which an abundant supply of air is forced or drawn, the carbon will be completely oxidized; the product of this complete combustion being carbon dioxide, and the quantity of heat developed from 12 lbs. of carbon would be 97,200 lb. calories.

This reaction is represented by the following chemical equation:—

(1) $C + O_2 = CO_2 + 97{,}200$ lb. cals.[1] (174,960 B.T. units).[2]
where C and O stand for carbon and oxygen respectively.

If, however, there is a considerable depth of carbon in the producer (which there must be in practice) the carbon dioxide resulting from the complete combustion of the carbon on the grate (when the air is drawn up through the grate bars) will be reduced to carbon monoxide according to the following reaction:—

(2) $CO_2 + C = 2\ CO - 38{,}880$ lb. cals. (69,984 B.T. units).

In the former case (1), a quantity of heat equal to 97,200 lb. calories was evolved from the complete combustion of the carbon, to carbon dioxide. In the latter case (2), a quantity of heat equal to 38,880 lb. calories must be applied in order to effect the decomposition of the carbon dioxide by reaction with an additional 12 lbs. of carbon. In this case, heat is absorbed.

When 12 lbs. of carbon are burned to carbon monoxide, a quantity of heat equal to 29,160 lb. cals. will be developed according to the reaction:—

---

[1] The "lb. calorie" is the quantity of heat required to raise the temperature of 1 lb. of water through 1° C.

[2] The "British Thermal Unit" (B.T.U.) is the quantity of heat required to raise the temperature of 1 lb. of water through 1°F.

1 lb. calorie = 1·80 B.T.U.
1 B.T.U. = 0·555 lb. calorie.

(3) $C + O = CO + 29{,}160$ lb. cals. (52,488 B.T. units); consequently, when the 28 lbs. of carbon monoxide, resulting from the reaction of carbon with oxygen—according to equation (3)—is completely burned to CO_2, a quantity of heat equal to 68,040 lb. cals. is developed as follows:—

(4) $CO + O = CO_2 + 68{,}040$ lb. cals. (122,472 B.T. units).

The final result of the two processes, namely, burning carbon to carbon monoxide; and then burning the resulting gas (carbon monoxide), to carbon dioxide, is as follows:—

(3) $C + O = CO + 29{,}160$ lb. cals. (52,488 B.T. units).

(4) $CO + O = CO_2 + 68{,}040$ lb. cals. (122,472 B.T. units).

By adding (3) and (4) $C + O + CO + O = CO + CO_2 + 97{,}200$ lb. cals. (174,960 B.T. units), which equals $C + O_2 = CO_2 + 97{,}200$ lb. cals. (174,960 B.T. units). (1).

From the above it will be seen that when carbon is converted into carbon monoxide, about 30 per cent of the total heat of combustion of the carbon is liberated; the remaining 70 per cent will be liberated when the carbon monoxide is burned in a furnace or gas engine.

Most of the heat liberated from the combustion of the carbon to carbon monoxide appears as sensible heat of the gas: that is, the heat carried away by the gas when it leaves the producer. All of the heat set free in the producer need not be lost if the hot gas can be utilized for furnace work or for any other purpose in which it is not necessary to cool the gas to ordinary temperature. If, however, the gas is burned in a gas engine, the gas as it leaves the producer must be cooled; the sensible heat of the gas is then carried away by the water used for cooling. In order to reduce the quantities of heat liberated in the producer—which pass off as sensible heat of the gas, and cannot be recovered after leaving the producer—steam is mixed with the air drawn through the producer. The water vapour mixed with the air, in passing through a bed of hot carbon, is reacted upon by the carbon and decomposed, resulting in either CO or CO_2, and setting free, hydrogen. This reaction is accompanied by an absorption of heat. When 2 pounds of hydrogen combine with 16 lbs. of oxygen to form 18 pounds of water vapour, a quantity of heat equal to 58,060 lb. calories is liberated and when this water vapour is decomposed, the same quantity of heat is absorbed. The combustion of the oxygen of the steam with the carbon is accompanied, however, by the evolution of heat according to either of the equations:—

$C + O = CO + 29{,}160$ lb. cals. (52,488 B.T. units). or $C + O_2 = CO_2 + 97{,}200$ lb. cals. (174,960 B.T. units).

The resulting chemical effect of the decomposition of steam by carbon is equal to the sum of the chemical effects of the two separate reactions.

When the first reaction takes place, the quantity of heat liberated by the interaction of 12 lbs. of carbon with 16 lbs. of oxygen is 29,160 lb. calories. The equation representing these reactions may be written as follows:—

(5) $H_2O + C = H_2 + CO - 58{,}060 + 29{,}160$
$= H_2 + CO - 28{,}900$ lb. cals. (52,020 B.T. units).

In the second case, when the products resulting from the decomposition of the water vapour are free hydrogen and carbon dioxide, it is necessary to make the supposition that 36 lbs. of steam are decomposed.

yielding 4 lbs. of hydrogen, and 32 lbs. of oxygen, with the absorption of 116,120 lb. calories. The combination of the 32 lbs. of oxygen with carbon, to form carbon dioxide, liberates 97,200 lb. calories. The reaction is represented by the equation:—

$$(6)\quad 2\,H_2O + C = 2\,H_2 + CO_2 - 116{,}120 + 97{,}200 \text{ lb. cals.}$$
$$= 2\,H_2 + CO_2 - 18{,}920 \text{ lb. calories } (34{,}056 \text{ B.T. units}).$$

It will be seen from the above equations (5) and (6), that in both cases, there is a large absorption of heat; it is apparent, therefore, why even the addition of small quantities of steam to the air drawn through the producer reduces the working temperature. The decomposition of steam, resulting in free hydrogen and the interaction of the oxygen with carbon forming either carbon monoxide or carbon dioxide, requires the application of a large quantity of heat, which consequently lowers the working temperature of the producer. The heat thus absorbed can be partially, but not wholly recovered, when the free hydrogen and carbon monoxide are burned in the cylinder of the engine: forming water in the first case; and carbon dioxide in the second.

By means of the process just described, the actual thermal efficiency of a producer which can be realized in practice, is considerably increased.

When fuels—other than pure carbon—such as bituminous coal, lignite, peat, etc., are gasified in the producer, the reactions become more complex. The general principles, however, are unchanged, hence no further reference to the chemical reactions which take place in the producer when fuels high in volatile matter are gasified, will be made in this report.

PEAT GAS PRODUCER.

Description.

The producer shown in Plate II consists of a rectangular steel shell, having the following outside dimensions: 2′-9″ × 5′-2″, in horizontal section, and 15′-0″ high, from floor level to top of charging hoppers. For cleaning fires and removing ashes, 12 doors are provided: four on each side, and four on the back. These doors are shown on Plate II.

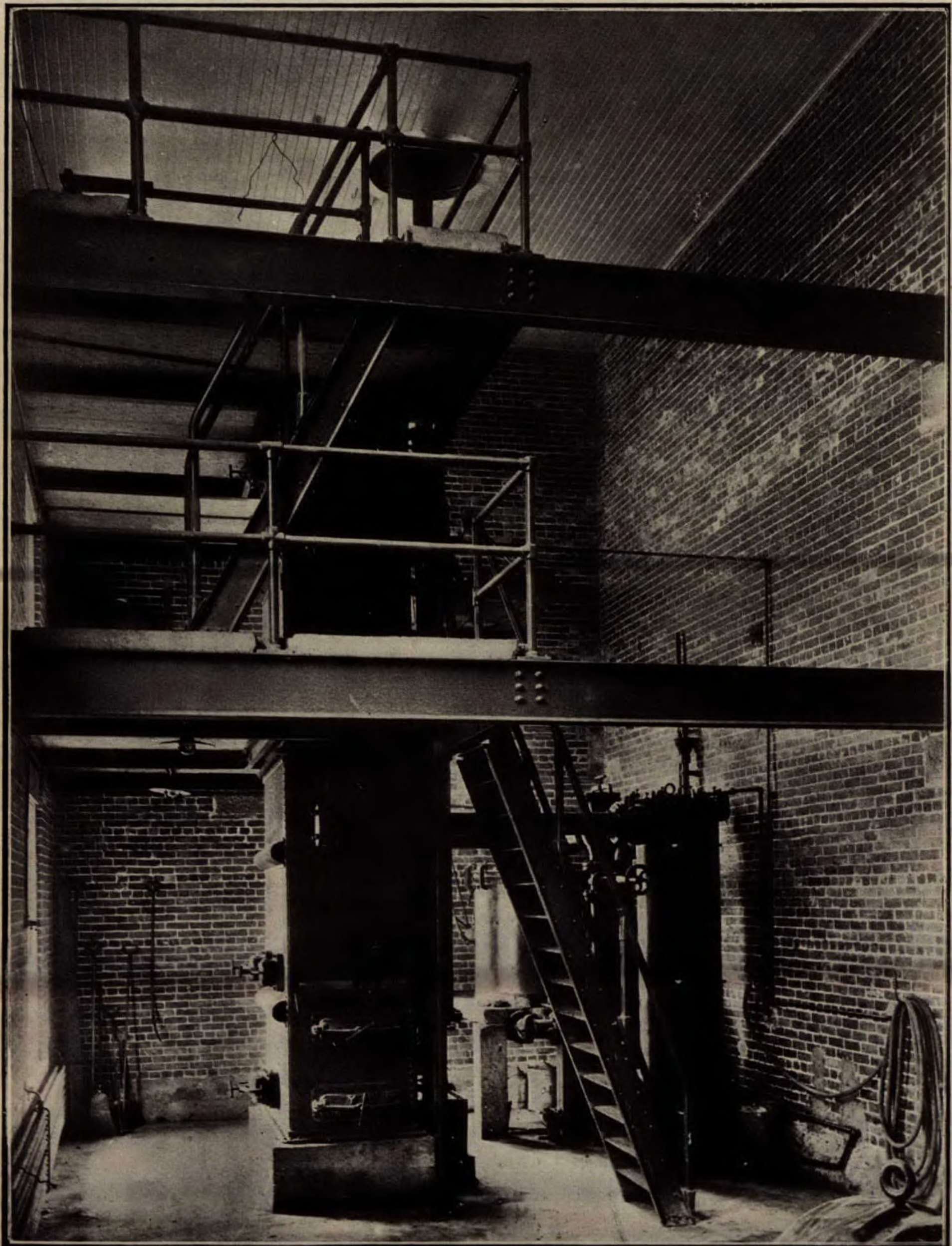
On Figs. 2, 3, and 4, the producer is shown in section, rear elevation, and side elevation, respectively.

It can be seen by Fig. 2, that the producer consists of two combustion zones: F-F at the top and M at the bottom. F-F represents inclined grate bars; D-D doors for poking and cleaning the fires resting on the grates F-F. The ashes resulting from the combustion of the fuel on these grates drop into the chambers Z-Z, and are removed through the doors E-E. The gases evolved at this zone are drawn off through the chamber B. The dust and tar which are caught in this chamber are removed through door P on the back of the producer, as shown in Fig. 3. A-A represents charging hoppers.

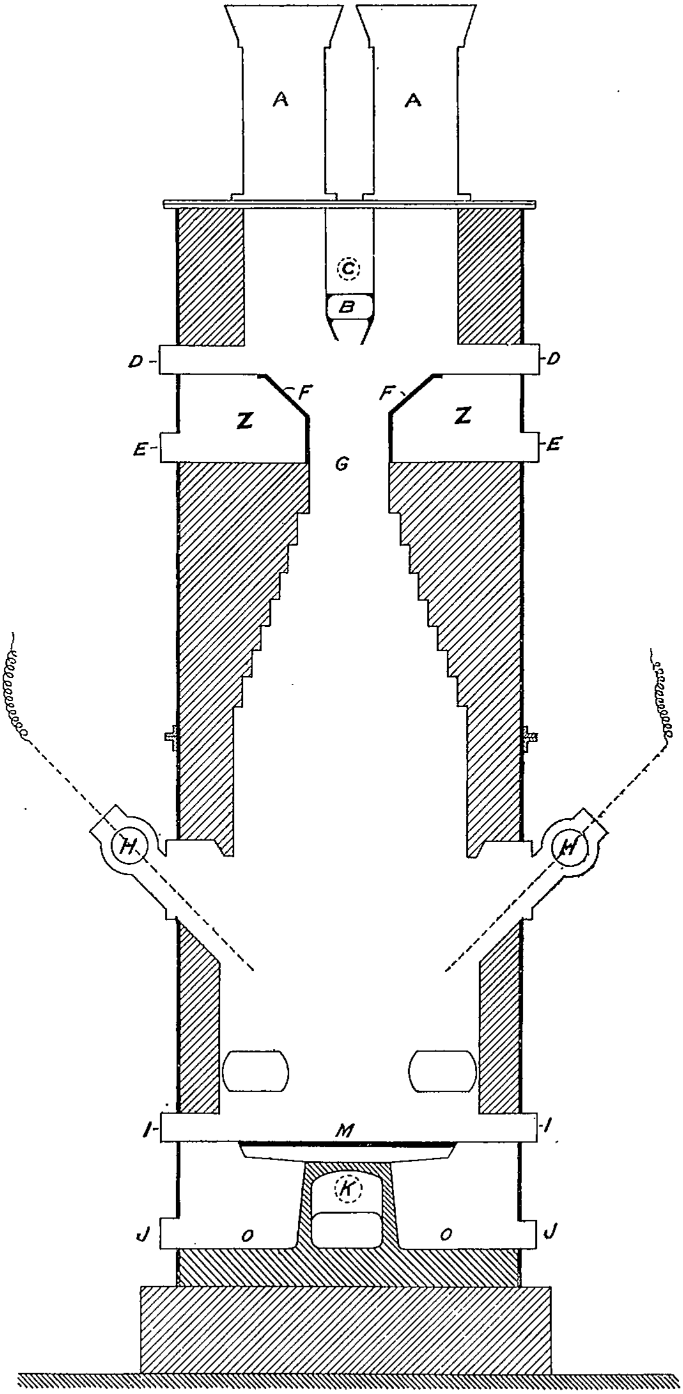
M, on Fig. 2, represents the grate bars of the lower zone, and I-I the doors through which the fires of the lower zone are poked and cleaned. The fire above the grates of the lower zone is poked through the doors Q-Q, as shown in Figs. 3 and 4. The ashes resulting from the complete combustion of the fuel in this zone fall through the grate bars into the chambers O-O, and are removed through the doors J-J.

The products of the combustion taking place in the upper zone are drawn off through chamber B, through the pipe C, and vertical pipe V,

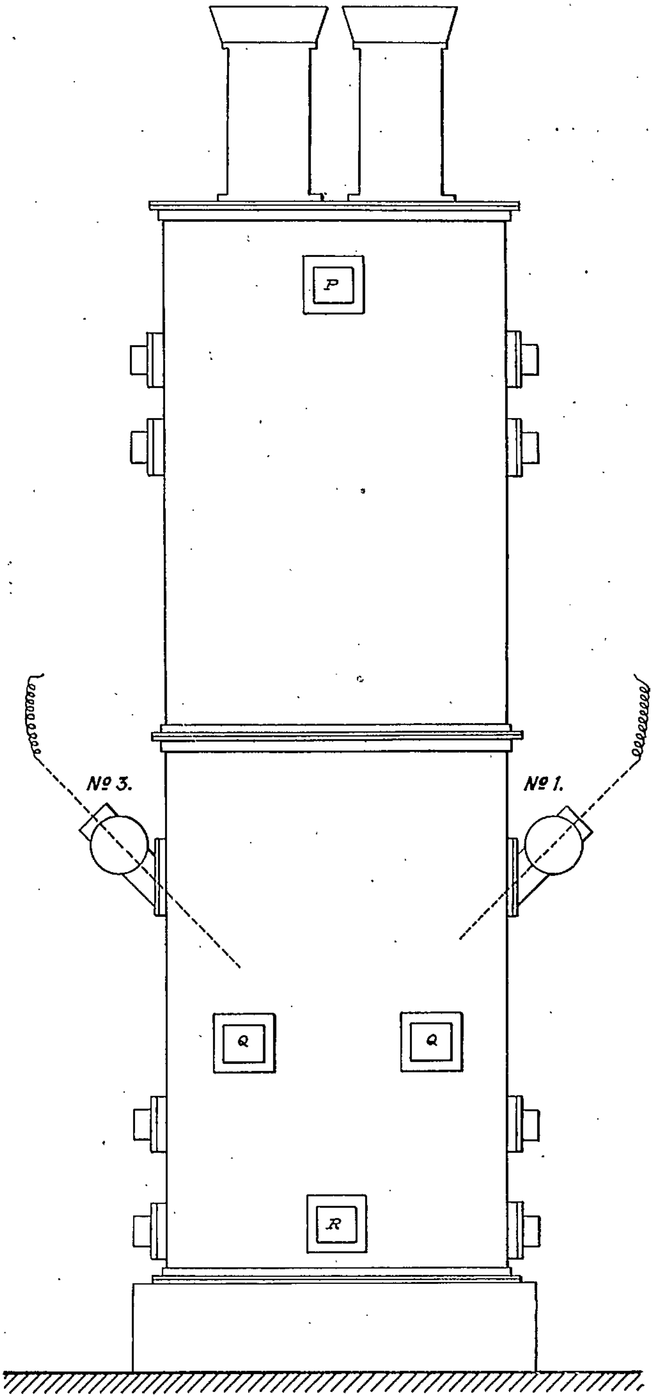
PLATE II.



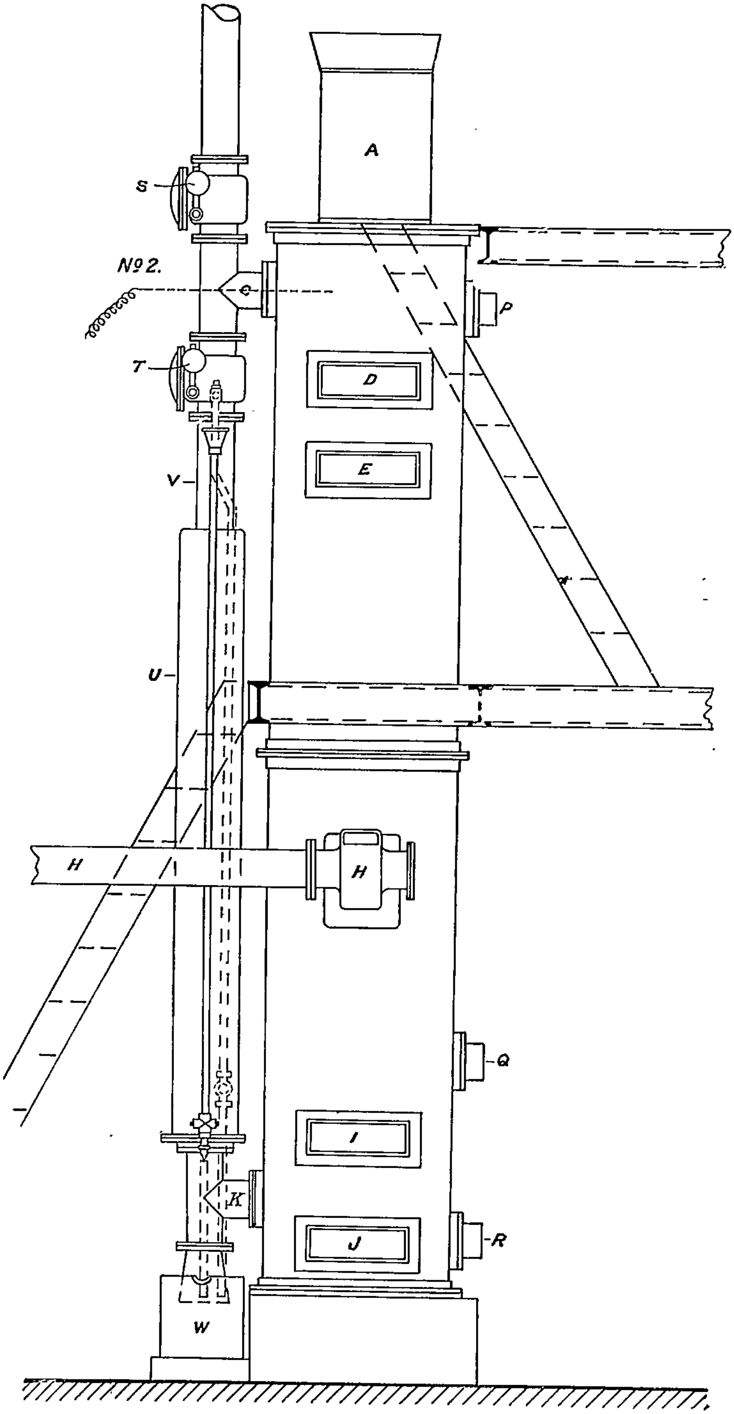
General view of Peat Gas Producer.



Sectional elevation through A-A.
Fig. 2.—Körting Peat Gas Producer.



Rear Elevation.
FIG. 3.—Körting Peat Gas Producer.



Side Elevation.
Fig. 4.—Körting Peat Gas Producer.

shown in Fig. 4, to chamber K, Fig. 2; when they pass finally through the fuel of the lower zone to the two gas, off-takes, H-H Fig. 2.

S, on Fig. 4, at the top of vertical pipe V, is a damper which is opened to allow the gases resulting from the combustion of the peat to pass into the atmosphere—when the producer is standing idle. The damper T, also on Fig. 4, is closed while the producer is standing idle; but it is opened and the damper S closed when the producer is in operation. These two dampers are provided with cover plates, which can be readily removed when it is necessary to remove from the damper chambers any material which has collected therein. The vertical gas pipe V, is cooled by means of cold water continually circulating in the jacket U. The cooling water enters at the bottom of this jacket, and overflows at the top. W, is a water seal, which covers the open bottom of the vertical pipe V.

The ashes which fall through the grate bars M into the gas chamber K—shown in section in Fig. 2—are removed through door R, shown in Figs. 3 and 4.

The off-takes, H-H, shown in Fig. 2, are provided with caps held firmly in place by clamps; which may be removed for the purpose of inspecting the interior of the producer, at this point, or, for the purpose of removing any dust or tarry matter which may collect in the gas chambers.

Referring to Fig. 1—which shows a plan of the producer, gas piping and cleaning systems—the two ends of the pipes connecting the producer to the cleaning system are provided with caps 1, 2, 3, and 4, respectively, which can be easily removed, when necessary, for the purpose of clearing them of any matter which may adhere to the walls of these pipes.

For the purpose of regulating the amount of air entering the producer at the top and bottom zones, two adjustable air-openings—not shown in the figures—are provided on each of the doors E-E and J-J.

Cleaning System.

In order that a sufficiently cooled gas, free from tar and dust, may be delivered to the engine, the gas, after leaving the producer, passes through a cleaning system which is composed of a wet coke scrubber D. (Fig. 1), tar filter, and dry saw-dust scrubber F.

The general arrangement, and means of operating the cleaning system, will be readily understood by referring to Fig. 5: which represents an ideal section of the producer-cleaning system and engine. The producer shown in section in this figure is not of the same design as the one installed at the Fuel Testing Plant at Ottawa; but the general arrangement, and construction of the cleaning system, are practically the same as that illustrated in Fig. 5.

The gas, after leaving the producer, enters the wet coke scrubber A Fig. 5, at the bottom, and passes upward through about 3 feet of closely packed coke, which is continuously sprayed with water by the sprays marked E-E-E. In this scrubber, the hottest gases come into contact with the warmest water at the bottom; finally passing off at the top through the coldest spray. In this manner, the greatest cooling effect with a given amount of water is obtained. In passing through the wet coke, the gas not only loses the greater part of its sensible heat, but is freed from dust, and some of the tarry matter which was carried in suspension in the gas.

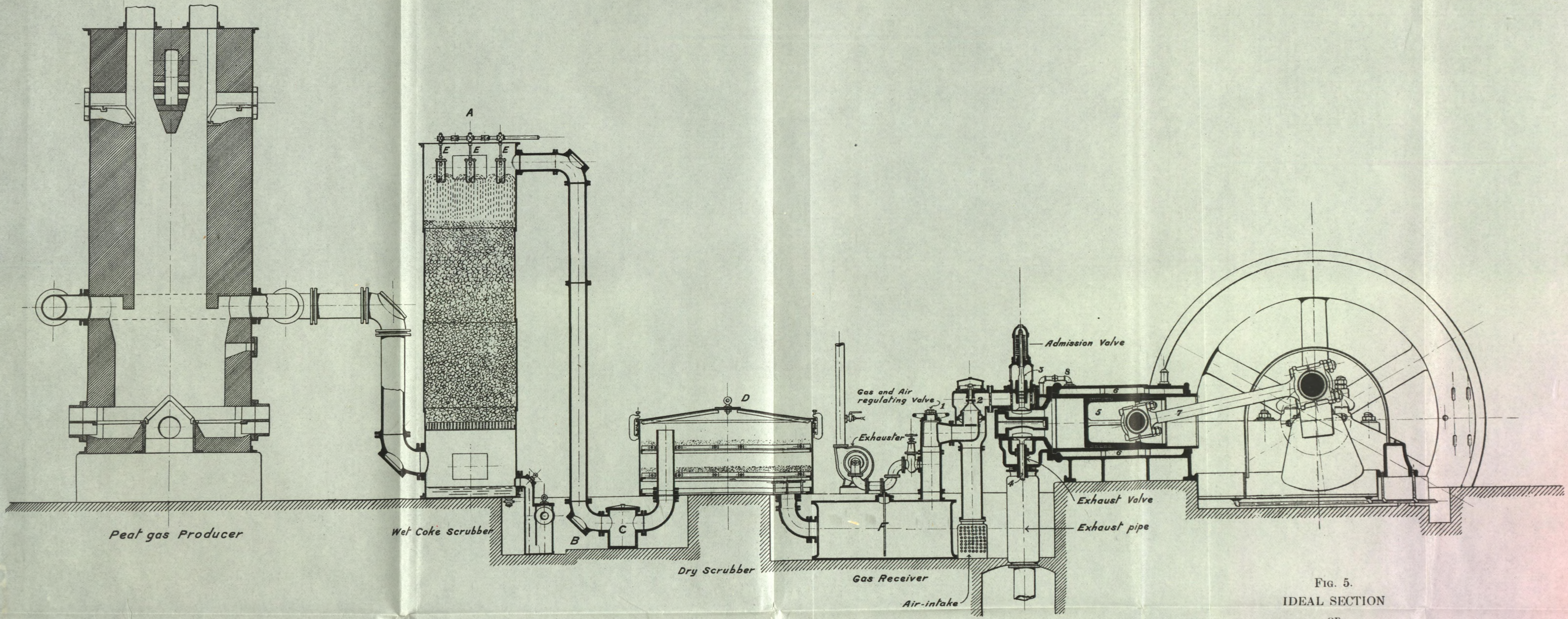


Fig. 5.
IDEAL SECTION
OF
KORTING PEAT PRODUCER—GAS PLANT.

From the wet coke scrubber just described, the gas passes through a tar filter placed at C, but not shown in this figure. This filter is composed of a number of staggered baffle plates, around which the gases pass before passing finally through four perforated metal plates. The baffle plates and perforated plates are washed by sprays of hot water. The hot water for spraying the tar filter is obtained from the return cooling water of the gas engine. This filter removes the larger portion of the tarry matter carried over from the coke scrubber. After leaving the tar filter, the gas finally passes through the dry scrubber B. This scrubber is filled with excelsior at the Fuel Testing Station instead of with saw-dust which is used in some plants. The "excelsior" (wood fibre) absorbs most of the moisture and some of the tarry matter which is carried in a very finely divided state past the tar filter. Before entering the engine, the gas passes through a gas receiver; where the moisture still contained in the gas, after passing through the dry scrubber, is deposited. The water collected in this gas receiver is pumped out from time to time—preferably at the end of a week's run.

The wet coke scrubber contains about 500 lbs. of coke. This coke should be taken out and washed about once every two or three months. The excelsior in the dry scrubber should be renewed every two or three months. The condition of this excelsior can be readily ascertained at any time, when the plant is not in operation; simply by removing the cover of the dry scrubber and inspecting the contents. The frequency with which the cleaning materials require to be treated or renewed, varies with the cleanliness of the gas. If the gas passed through the system contains much tarry matter, which is not separated out before reaching the dry scrubber, the excelsior in the scrubber will soon become clogged, and cease to fulfil its function of absorbing moisture and further cleaning the gas; and will, moreover, offer a considerable resistance to the passage of the gas. The resistance met with by the gas in the different parts of the cleaning system is shown by means of suitably placed water gauges.

Principle of Operation of the Körting Peat Gas Producer.

When the producer is in the proper condition for operation, that portion between the lower grate bars M and the grates F-F (Fig. 2) of the upper zone is completely filled with peat coke: peat free from moisture and volatile matter. That portion of the producer between the upper grate level and tops of hoppers A-A. is filled with raw peat: peat as it comes from the shed. The function of the upper zone consists in driving the moisture and volatile matter from the peat which supplies the lower zone. To prevent, as far as possible, the products of combustion in the upper zone from being drawn by the suction of the exhauster or gas engine, straight down through the producer and out through the off-takes H-H. instead of being drawn out through C and then having to pass up through the incandescent fuel in the lower zone before reaching H, the construction of the firebrick lining is made as shown in Fig. 2; a contracted neck, G, being made just below the upper zone. When the producer is entirely filled with peat coke to the upper zone grate level, the resistance offered to the passage of the gases evolved in this zone through the contracted neck G is greater than that offered to the passage of the gases through chamber B and pipe C (Fig. 2), down through pipe V (Fig. 4) and chamber K to the lower zone; and then up through the incandescent carbon to the off-takes H-H. This double zone construction makes it possible to feed tar, and moisture-free fuel, to the lower zone, where the bulk of the final gas is formed.

The combustion taking place at the upper zone is just sufficient to supply the heat necessary to evaporate the moisture and drive off the volatile matter contained in the peat fed into the hoppers A-A.

The gaseous products, viz., water vapour, tarry vapours, carbon monoxide, carbon dioxide, and a small percentage of gaseous hydrocarbons, in the form of stable gases, resulting from the combustion taking place in the upper zone, are drawn off, as explained previously, through the chamber B (Fig. 2) and down through the water-cooled pipe V (Fig. 4) to the gas chamber K, located under the fires of the lower zone. Some of the moisture and tarry vapours are condensed on the water-cooled surface of pipe V, and drop to the bottom of the water seal W (Fig. 4), from which the tar can be readily removed. That portion of the water and tarry vapours which escapes condensation in passing down through the water-cooled pipe V is drawn up through the incandescent peat coke of the lower zone, and through the gas off-takes.

A part of the moisture which escapes condensation in the water-cooled pipe V is decomposed by reaction with the hot carbon, forming free hydrogen, carbon-monoxide, and carbon dioxide. Part of the carbon dioxide is reduced to carbon monoxide, and some of the tarry vapours are changed to stable gaseous, hydrocarbon compounds. The following analysis shows the composition of a sample taken from the gases evolved in the upper zone:—

CO_2	15·3	per cent by volume.
CO	7·2	" "
O_2	3·2	" "
C_2H_4	0·7	" "

the residue being chiefly nitrogen. The gases also contain water and hydrocarbon vapours, which condense in the sample bottle before analysis.

In order to ensure the best operation of this producer, care must be exercised to ascertain the most suitable size to which the peat fed into the hoppers should be crushed; since the peat in passing through the producer, remains only a comparatively short time in the upper combustion zone; and the process of coking must be completed in this interval. If the peat is too wet or is not crushed small enough, the peat passing through the contracted neck G to the lower zone will be only partially coked, and in some cases only the moisture will be evaporated. The greater the moisture content the smaller should be the pieces of peat fed into the producer.

When peat only partially coked finds its way into the lower combustion zone, it is impossible to obtain a gas sufficiently free from tar for use in the gas engine.

PREPARATION OF PEAT GAS PRODUCER FOR OPERATION.

In starting up a clean producer, a wood fire, or preferably one of coke, is built on the grate bars of the lower zone. When this is well under way, peat is slowly fed into the hoppers; time being allowed for the peat to become thoroughly heated before a new charge is put in. In this manner the producer is slowly filled, until the grate bars of the upper zone are passed. A fire is now built under the grate bars of the upper zone; and when this fire is well under way the hoppers may be completely filled. The damper S Fig. 4, must remain entirely open, and the damper T closed during the operation of building up the producer. The lower doors J-J and R Fig. 4, should be opened wide to allow of a good draft through the producer.

When the producer is sufficiently hot and the fires of the upper and lower zones are burning well, the doors I-I and E-E can be closed, and the damper T and the valve admitting gas from the producer to the cleaning system opened. The exhauster above referred to is now put into operation, and allowed to run until the gas will burn with a strong, clear, blue flame. For the purpose of determining, approximately, the quality of the gas—as described above—a pilot burner is provided. The damper S is closed immediately after the engine is put into operation.

THE GAS ENGINE.

A Statement of the Principles Underlying Its Operation, and a Description of the Principal Parts Entering Into Its Construction.

Of all the prime movers used for the production of power by the conversion of the heat energy of fuels into useful work, the gas engine, or internal combustion motor, is the least understood: particularly in Canada. The lack of information on the part of those possessing but little technical knowledge, is due to the comparatively recent development of this prime mover. Not very many years ago, the gas engine could scarcely be called a commercial success, depending as it did on town gas for its operation. During that period, all the engines constructed were of small size: 25 H.P. being termed a large gas engine. This limitation was largely influenced by the fact that, the only fuel available was town-gas—a naturally expensive fuel; and that these engines were installed at that time, not on account of their superior economy over steam, but on account of their simplicity of operation. Due, however, to the marked improvement in both design and construction of gas engines, resulting in greater efficiency and reliability, and due to the introduction on the market of commercially successful gas producers, capable of furnishing a cheap power gas, the development of this class of power plant has been very great.

Today, gas engines are built in sizes varying from a few horsepower, to 3,000 or 4,000 H.P.; and the varied application of this prime mover in all manufacturing industries, testifies to its great success. Moreover, the possibility of generating a clean and cheap producer gas from the coals found on this continent—coals which can be utilized with great economy in the modern producer-gas power plants—is resulting in the gradual displacement of the steam engine, by its more efficient and economical competitor, the gas engine.

It is for these reasons, and the fact that so little is known concerning the application of the producer-gas engine to the varied industries in Canada—a lack of knowledge which has been responsible for many ridiculous statements—that the fundamental principles on which the gas engine is designed have been stated. And since manufacturers and others directly interested in the production of a cheaper power than can be developed from steam, may be desirous of knowing more of the gas engine, the principal parts entering into its construction are both illustrated and described in the following pages.

THE INTERNAL COMBUSTION MOTOR.

When a combustible gas, such as town gas, natural gas, or producer gas, is mixed with the amount of air necessary for its complete combustion, and then ignited, the products of combustion will be a highly heated gas occupying a very much larger volume at atmospheric pressure than the mixture of the gases did before ignition. This property possessed by gases has been made use of in the gas or internal combustion engine, and is the basic principle underlying its operation.

The internal combustion motor derives its name from the fact that the necessary heat required to develop the power in the engine is furnished by the combustion of a mixture of a combustible gas and air in the cylinder of the engine itself.

There are two principal types of gas engines: (1) those operating on the 4 cycle—which are generally single-acting, and (2) those on the 2 cycle principle—which are generally double-acting.

A 4 cycle engine is one which, when single acting, develops one power stroke for every two complete revolutions; while a 2 cycle, single-acting engine, develops one power stroke or impulse for every single revolution. The majority of gas engines, both small and large, operate on the 4 cycle principle; and this type of engine—one of which is installed at the Fuel Testing Plant, Ottawa—will be described here.

An explanation of the operation of the 4 cycle gas engine will be better understood by referring to the ideal section of the peat producer-gas power plant shown in Fig. 5.

The principal parts entering into the construction of any gas engine are (1) the movable parts controlling the inlet valve for the mixture of gas and air; (2) the piston which draws in this combustible mixture and compresses it; (3) the ignition device—which at the proper moment ignites the inflammable mixture, causing it to burn; and (4) the exhaust valve through which the spent gases are discharged into the atmosphere.

The governor which controls the speed of the engine is one of the most important features of any engine, and is shown, in detail, in another illustration which will be described later.

DETAILED DESCRIPTION OF GAS ENGINE PARTS.

Referring now to Fig. 5, the different parts will be enumerated in their order:—

No. 1 is the valve for regulating the air and gas mixture.

No. 2 is the valve automatically operated by the suction stroke of the gas engine, through which the mixture of air and gas is admitted to the cylinder.

No. 3 is the admission valve.

No. 4 is the exhaust valve.

No. 5 is the connecting rod which transmits the energy developed in the cylinder to the crank shaft and fly-wheel.

No. 6-6 is a space between the cylinder liner and the cylinder casting which is cooled by circulating water. This water absorbs part of the large quantity of heat developed within the cylinder and thus keeps this part of the engine cool.

No. 8 is a pipe through which the cooling water from the gas end passes to the cylinder jackets. These are the principal parts which need be here enumerated, and which will be more fully described later on.

The operation of the engine can be explained as follows:—

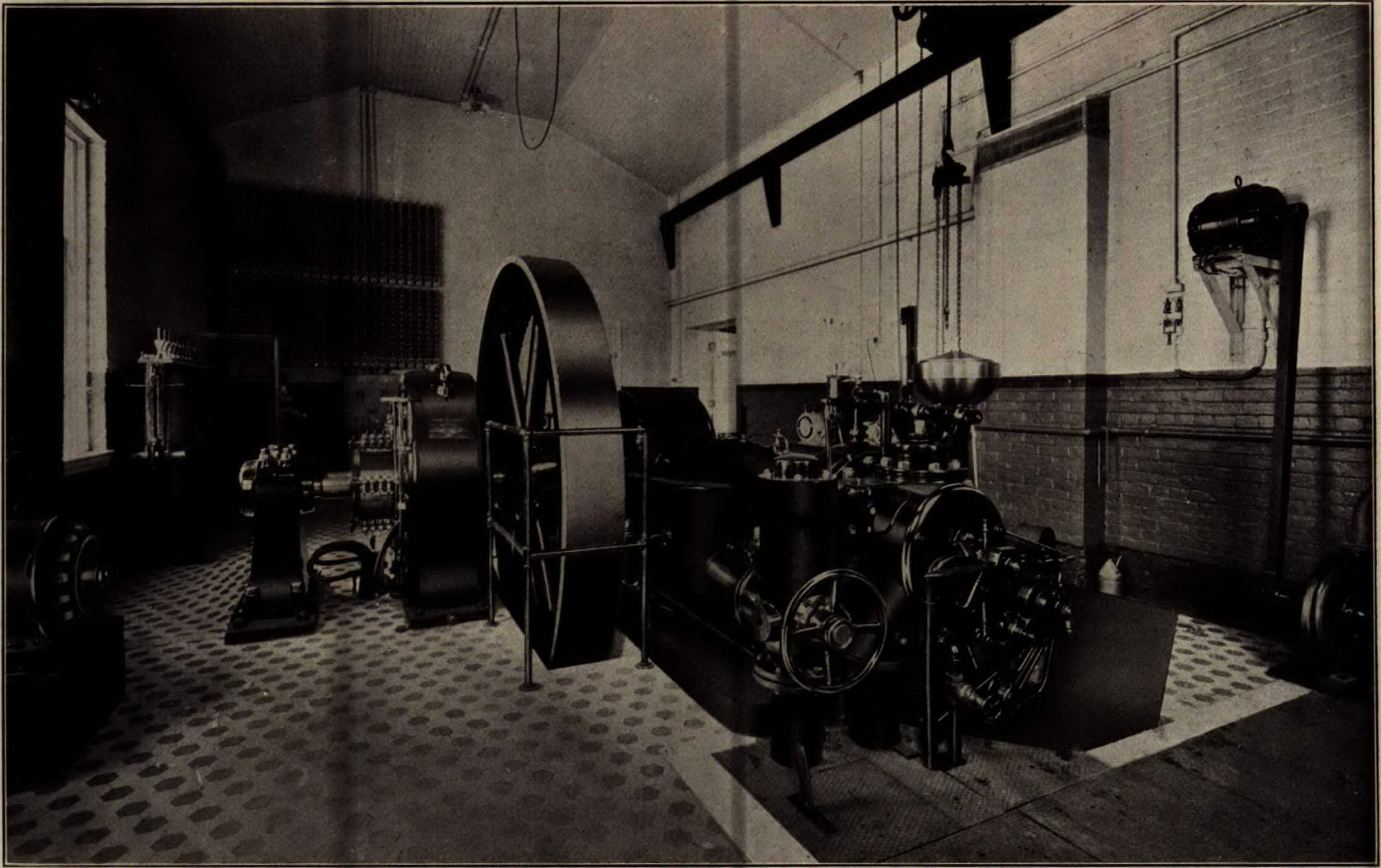
After adjusting valve I—so that the necessary amount of air can be drawn in with the gas, to ensure complete combustion—consider the engine to be beginning on its dead centre, with the piston as far back as it can go. During the first forward stroke or first half revolution, the admission valve opens and an amount of a mixture of air and gas equal in quantity to the piston displacement is drawn in. This mixture, during the second half revolution or backward stroke, is compressed, and then ignited at some point determined by the ignition regulator, before the compression stroke is quite completed. The gases now ignited are further compressed until the dead centre is passed, then the piston is forced forward during the first half of the second revolution by the expansion of the highly heated gases. In expanding, some of the heat of the gases is converted into useful work, while the larger quantity is lost in the cooling water and in the exhaust gases which are discharged into the atmosphere. During the next backward stroke or completion of the second revolution, the exhaust valve opens and the spent gases are discharged through the exhaust pipe into the atmosphere. This completes the cycle of operations. Since producer gas is a comparatively lean or weak combustible gas—that is, a gas which has a low heating value per cubic foot—it may generally be compressed to a comparatively higher degree than a rich gas, thereby increasing the thermal efficiency of the engine. The compression with which gas engines are designed to operate depends upon the nature of the gas it is intended to use. For producer gas a compression of 140 pounds per square inch is common; while a higher compression is used, when utilizing very lean gases, such as blast furnace gas. Through the introduction of high compressions, the thermal efficiency—i.e., the percentage of the total heat units of the gas burned in the cylinder, which are converted into useful work—has been largely increased. There is a limit, however, to the degree of compression which it is practicable or possible to use, and this limit is determined to a large extent by the components of the gas.

The thermal efficiency of a well designed gas engine is in the neighbourhood of 30 per cent, although for some engines a somewhat higher thermal efficiency has been recorded. From this it will be seen that only 30 per cent of the heat units of the gas delivered to the engine is converted into work. The other 70 per cent is lost in the exhaust gases and cooling water. The whole of the 30 per cent referred to, however, is not available for power purposes; since a portion of it is absorbed in overcoming the resistance of the moving parts of the engine. For example, if the mechanical efficiency of the engine is 90 per cent—10 per cent of the energy developed in the cylinder being used in driving the engine itself—then 30 × 90, or 27 per cent, will represent the net or real efficiency of an engine whose thermal efficiency is 30 per cent.

This efficiency, however, will be seen to be very high, when compared with the very low efficiency which is realized with the average small steam plant. In these plants, the conversion of the total heat units of the fuel burned under the boiler into useful work is often below 3 per cent; while the efficiency of the engine for small plants seldom exceeds 6 or 7 per cent. This low thermal efficiency compares very unfavourably with that which can be realized with almost any gas engine.

In the case of the steam engine, a large overload may be obtained by making the cut-off later than is compatible with economy. On the other hand, the gas engine runs more nearly with maximum economy at its maximum load and has, therefore, a much smaller overload capacity.

PLATE III.

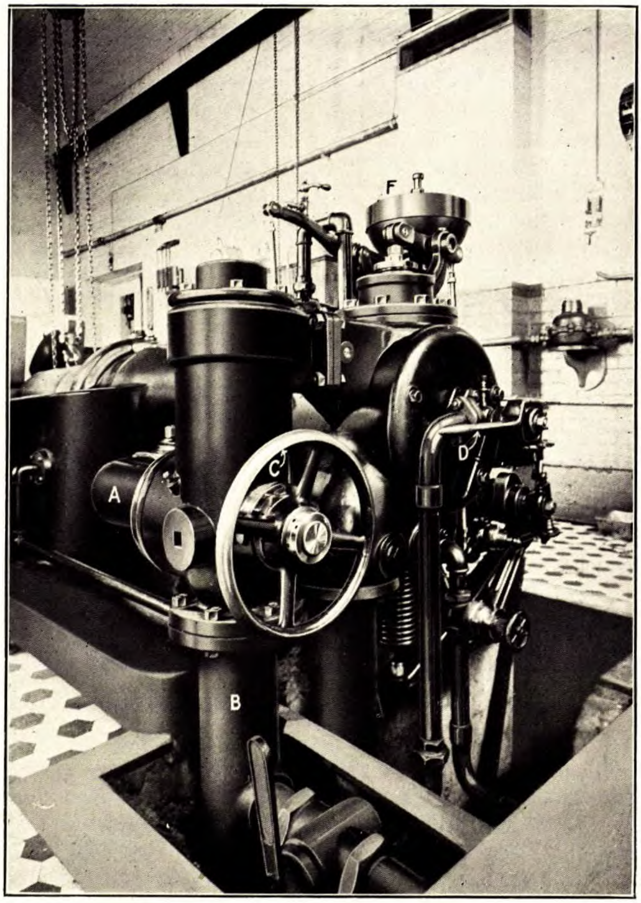


General view of the Körting gas engine, and interior of engine room.

The maximum economy of the steam engine, however—as with other engines—is only realized when it is operated at its normal rating or load.

But the case is entirely different with the gas engine, in which the piston displacement, compression, and quality of the mixture, limit the maximum power developed when the engine freely draws in a complete cylinder volume consisting of a mixture of combustible gas and air. The maximum power the gas engine is capable of developing occurs when the above conditions are complied with; greater loading will slow the engine down and finally stop it. Manufacturers in selling gas engines often state that a 10 per cent or even 20 per cent overload can be carried for short periods. This simply means that the normal rating of the engine is 10 per cent or 20 per cent under the maximum power which the engine is capable of developing, as explained previously. Moreover, the efficiency of a gas engine falls off rapidly with diminution of load below the maximum rating so that in order to realize the maximum economy it should be operated as near its maximum rating as is possible.

PLATE IV.



Detail: showing wheel for regulating air and gas mixtures, also air valve for starting the engine.

DESCRIPTION OF SOME OF THE PRINCIPAL PARTS ENTERING INTO THE CONSTRUCTION OF THE KÖRTING GAS ENGINE.

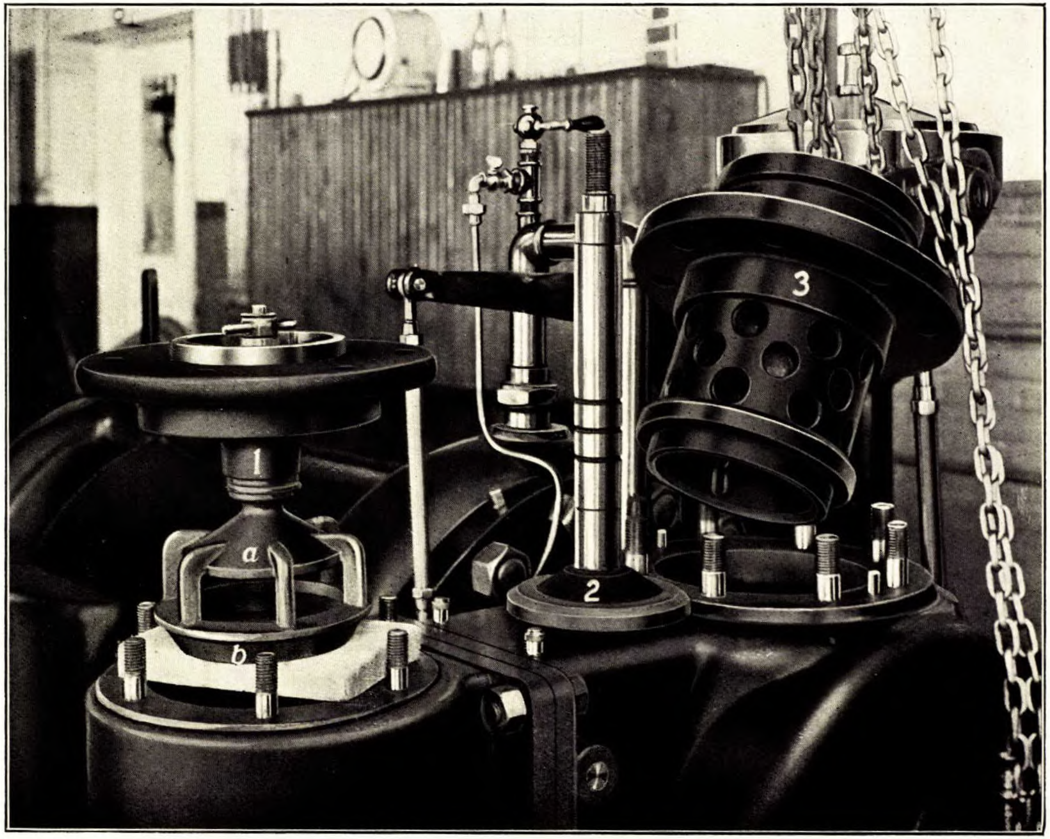
Mixing Valve.

The hand wheel for regulating the mixture of gas and air is shown on Plate IV. The hand wheel C has on its hub, just under the letter C, a graduated scale, which shows at a glance the proportion of gas to air in the mixture. By turning the wheel to the left, the quantity of air is increased and the gas decreased, and *vice versa,* the gas is increased and air decreased when the wheel is turned to the right. The air is drawn through the pipe A and the gas through pipe B, and enters the mixing valve through oblong slits cut on a conical drum attached to the hand wheel C.

The gas and air are thoroughly mixed and admitted to the combustion chamber through two annular ports, which are covered by the two annularvalve seats (a) and (b), respectively, as indicated on Plate V, which shows the top of the mixing valve removed. This valve is operated by the suction stroke of the gas engine, which, by creating a partial vacuum between the top of valve 1 and the top of annular valve seat (a), causes the valve to rise; it closes immediately when the cylinder is filled with the mixture of gas and air. Any impurities which may be, and often are, carried in the gas, such as tar, dust, etc., collect on the two seats (a) and (b), and if deposited in large quantity may interfere with the proper working of the valve. The cleanliness of the valve can be readily ascertained by the sound made by the metal plate attached to the top of the spindle carrying the two valve seats, when seating on a flat metal surface in the depression shown in the top of the cover plate of the entire valve top; the metallic nature of the sound, when the valve is clean, is notably modified by a slight deposit of tar on the seat of the valve. Since this top can be very easily and rapidly removed, it should be taken out at the termination of a run, and cleaned whenever it becomes sluggish in its operation. If at any time during the operation of the engine this valve shows signs of sticking, a few drops of gasoline put in the cup on top of the valve chamber will remove the sticky matter. These precautions are, however, entirely unnecessary when the producer is in good order.

Admission Valve.

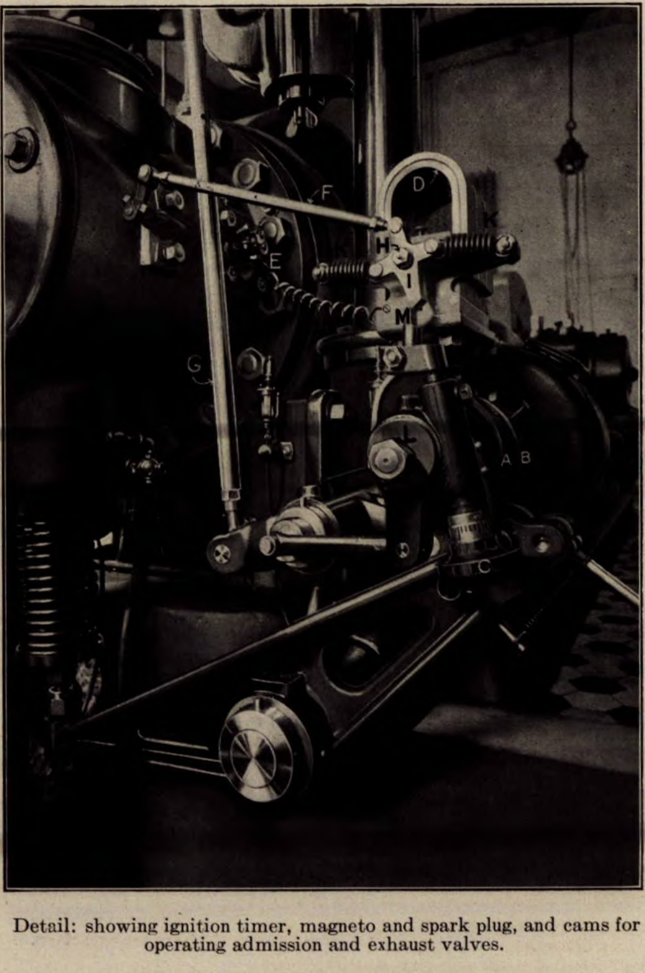
The gas admission valve is shown removed from the gas chamber on Plate V; 2 is the mushroom valve and spindle, and 3 is the valve seat and cage. This valve is actuated through two levers and a connecting rod, by a cam on the lay shaft which is driven at half speed. The valve is closed by a compression spring. If tar is carried in the gas, some of it generally collects on the bevel seat of this valve, and the heat in the combustion chamber below has a tendency to bake the tar on the valve, causing it to seat imperfectly; or, if the tar is not heated sufficiently to bake it, the valve becomes sticky. To remove this difficulty, pour a mixture of oil, soap, and water, in the proportion of about half a pound of oil soap to a large pailful of water, around the compression spring above the valve. This will last for a long time, and prevent any further sticking.



Detail: showing mixing valve and admission valve removed.

The valve should be removed about once a week for the purpose of thoroughly cleaning and polishing the bevelled edges of the mushroom, and valve seat. If it is deemed necessary, the valve can be removed more often, since this operation entails very little work, and requires only a few minutes.

PLATE VI.



Detail: showing ignition timer, magneto and spark plug, and cams for operating admission and exhaust valves.

Exhaust Valve.

The exhaust valve is situated directly underneath the admission valve, and consists of a mushroom valve bevelled on its underside, and a spindle which extends some distance beyond the bed-plate of this part of the engine, on which is placed a strong compression spring, which serves the purpose of holding it firmly in place, and also of closing it. The opening of the valve is accomplished by a cam on the lay shaft—which is driven at half the speed of the crank shaft—and a rocking beam, which turns upon an axis situated at about its centre. One end of this rocking beam rests against the cam, and is held firmly against it by means of the spring above referred to, and illustrated on Plate VI. The motion imparted to the rocker by the cam, compresses the spring, and opens the valve. The valve is closed in the manner described above.

To clean the exhaust valve, and regrind the bevels of the valve and valve seat it is necessary to remove the admission valve, also the spring from the lower end of the spindle of the exhaust valve—to permit the withdrawal of this valve and stem.

For regrinding both the exhaust and admission valves, a small amount of fine emery and oil is distributed on the bevels of the valve seats. The spindle and valves are then put in place, without their springs, and rotated by hand until a smooth bright surface is obtained.

IGNITION TIMING DEVICE.

The spark for igniting the gaseous mixture in the cylinder is generated by a magneto machine, D, see Plate IX. This machine is mechanically operated by an eccentric fixed upon the lay shaft, and connected with the armature in such a manner that the latter is slowly moved through a definite cycle, and then, the levers slipping out of contact, the original position is quickly regained under the influence of two strong springs. The rapid motion of the armature through the field of the horseshoe magnets, momentarily creates a current which passes through the contacts arranged inside the cylinder; and by a mechanical movement the latter are then separated suddenly, causing the circuit to "break," and, in doing so, to produce a spark. Plate VI shows the arrangement of all the fittings for the magneto electric ignition appliance, which is employed on the Körting engine. D, is the magneto machine, constructed of horseshoe magnets, between the iron pole pieces of which the armature pivoted at H oscillates. The slow motion is imparted to the armature by means of the tooth M engaging on the knife edge of the cross I. This motion is given to the tooth by the rotation of the eccentric L. After the knife edge is released from the tooth M, the two springs K-K rapidly bring the armature to its original position. The rod F, pivoted to the upper projection of cross I, makes and breaks the connexion of the spark plug at E.

The time of ignition can be retarded or advanced, i.e., made to occur later or earlier in the stroke, by raising or lowering the tooth M. This is accomplished by turning the graduated dial (C). In starting the engine, the igniter is so timed that the spark occurs just before the inner dead centre; this corresponds to about four points on the dial. After the engine has acquired the normal speed, the spark is advanced about ten points, i.e., to fourteen points on the dial (C); or about 8 per cent of the stroke before the inner dead centre.

It will be readily understood that the flame does not pass completely through the gases instantaneously at the time of ignition, consequently, an appreciable length of time elapses between the instant when the spark jumps across the terminals and the time when the gases have reached their maximum pressure. If the ignition occurred at the inner dead centre, the maximum pressure would not be developed until after the piston had covered an appreciable part of its stroke, consequently, the gases would not have a sufficient length of time to give up their energy to the piston before the opening of the exhaust valve occurred. By advancing the spark, the maximum pressure may be made to occur just after the inner dead centre is passed, which gives the maximum efficiency to the engine. By still further advancing it, the maximum pressure could be made to occur before the inner dead centre is reached; but in this case work is performed against the piston before the compression is completed: which tends to rotate the engine in the opposite direction, and would actually do so were the spark advanced sufficiently; in this case, therefore, the power of the engine is reduced. By so timing the ignition that the maximum pressure developed within the cylinder shall occur just after the inner dead centre is passed, the different engine details are relieved of undue strain and its mechanical efficiency is increased.

COMPRESSED AIR VALVE FOR STARTING ENGINE.

This valve is shown at D Plate IV. E is a pipe which conducts the compressed air to valve D. To start the engine, turn the fly wheel in a forward direction until the crank is just off its back dead centre and both admission and exhaust valves are closed. The valve D is now pressed in, allowing a full pressure of air to enter the cylinder. This valve must be closed before the piston begins the backward stroke. Generally the engine can be started upon one application of the air valve.

The Governor.

An illustration of the governor is shown on Plate IV, marked F.

Quantity governing is used on the Körting engine installed at the Fuel Testing plant. With this method, the quantity and not the quality of the mixture is regulated. The regulation is performed by the opening and closing of a butterfly valve placed between the mixing and inlet valves. A heavy centrifugal governor, rotating at a high speed, actuates, by the variation in the revolutions of the engine, the butterfly valve, through a system of multiplying levers. Thus, when the revolutions drop below normal, the governor drops and the valve is opened wider, thus admitting a larger quantity of gas to the cylinder. This method of governing is very sensitive, and controls the speed of the engine within 1 per cent—when the fluctuations in the load are not too great.

Cooling Water.

The amount of water deemed necessary to pass through the cylinder jacket in order to properly cool those parts of the engine subject to high temperatures, must be determined for different types and sizes of engines. Several authorities maintain that an excessive supply of cooling water diminishes the efficiency of small engines; a higher efficiency being obtained with a moderate supply.

The same authorities maintain that, for large engines, an abundant circulation has no influence on the efficiency of the engine: but that this is absolutely necessary in order to prevent premature firing which, without exception, would otherwise occur.

It has been found that the operation of the 60 B.H.P. Körting engine—installed at the Fuel Testing Plant—is most satisfactory when the outlet temperature of the cylinder cooling water is kept at about 50° C., or 122° F.

UTILIZATION OF THE HEAT OF THE EXHAUST GASES.

It was previously mentioned that only 30 per cent of the heating value of the gas delivered to the engine was converted into useful work in the cylinder; the other 70 per cent passing off in the exhaust gases and cylinder jacket cooling water. This latter amount of heat is approximately equal to 6,000 B. T. units, or half a pound of coal containing 12,000 B. T. units per pound, per B. H. P. hour. This heat loss is so considerable that, many attempts have been made by experimenters to recover at least a part of it by utilizing the heat of the exhaust gases and cylinder cooling water for power or other purposes. If this heat could be even partially converted into useful work, the efficiency of the gas engine would be appreciably increased.

The possibility of utilizing the heat of the exhaust gas for steam raising in specially designed steam generators has been investigated, and results have been attained which demonstrate that such a utilization of the heat of the exhaust gases is practically feasible.

In connexion with large gas engine installations, low pressure steam has been generated in this manner and utilized in low pressure steam turbines. The steam thus generated, or the water heated, might also be utilized for heating buildings or for drying purposes, etc.

If we assume, for example, that 3,000 to 3,600 B. T. U. per hour per B. H.P. developed by an engine is available, and can be utilized in the production of steam, an output not exceeding 2·2 lbs. of steam per hour, at a pressure of 70 to 85 lbs. per square inch per B. H. P. developed, could probably be obtained. But, in order to recover this waste heat, the engine must work at least at about two-thirds of its maximum power; if not, the exhaust gas is expanded down so much by the modern methods of governing that it is not hot enough to give up any appreciable quantity of heat for recovery in this manner.[1]

By way of illustration, we will consider the case of a 100 B. H. P. gas engine working at full load. The amount of heat available per hour will be approximately 350,000 B. T. units; and since 3,500 B. T. units will generate 2·2 lbs. of steam at a pressure of 70 to 85 lbs. per square inch, the total amount of steam generated from the utilization of the 350,000 B. T. units will be 220 lbs. If this were utilized in a non-condensing steam engine, the power developed would be about 6 H. P., or 6 per cent of the power of the gas engine. This is not inconsiderable, and will become a very appreciable factor in large gas engine installations.

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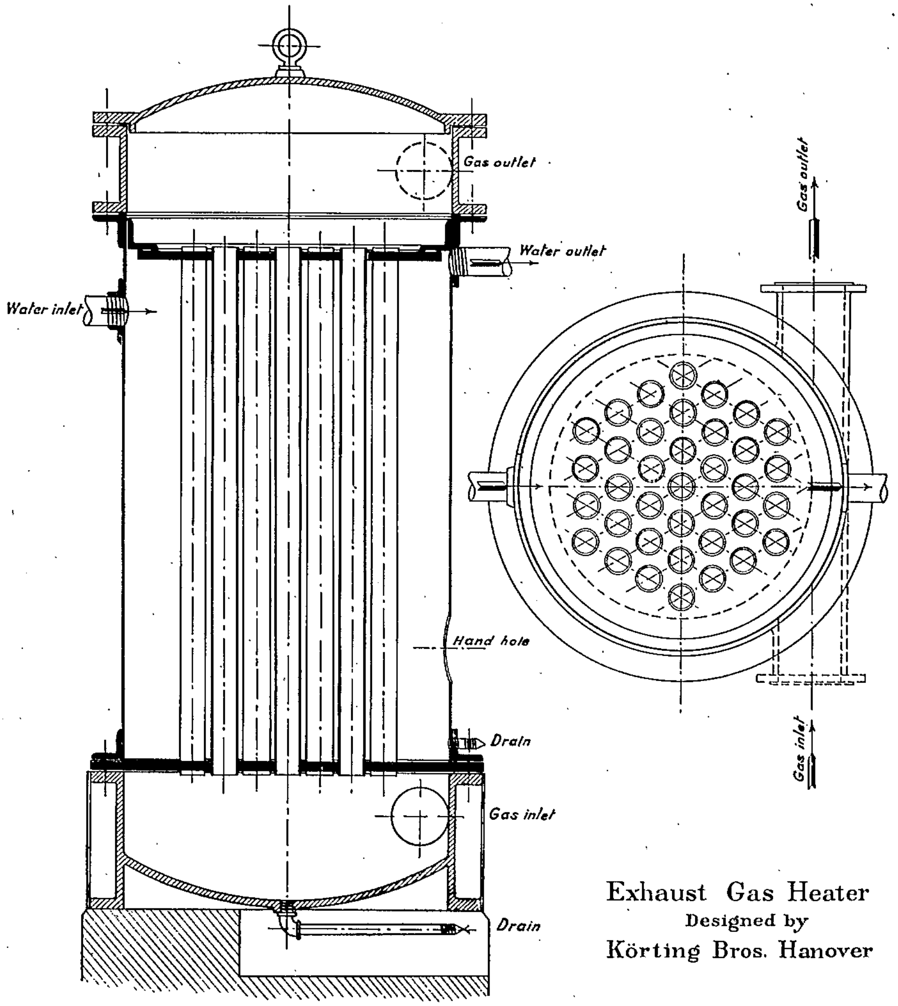
[1] Construction and working of internal combustion engines, R. E. Mathot, pages 198-199.

Experimentation will shortly be undertaken at the Fuel Testing Plant to determine the steam-raising capacity of the heat of the exhaust gases in a small heater which was constructed for the purpose. The object of these experiments will be to ascertain the feasibility of introducing such apparatus for the heating of buildings, or other purposes, in small engine installations, similar to that installed at the Fuel Testing Plant, which is of 60 B. H. P. capacity, and similar to that designed by Messrs. Körting Bros. shown in Fig. 6.



Exhaust Gas Heater
Designed by
Körting Bros. Hanover

Fig. 6.

The only practical tests carried out along this line with which the writer is familiar, are those conducted at the Westinghouse Machine Company's Works at East Pittsburgh, Pennsylvania: with a No. 8 Transverse-Current Heater, manufactured by the Williams Tool Company.

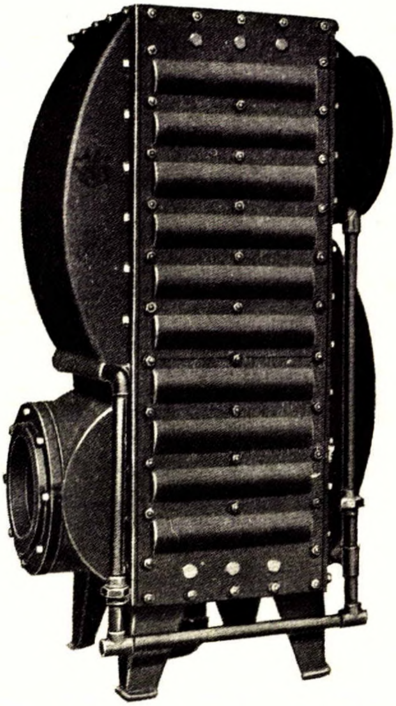


FIG. 7.—Transverse Current Water Heater, manufactured by Williams Tool Co., Erie, Pa., U.S.A.

And since the information contained in these tests may prove of interest to gas engine operators, or to those intending to install such a power plant, a copy of these *Westinghouse* tests has been incorporated in this report, as follows:—

TABLE I.

FULL LOAD.

HEATER TEST No. 1.

Time.	TEMPERATURES F°.						Wt., Bl. at start.	Wt., Bl. at finish.	Wt. Water through Heater during Test.	Length of Test in Sec.	Lbs. Water per hr. through heater.	WATER TEMPERATURE INCREASE.	
	t 1 Water to Jackets.	t 2 Inlet Heater.	t 3 Outlet Heater.	t 4 Exhaust Gases in Heater.	t 5 Exhaust Gases in Heater.	t 6 Heater Outlet Gases.						Jackets F°.	Heater F°.
12-00-00........	47°	134°	193°	....	....	268°	....	....	....	....	....	....	....
....	"	133°	189°	....	....	....	....	....	....	....	....	....	....
12-10-00........	"	132°	191°	....	....	....	....	....	....	....	....	....	....
....	"	131°	188°	steam	makes	outlet	water	irregular	....	....	....	....	....
....	"	"	192°	....	....	....	....	....	....	....	....	....	....
....	"	"	186°	....	....	264°	....	....	....	....	....	....	....
....	"	"	190°	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	77	429	352	155	8,175	84°	59°
12-20-00........	47°	131°	190°	....	....	264°	....	....	....	....	....	....	....
Average....	....	131°	190°									84°	59°

84°×8,175 lbs. = 687,000 B. T. U. per hour from jackets.
59°×8,175 lbs. = 482,000 " " " " heater,

143°×8,175 lbs. =1,169,000 " " " " Total.
201 B. H. P. on engine using 2,175 cub. ft. natural gas per hour at 62° F. and 30″ Hg., having heat value of 966 total B. T. U. per cub. ft.
2,175 cub. ft.×966 total B. T. U. = 2,100,000 B. T. U. per hr. to eng.

201 B. H. P.×2,545 B. T. U.	=	512,000 B. T. U. per hour	= 24·4%	of total to engine.
Absorbed by jackets, -	=	687,000 " " "	= 32·7 "	" "
" " heater, -	=	482,000 " " "	= 22·9 "	" "
Exhaust, radiation, and friction	=	419,000 " " "	= 20·0 "	" "
Total, - -		2,100,000	100·0%	" "

Combined heating efficiency - engine and heater: $\frac{1,169,000}{1,588,000} = 73{\cdot}5\%$

TABLE II.

FULL LOAD.

HEATER TEST No. 2.

Time.	TEMPERATURES F°.						Wt., Bl. at start.	Wt., Bl. at finish.	Lbs. Water through Heater during Test.	Duration of test in Sec.	Lbs. Water per hr. through Heater.	WATER TEMPERATURE INCREASE.	
	t 1 Inlet Jacket Water.	t 2 Inlet Heater.	t 3 Outlet Heater.	t 4 Exhaust Gases in Heater.	t 5 Exhaust Gases in Heater.	t 6 Heater Outlet Gases.						Jackets F°	Heater F°
4-20-00..........	47°	100°	136°	....	....	236°	....	....	....	....	....	53°	36°
4-22-32..........	“	99°	134°	....	....	233°	77	428	351	92	13,730	52°	35°
4-33-00..........	....	....	....	598	370°	....	....	....	....	....	....	....	....
4-34-00..........	47°	99°	135°	....	....	240°	....	....	....	....	....	52°	36°
4-38-00..........	“	100°	136°	....	....	238°	....	....	....	....	....	53°	36°
4-45-00..........	“	“	137°	....	....	239°	....	....	....	....	....	53°	37°
4-47-38..........	“	“	136°	....	....	237°	77	444	367	98	13,490	53°	36°
4-55-00..........	“	“	136°	....	....	240°	....	....	....	....	....	....	....
4-56-00..........	“	“	136°	....	....	239°	77	432	355	93·5	13,680	53°	36°
Average....	....	100°	136°								13,630	53°	36°

53°×13,630 lbs. = 723,000 B. T. U. per hour from jackets,
36°×13,630 “ = 491,000 “ “ heater,

89°×13,630 “ = 1,214,000 “ “ Total.
201 O. B. H. P. on engine using 2,130 cub. ft. natural gas per hour at 62° and 30″ Hg. heat value = 965 total B. T. U. per cub. ft.
2,130 cub. ft.×966 B. T. U. = 2,060,000 B. T. U. per hour to engine.
201 B. H. P.×2,545 B. T. U. = 512,000 B. T. U. per hour = 24·9% Total to engine.
Absorbed by jackets, = 723,000 “ “ = 35·1% “
“ heater, = 491,000 “ “ = 23·8% “
Exhaust, radiation, and friction = 334,000 “ “ = 16·2 “ “

Total, = 2,060,000 100·0%

Combined heating efficiency – engine and heater... $\frac{1,214,000}{1,548,000} = 78\cdot5\%$

TABLE III.

HALF LOAD. HEATER TEST No. 3.

Time.	TEMPERATURES F°.						WEIGHT OF BARREL.		Lbs. Water Through Heater During Test.	Duration of Test in Sec.	Lbs. Water per hr. through Heater.	WATER TEMPERATURE INCREASE.	
	t 1 Inlet Jacket Water.	t 2 Inlet Heater.	t 3 Outlet Heater.	t 4 Exhaust Gases in Heater.	t 5 Exhaust Gases in Heater.	t 6 Heater Outlet Gases.	At Start.	At Finish.				Jackets F°.	Heater. F°.
2-28-00	47°												
2-35-00	“	141°	197°	560°	352°	215°						94°	56°
2-46-00	“	137°	193°			216°	77	430	353	262	4,850	90°	56°
	“	140°	195°									93°	55°
to	“	140°	196°			216°						93°	56°
2-52-22	“	141°	196°			216°						94°	55°
2-54-00	“	143	196°									96°	55°
3-12-00	“	137°	198°			220°						90°	59°
3-13-00	”	137°	196°			220°	77	427	350	240	5,250	90°	59°
	“	139°	“									92°	57°
to	”	140°	“									93°	56°
3-14-00	“	141°	“									94°	55°
Average		140°	“								5,050	93°	56°

93° × 5,050 lbs. = 470,000 B. T. U. per hour from jackets,
56° × 5,050 lbs. = 283,000 “ “ “ heater,

149° × 5,050 lbs. = 753,000 “ “ “ Total.
100·8 B. H. P. on engine using 1,411 cub. ft. gas per hour at 62° and 30″ Hg. heat value = 966 total B. T. U. per cub. ft.

1,411 cub. ft. × 966 total B.T.U. = 1,363,000 B.T.U. per hr. to eng.
100·8 B. H. P. × 2,545 B.T.U. = 256,500 B.T.U. per hour = 18·8% of total to engine.
Absorbed by jackets, = 470,000 “ “ “ = 34·5 “ “
“ heater, = 283,000 “ “ “ = 20·8 “ “
Exhaust, radiation, and friction = 353,500 “ “ “ = 25·9 “ “
Total, = 1,363,000 100·0%

Combined heating efficiency - engine and heater: $\frac{753,000}{1,106,500} = 68{\cdot}1\%$

TABLE IV.

LIGHT LOAD.

HEATER TEST No. 4.

Time.	TEMPERATURES F°.						WEIGHT OF BARREL.		Lbs. Water Through Heater During Test.	Duration of Test in Sec.	Lbs. Water per hr. Through Heater.	WATER TEMPERATURE INCREASE.	
	t 1 Jacket Inlet Water.	t 2 Heater Inlet.	t 3 Heater Outlet.	t 4 Exhaust Gases in Heater.	t 5 Exhaust Gases in Heater.	t 6 Heater Outlet Gases.	At Start.	At Finish.				Jackets F°.	Heater F°.
1-10-00..........	46°	141°	186°	....	....	187°	....	....	....	....	....	95°	45°
....	"	141°	186°	....	....	185°	....	....	....	....	....	95°	45°
....	"	140°	186°	....	....	185°	77	430	353	296	4,300	94°	46°
1-30-00..........	"	140°	188°	501°	296°	183°	....	....	....	....	....	94°	48°
1-44-00..........	"	141°	186°	....	....	186°	....	....	....	....	....	95°	45°
1-45-00..........	"	141°	190°	....	....	184°	77	427	350	302	4,180	95°	49°
1-50-02..........	"	142°	190°	....	....	183°	....	....	....	....	....	96°	48°
Average....	....	141°	187·5°								4,240	95°	46·5°

95° × 4,240 lbs. = 402,500 B. T. U. per hour from jackets,
46·5° × 5,240 lbs. = 197,000 " " " heater,

142·5° × 4,240 lbs. = 599,500 " " " Total.
41·0 B. H. P. on engine using 976 cub. ft. gas per hour at 62° F. and
30″ Hg. heat value = 966 total B. T. U. per cub. ft.
976 cub. ft. × 966 total B. T. U = 944,000 B. T. U. per hour to engine.
41·0 B. H. P. × 2,545 B. T. U. = 104,500 B. T. U. per hour = 11·1% of total to engine.
Absorbed by jackets, = 402,500 " " " = 42·7 " "
" heater, = 197,000 " " " = 20·8 " "
Exhaust, radiation, and friction = 240,000 " " " = 25·4 " "
Total, = 944,000 " " " = 100·0%

Combined heating efficiency - engine and heater.... $\frac{599,500}{839,500} = 71·5\%$

Fig. 8 shows the heater with front and back circulation plates removed, exposing the water passages and showing their accessibility for cleaning. The exhaust passages open into the circulation plates on the right and left hand sides of the heater, and extend transversely to the water passages, the walls of the water passages forming the walls of the exhaust passages.

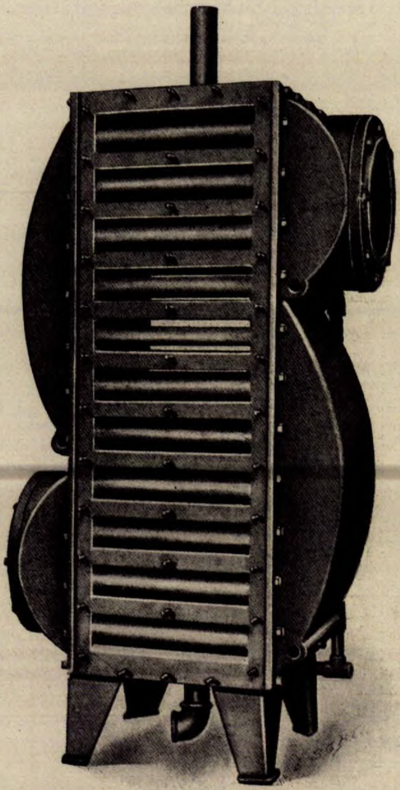


FIG. 8.—Williams Transverse Current Water Heater. Front and back circulation plates removed: exposing the water passages, and showing their accessibility for cleaning. The exhaust passages open into the circulation plates on the right and left-hand sides of the heater, and extend transversely to the water passages, the walls of the water passages forming the walls of the exhaust passages.

Fig. 9 shows the internal view of the transverse current water heater. The exposed section shows the water passages on the right, and the exhaust passages on the left.

This method of utilizing the heat of the exhaust gases and the jacket water may find a practical application in factories or other industrial establishments, where exhaust steam is used for drying purposes. It has often been cited as an argument against the introduction of the gas engine power plant into factories, as a substitute for steam, that auxiliary boilers had to be installed for heating the buildings and for drying purposes; and that, therefore, the system was neither practical nor economical.

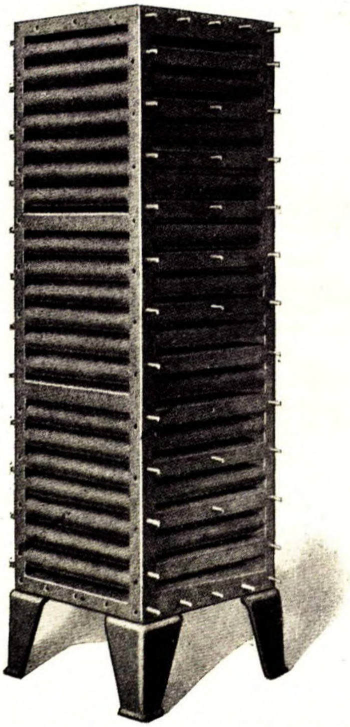


FIG. 9.—Williams Transverse Current Water Heater. Exposed section, showing the water passages on the right and the exhaust passages on the left.

While in factories requiring only comparatively small power plants the possibility of heating the buildings in the manner referred to may prove impossible; for those using large amounts of power the problem

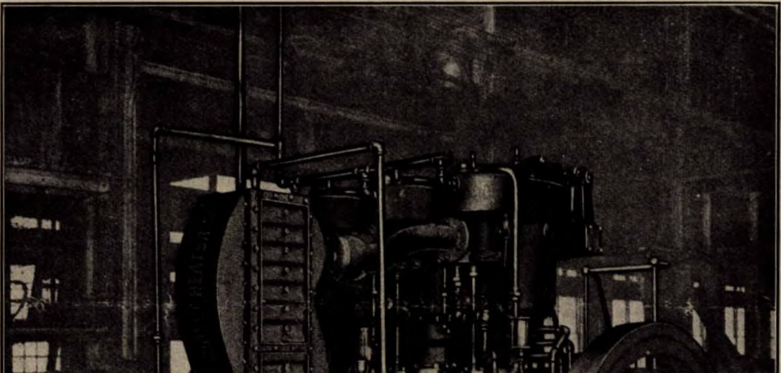


FIG. 10.—No. 8 Williams Transverse Current Water Heater, connected to Westinghouse Machine Co.'s 200 H.P. Engine.

may be solved satisfactorily, by means of the gas engine power system: especially in those instances where a steady load is carried continuously during the entire day.

EQUIPMENT OF GAS ANALYTICAL LABORATORY.

The equipment of the chemical laboratory—in addition to ovens, muffles, furnaces, and various other pieces of apparatus, which need not be described here—consists of a Bone and Wheeler, and a Randall and Barnhart gas analysis apparatus; a Junker's and a Boys' calorimeter, with meters, pressure regulators, etc., for determining the calorific value of gases; and a Fritz Köhler bomb calorimeter—with accessories, for determining the calorific value of fuels. For determining the quantity of tar carried in the gas after passing through the cleaning system, a Brady gas filter, with electric heating sleeve, is provided. A Simmance and Abady carbon dioxide recorder; a Keiser and Schmidt, and a Stansfield electric pyrometers, with milli-voltmeters, and a Junker's exhauster set, are also provided.

Plate VII.

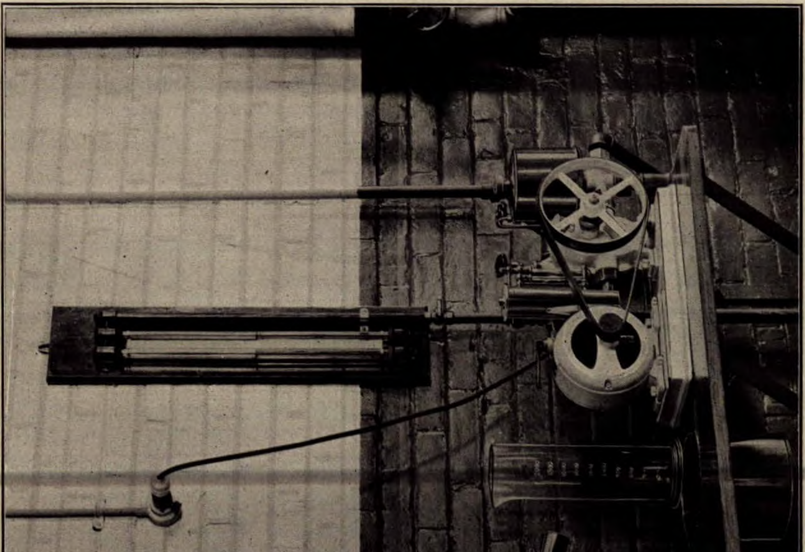
Interior of Chemical Laboratory.

The Junker's calorimeter was used during the several tests made for determining the calorific value of the gas. This apparatus is clearly shown in Plate VIII, set up on the special bench made for the purpose. This bench is provided with a copper sink for carrying off the overflow water, etc. The Junker's calorimeter set with the small exhauster also shown on Plate VII is placed as near as convenient to the gas main leading to the engine. Since high and varying suctions are encountered in a suction gas producer plant, the Junker's exhauster was installed for the purpose of delivering a gas of constant pressure to the calorimeter.

The exhauster consists of a small blower, pressure regulator, gas filter, and a $\frac{1}{10}$ H. P. alternating current motor set up on a cast iron base. The tar filter is connected to the gas main leading to the engine;

consequently, all the gas drawn through the exhauster, and forced under pressure to the calorimeter, is cleaned of any tarry matter which would otherwise clog the meters and rubber tubing connecting the meter with the gas burner. A waste pipe is provided for carrying off the surplus gas. This apparatus delivers a uniform supply of gas at constant pressure regardless of the suction in the gas system, which varies from time to time.

Plate VIII.



Junker gas calorimeter and gas exhauster.

APPARATUS FOR DETERMINING THE AMOUNT OF TAR IN THE GAS.

Instead of drawing the gas through the filter provided with the exhauster, the gas may be cleaned of any tarry matter by passing through a specially designed filter paper and holder before it enters the exhauster. By this means the gas entering the exhauster and meter is not only thoroughly freed from tarry and other matter; but at the same time the amount of tar carried by the gas and deposited on the filter paper can be weighed, and the amount of tar per cubic foot determined, when the volume of gas passing through the filter paper is accurately measured with a meter. The Brady gas filter consisting of a filter paper cup and holder was used for this purpose during some of the tests. The electric heating sleeve furnishes the requisite heat to drive off the moisture which would otherwise saturate the filter paper cup, and interrupt the free passage of gas to the calorimeter.

For determining the tar in the gas before entering the cleaning system, or just as it leaves the producer, a special gas filter—in which ordinary filter paper can be inserted—is used. This gas filter, shown in Plate IX, is manufactured by the Westinghouse Machine Co., Pittsburgh, Pa., and was first seen in use at their experimental laboratory.

The volume of gas passed through this gas filter is measured by means of a gas holder.

PYROMETRIC MEASUREMENTS.

The temperature of the producer-gas was determined during four of the tests with the Stansfield electric pyrometer. For this purpose, the pyrometer was inserted through a hole drilled in the cap covering the gas off-take, and the wires connecting the terminals of the pyrometer were led into the engine room and connected to the milli-voltmeter, which was placed near the switchboard, so that the readings of the switchboard instruments and the milli-voltmeter could be made, conveniently, at the same time.

SAMPLING OF GAS FOR ANALYSIS.

Samples of gas were taken for analysis every hour throughout the tests, except in two tests when it was not necessary to sample so often. The gas samples were taken between the tar filter and dry scrubber, just before the gas entered the dry scrubber; and since the samples taken at this point did not show the final condition of the gas, after passing through the dry scrubber—as far as moisture is concerned—no determinations of moisture were made.

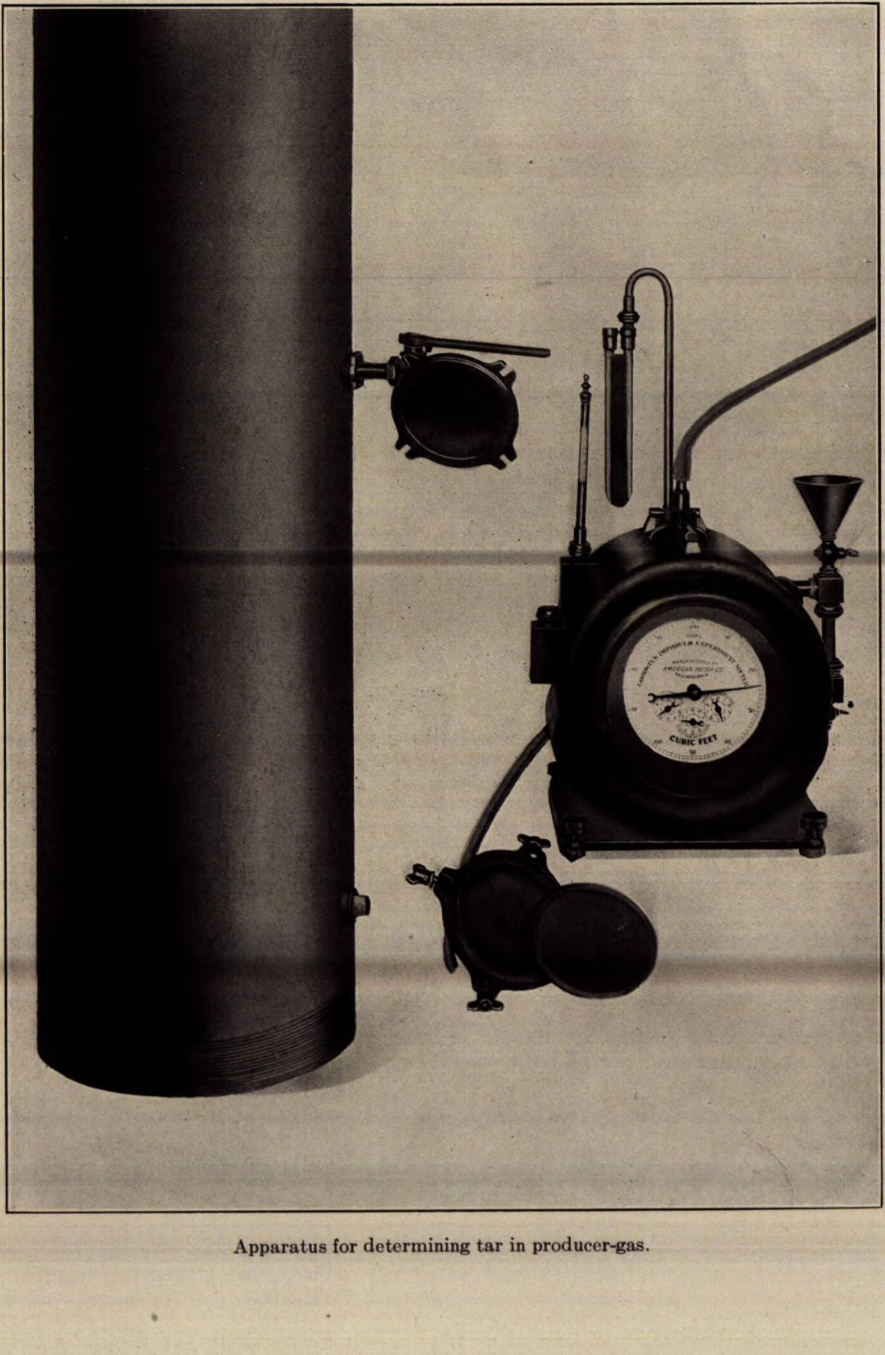
The gas drawn off from the upper zone of the producer was sampled from time to time, but not regularly, during a test. Samples were also taken at other points of the system.

In all cases the gas was collected over a mixture of glycerine and water, with two aspirator bottles, and since the samples, as soon as collected, were immediately taken to the laboratory for analysis, no appreciable absorption of any of the components of the gas by the water would occur during this short time. The calorific value of the gas was calculated from its analysis: the results in all cases being expressed in B. T. units per cubic foot of gas measured moist at 60° F., and at 30″ of mercury pressure.

SAMPLING OF PEAT; ANALYSIS, AND DETERMINATION OF MOISTURE.

In order to obtain a general sample of peat—which would be, as nearly as possible, representative of its condition when fired—a sample was taken from every 50 lbs. charged into the producer. These samples were collected during the trial in a large can, provided with a tight fitting

PLATE IX.



Apparatus for determining tar in producer-gas.

cover. At the end of the trial the peat contained in this can was pulverized, and an average sample taken for analysis, and determination of moisture.

GAS PRODUCER TESTS.

Previous to the erection of the Fuel Testing Station at Ottawa, and the installation of the present equipment, the Mines Branch undertook the manufacture of peat at the Victoria Road peat bog near Lindsay, Ont. The peat manufactured at this bog, amounting to some 70 tons, was stored under cover in a shed on the bog for more than a year—awaiting the completion of the plant at Ottawa. After the installation of the machinery in the fuel testing plant, this peat was shipped to Ottawa, and was used for making several tests for fuel consumption.

Owing to long storage under cover, the peat lost most of its moisture, hence was in too dry a condition when received at Ottawa, to work well in the Körting producer—which is not provided with an evaporator for steam raising. Some method of introducing moisture into the producer is necessary when operating on dry fuels. Moreover, the peat was taken from a shallow part of the bog, underlain by sand, consequently, the percentage of ash—consisting mainly of siliceous matter—was very high; averaging about 10 per cent. These negative conditions, together with the excessively high internal temperature due to the dryness of the fuel, caused some trouble, from the formation of clinkers, which could not be easily broken up. This trouble could have been avoided had there been some provision for the introduction of steam—as stated above.

The Körting peat gas producer is designed to operate with peat containing from 25 to 30 per cent moisture; and since, when working under these conditions, no further moisture in the form of steam is required, it was not provided with the vaporizer generally found in other producers. However, during the tests made with this peat an attempt to introduce moisture was made by the erecting engineer representing the Körting firm: by injecting water inside the two doors used for poking and cleaning the fires of the lower zone. But this did not prove entirely satisfactory, consequently it was discontinued after a few runs.

Notwithstanding the unsuitability of this peat as regards moisture and ash, the tests demonstrated that, even under these unfavourable conditions, the plant could be successfully worked on a commercial basis.

The peat, on account of its dry condition, was badly shattered by the several handlings it received before being stacked in the shed at Ottawa; consequently, it was sufficiently broken up to be fed into the producer without further crushing.

Three tests were made with this peat, under varying conditions, to determine the fuel consumption per brake horse-power hour; but inasmuch as the general testing equipment, chemical laboratory, etc., had not been installed, at the time, the gas was neither analysed nor metered.

The load carried on the engine was determined by taking readings of the voltmeter and amperemeter at intervals of fifteen minutes. For the purpose of calculating the load or brake horse-power developed at the engine, the efficiency curve of the electric generator—as determined by tests carried out by the makers—was used. At full load, or 50 K.W., the efficiency of the electric generator is 88 per cent; at 60 B. H. P. = 45 K. W., at 90 per cent full load, the generator efficiency is practically the same as at full load, viz., 88 per cent. This factor was used in converting the electrical horse-power—as calculated from the switchboard instruments—into brake horse-power, at the engine.

The weight of the fuel charged into the producer during the tests made with this peat was not determined hourly, as was done with the tests made with the peat manufactured at the Alfred peat bog; but the amounts of fuel required to fill the producer hoppers whenever charging was deemed necessary (which chargings occurred at irregular intervals) were totalled at the end of the tests.

With a view to enabling the readers of the report to judge for themselves the character of the load carried during these tests, a full table is given (pages 42, 44, and 46) of all the switchboard readings, as well as the calculated watts, and electric and brake horse-powers.

DURATION OF TESTS.

On account of the construction of the Körting peat gas producer, described earlier in this report, the duration of a test need not necessarily be longer than seven hours—the length of time prescribed by the makers. This will be readily understood when it is stated that, the fires of the upper and lower zones rest on grate bars, and, therefore, can be readily cleaned of ashes. Further, since that portion of the producer below the upper grate level is filled, or should, always be filled with coked peat, it is possible to bring the producer—after a seven hours' run—to nearly the same state, as regards condition and weight of fuel, as it was in at the beginning of the run or trial. Hence, for the determination of fuel consumption per B. H. P. hour, seven hours is probably a sufficient length of time in which to arrive at an approximately correct result; providing the producer is run for two or three hours before the beginning of the test under the same conditions as during the test. The majority of the tests, however, were run for at least ten hours.

TESTS MADE WITH THE PEAT MANUFACTURED AT THE VICTORIA ROAD PEAT BOG, NEAR LINDSAY, ONT.

Test No. 1, February 24, 1910.

As previously stated, the dry condition, and large amount of fusible ash in the peat, coupled with the high working temperature which could not be controlled, caused the formation of clinkers, and interfered, to some extent, with the regular operation of the producer. The trouble most noticeable was, the irregular feeding of the fuel into the lower zone. This was caused by clinkers adhering to the walls above the doors provided for poking, and resulted in scaffolding. The large hollow spaces thus formed in the lower zone, caused irregularity in the composition of the gas, and the formation of some tar. The tar was due to the feeding into the lower zone of uncoked peat; for, when the clinkers broke away—on account of the weight of fuel resting on them, or when broken away by poking—large quantities of green or partially coked peat dropped into this zone from the upper portions of the producer, instead of passing slowly and regularly down through the upper zone. The tar carried over through the cleaning system, only gave trouble at the admission valve, which showed signs of sticking several times during the trial. This trouble was, however, easily overcome by dropping a little gasoline around the spindle of the valve. The irregularity in the composition of the gas was easily taken care of by the air and gas regulating valve; and at no time during the trial was this irregularity serious enough to necessitate a reduction of the load carried on the engine: as can plainly be seen by consulting the accompanying table of results. In this table are recorded the observations taken at fifteen minute intervals: the watts, the horse-power at switchboard, the brake horse-power developed at the engine, and the average brake horse-power developed during the trial; so that the variations occurring in the load during these intervals can easily be seen. In addition to the above recorded results, the time of poking and charging producer are included in the table.

It will be seen by referring to Table V that the fuel charged into the producer at 11.45 a.m., and 3.38 and 4.40 p.m., is of a larger amount than that charged at any other time. This was due, as explained previously, to the formation of clinkers, which kept the fuel from feeding regularly into the lower zone; so that when the obstructions to the free passage of the fuel broke away, a sudden drop occurred, which at times—as at 4.40 p.m.—almost completely emptied the charging hoppers. The fires were cleaned at 10.30 a.m., 3.35 and 6.00 p.m.

ANALYSIS OF PEAT.

The following is the analysis of the peat used during these trials:—

Volatile matter	69·5
Fixed carbon	25·2
Ash	5·3
Calorific value of dry fuel	8650 B. T. U. per lb.

The high amount of ash (10 per cent) mentioned above, was due to a large amount of free sand contained in the peat manufactured and used during the trials. The above analysis was made from a general sample of the peat contained in the entire bog which was obtained before manufacturing began.

The following is a summary of the results of the test:—

Fires cleaned and hoppers filled at	10.30 a.m.
Test started	10.30 a.m.
Test terminated	6.00 p.m.
Duration of test	7 hrs., 30 mins.
Average volts	124
" amperes	311
" watts delivered at switchboard	38700
" H. P. at switchboard	51·9
" B. H. P. developed at engine	58·9
Moisture content of fuel	13%
Ash content of dry fuel	10%
Calorific value of dry fuel	8650 B. T. U. per lb
Total fuel as fired	904 lbs
" " calculated dry	786 "
Fuel consumption per hour as fired	120·5 lbs.
" " hour calculated, dry	104·9
" " B.H.P. hour as fired	2·04 lbs.
" " B.H.P. hour as calculated, dry	1·78 "
Speed of gas engine	200 R. P. M.

TABLE V.

Test No. 1, February 24.

SWITCHBOARD OBSERVATIONS, AND CALCULATED WATTS, HORSE-POWER AT SWITCHBOARD, B.H.P. AT ENGINE AND FUEL CONSUMPTION.

Time.	Amperes.	Volts.	Watts.	H.P. of Switchboard.	B.H.P. on Engine.	B.H.P. Hourly Average	Time of Charging.	Fuel, lbs. Chgd.	Time of Poking	Consumption of peat per B.H.P.
a.m. 10.30	310	124	38440	51·5	58·5	59.9	a.m. 10.30	Filled	a.m. 10.30	
10.45	322	125	40250	53·9	61·3					
11.00	320	125	40000	53·6	60·9	59·9				
11.15	315	125	39380	52·8	60·0					
11.30	312	124	38690	51·9	58·9					
11.45	312	124	38690	51·9	58·9		11.45	168		Average Consumption of Peat per B.H.P.hour during trial as fired 2·04 lbs. Dry: 1·78 lbs.
m. 12.00	310	123	38130	51·1	58·1	58·5				
p.m. 12.15	310	123	38130	51·1	58·1					
12.30	310	124	38440	51·5	58·5					
12.45	307	124	38070	51·0	58·0					
1.00	307	125	38380	51·4	58·4	59·0	p.m. 1.00			
1.15	318	125	39750	53·3	60·5					
1.30	315	124	39060	52·3	59·5					
1.45	328	125	41000	54·9	62·4					
2.00	325	125	40630	54·4	61·9	60·9				
2.15	320	124	39680	53·2	60·4					
2.30	317	125	39630	53·1	60·3		2.20	133		
2.45	307	125	38380	51·4	58·4					
3.00	315	126	39690	53·2	60·4					
3.15	308	125	38500	51·6	58·6	59·4				
3.30	310	125	38750	51·9	59·0				p.m. 3.35	
3.45	300	118	35400	47·4	53·9		3.38	163		
4.00	305	122	37210	49·9	56·7					
4.15	302	124	37450	50·2	57·0	56·9				
4.30	305	125	38130	51·1	58·1					
4.45	305	125	38130	51·1	58·1		4.40	175		
5.00	305	125	38130	51·1	58·1	58·4				
5.15	305	125	38130	51·1	58·1					
5.30	311	126	39180	52·5	59·7					
5.45	305	126	38130	51·1	58·1					
6.00	305	125	38130	51·1	58·1		6.00	139	6.00	
Av...	311·2	124·4	38698	51·9	58·9					
Total. .								904		

Test No. 2, February 28, 1910.

During this test, the producer was poked every two hours—six times in all. Considerable water was admitted through the lower fire doors by two pipes connected to the water main and the two sides of the producer, just above the fire doors. Most of this water found its way into the gas chamber just below the grate bars, and thoroughly saturated the ashes which accumulated there. It was believed that the hot gases passing through this gas chamber would take up a certain amount of moisture which, in passing through the hot carbon of the lower zone, would be decomposed, as already explained (see pages 6 and 7) and thus cool the fuel bed sufficiently to prevent the formation of clinkers. To a certain extent, this device materially improved the operation; but it was found that moisture could not be effectively introduced in this manner.

The feeding of fuel from the upper into the lower zone was more regular, and no noticeable air spaces occurred in the lower fuel bed. Moreover, the tar carried past the cleaning system did not at any time prove more troublesome than in the previous run. The fuel consumption was, however, noticeably higher.

In Table VI the readings of the switchboard instruments, and the calculated watts; horse-power at switchboard, and brake horse-power at engine, are tabulated for every fifteen minutes interval. In addition, the hourly average brake horse-power developed at the engine, and the average volts, amperes, watts, etc., are also tabulated.

During this trial, the amounts of fuel charged into the producer hoppers, and the times of charging were not recorded; only the total amount of fuel charged during the entire run was determined.

The following is a summary of the results:—

Fire cleaned, ashes removed, and hoppers filled.......	10.00 a.m.
Test started..	10.00 a.m.
Test terminated...	10.00 p.m.
Duration of test...	12 hrs.
Average volts..	126
“ amperes..	303
“ watts delivered at switchboard..............	38070
“ H. P. at switchboard............................	51·0
“ B. H. P. developed at engine...............	58·0
Moisture content of fuel..................................	13%
Ash content of dry fuel..................................	10%
Calorific value of dry fuel..............................	8650 B.T.U.per lb.
Total fuel as fired..	1704 lbs.
“ fired dry...	1482 “
Fuel consumption per hour as fired..................	142 “
“ “ “ calculated dry............	123 “
“ “ B.H.P. hour as fired...........	2·45 lbs.
“ “ “ calculated dry......	2·12 “
Speed of gas engine......................................	200 R.P.M.

Table VI.

Test No. 2, February 28, 1910.

SWITCHBOARD OBSERVATIONS AND CALCULATED WATTS AND BRAKE HORSE-POWER.

Time.	Ampères.	Volts.	Watts.	E. H. P. at switch-board.	B.H.P. at engine.	B.H.P. Hourly Average.
10.00 a.m.	310	121	37510	50·3	57·1	
10.15	305	125	38130	51·1	58·1	
10.30	305	126	38430	51·5	58·5	59·0
10.45	315	126	39690	53·2	60·4	
11.00	315	127	40010	53·6	60·9	
11.15	305	127	38740	51·9	59·0	
11.30	305	127	38740	51·9	59·0	59·1
11.45	305	127	38740	51·9	59·0	
12.00	300	126	37800	50·7	57·6	
12.15 p.m.	298	127	37850	50·7	57·6	
12.30	299	125	37380	50·1	56·9	57·4
12.45	299	127	37970	50·9	57·8	
1.00	298	126	37550	50·3	57·2	
1.15	300	126	37800	50·7	57·6	
1.30	305	125	38130	51·1	58·1	57·8
1.45	305	125	38130	51·1	58·1	
2.00	300	127	38100	51·1	58·0	
2.15	305	125	38130	51·1	58·1	
2.30	305	125	38130	51·1	58·1	57·8
2.45	300	125	37500	50·3	57·1	
3.00	302	125	37750	50·6	57·5	
3.15	300	126	37800	50·7	57·6	
3.30	305	127	38740	51·9	59·0	58·3
3.45	305	126	38430	51·5	58·5	
4.00	306	126	38560	51.7	58·7	
4.15	301	126	37930	50·8	57·8	
4.30	300	127	38100	51·1	58·0	57·8
4.45	300	125	37500	50·3	57·1	
5.00 p.m.	298	127	37850	50·7	57·6	
5.15	300	125	37500	50·3	57·1	
5.30	303	125	37880	50·8	57·7	57·83
5.45	300	125	37500	50·3	57·1	
6.00	300	125	37500	50·3	57·1	
6.15	300	125	37500	50·3	57·1	
6.30	300	125	37500	50·3	57·1	57·24
6.45	300	125	37500	50·3	57·1	
7.00	301	126	37930	50·8	57·8	
7.15	300	125	37500	50·3	57·1	
7.30	300	125	37500	50·3	57·1	57·16
7.45	298	125	37250	49·9	56·7	
8.00	300	125	37500	50·3	57·1	
8.15	305	127	38740	51·9	59·0	
8·30	301	126	37930	50·8	57·9	57·98
8.45	301	126	37930	50·8	57·9	
9.00	305	125	38130	51·1	58·1	
9.15	305	127	38740	51·9	59·0	
9.30	305	126	38430	51·5	58·5	58·91
9.45	308	127	39120	52·4	59·6	
10.00	307	127	38990	52·3	59·4	
Average.....	302·8	125·8	38073	51·0	58·0	

Test No. 3, March 2, 1910.

During this trial, the producer was only poked and cleaned at the beginning and end. Water was introduced in the same manner as in the preceding trial. The producer was charged whenever the fuel dropped to a certain level in the hoppers; and since the times of charging happened to fall at irregular intervals, the hourly amounts were calculated so that the fuel consumption per B. H. P. hour, for every hour, could be determined. By consulting Table III, it will be seen that the consumption of fuel per B. H. P. hour, for the last five hours, is very uniform; which indicates the uniform operation of the producer after the fifth hour. The irregularity of fuel consumption during the first five hours was probably due to the fact that the producer was not properly cleaned of clinkers produced during the previous days' run. These, after being released from the walls of the producer, dropped to the bottom, and were softened sufficiently by the moisture introduced through the fire doors to cause no further interference in the uniform feeding of the peat coke from the upper to the lower zone.

No trouble was caused by tar at the engine, and the trial, generally, was very satisfactory.

SUMMARY OF RESULTS.

Fires cleaned, ashes removed, and hoppers filled....	8.00 a.m.
Test started....................................	8.00 a.m.
“ terminated....................................	6.00 p.m.
Duration of test................................	10 hrs.
Average volts...................................	126
“ amperes.......................................	323
“ watts delivered at switchboard................	40590
“ B. H. P. developed at engine..................	61·8
Moisture content of fuel........................	13%
Ash “ “	10%
Calorific value of dry fuel.....................	8650 B. T. U. per lb.
Fuel consumption per hour, as fired.............	123·4 lbs.
“ “ “ calculated dry........	107·4 “
“ “ B.H.P. hour as fired........	1·99 “
“ “ “ calculated dry...	1·73 “
Speed of gas engine.............................	200 R. P. M.

TABLE VII.

Test No. 3, March 2, 1910.

SWITCHBOARD OBSERVATIONS. CALCULATED WATTS, ELECTRIC H.P. AND B.H.P.

Time of Obs't.	Amperes.	Volts.	Watts.	H. P. of switchboard.	B.H.P. at Engine	B.H.P. hourly average	Time of charging fuel.	Lbs. of Peat charged.	Calculated Hourly Consumption.	FuelConsumption per B.H.P. hour. lbs.
a.m.							a.m.			
8.00	305	127	38740	51·9	59·0		8.00	Filled		
8.15	315	127	40000	53·6	60·9	59·8			145	2·43
8.30	312	125	39000	52·3	59·4					
8.45	310	125	38750	51·9	59·0					
9.00	316	126	39820	53·4	60·6		9.15	167		
9.15	310	127	39370	52·8	60·0	59·7			110	1·84
9.30	310	125	38750	51·9	59·0					
9.45	310	126	39060	52·3	59·5					
10.00	310	126	39060	52·3	59·5					
10.15	310	126	39060	52·3	59·5	59·6			70	1·17
10.30	305	126	38430	51·5	58·5					
10.45	315	126	39690	52·2	59·3		10.55	174		
11.00	320	126	40320	54·0	61·4					
11.15	320	126	40320	54·0	61·4	61·4			150	2·44
11.30	318	126	40070	53·7	61·0					
11.45	320	126	40320	54·0	61·4					
12.00	325	125	40630	54·4	61·9		p.m.			
p.m.										
12.15	328	125	41000	54·9	62·4	62·4	12.16	173	171	2·74
12.30	325	125	40630	54·4	61·9					
12.45	331	125	41380	55·4	63·0					
1.00	330	125	41250	55·3	62·8					
1.15	335	125	41880	56·1	63·8	62·9	1.15	167	120	1·81
1.30	830	125	41250	55·3	62·8					
1.45	330	125	41250	55·3	62·8					
2.00	328	125	41000	54·9	62·4					
2.15	333	125	41630	55·8	63·4	63·3			115	1·81
2.30	332	125	41500	55·6	63·2					
2.45	334	125	41750	56·0	63·6		2.44	164		
3.00	335	125	41880	56·1	63·8					
3.15	335	125	41880	56·1	63·8	63·7			120	1·88
3.30	338	125	42250	56·6	64·3					
3.45	335	126	42210	56·6	64·3					
4.00	326	126	41080	55·1	62·6					
4.15	332	126	41830	56·1	63·7	62·8	4.13	176	115	1·83
4.30	322	126	40570	54·4	61·8					
4.45	329	125	41130	55·1	62·6					
5.00	329	126	41450	55·6	63·1					
5.15	318	125	39750	53·3	60·5	62·6			118	1·89
5.30	322	126	40570	54·4	61·8					
5.45	328	126	41330	55·4	62·9					
6.00	337	126	42460	56·9	64·7		6.00	213		
Av' e	323·2	125·6	40592	54·4	61·8					
Totals							10 hrs.	1234	123·4	1·99

TESTS MADE WITH THE PEAT MANUFACTURED AT THE GOVERNMENT PEAT BOG.

After the completion of the chemical laboratory, tests were begun with the peat manufactured at the Government peat plant at Alfred. Before beginning these tests, considerable time was spent in ascertaining the size to which the peat should be crushed, in order to obtain the best results in the producer. This is explained on page 14. It was found that peat containing 30 per cent of moisture should be crushed to about the size of a hen's egg; while for peat containing less moisture, larger sizes may be used, although the smaller sizes offer no difficulties to the operation of the producer—regardless of the moisture content.

The crushing is accomplished by a modified stone pulverizer. This, in its original form, consisted of two spiral corrugated steel rolls of about 6″ diamater, × 2 feet long, driven, by hand, through a system of cog wheels. The maximum clearance that could be obtained was only 1″; which crushed the peat too small. Moreover, the corrugations were only about ⅛″ deep, so that the rolls failed to grip the peat. The original rolls—which could not be adapted to this class of crushing—were replaced by two cast iron rolls, provided with spikes about 1½″ long. These proved to be both satisfactory and inexpensive. The crusher is driven by a 5 H. P. D. C. motor, which happened to be on hand. The power furnished by this motor is altogether too high, a 2 H. P. motor being sufficiently powerful to do the work. The considerable amount of fines which resulted from the crushing caused no trouble whatever in the operation of the producer. This was conclusively proved by the experiments carried out with screened peat, and also with the peat mixed with fines just as it left the crusher.

Several tests have been made with this peat, five of which are here recorded, namely, one 30 hour continuous test at full load, and four ten hour tests at full, three-fourths, one-half, and one-fourth loads.

All the chemical tests in connexion with this work, were conducted under the direction of Edgar Stansfield, M. Sc., who has charge of the Chemical Laboratory of the Fuel Testing Plant. During two of these tests assistance was rendered by Mr. M. F. Connor, of the Mines Branch chemical staff.

The following is a table of the analysis of fuels used in the producer trials:—

TABLE VIII.

ANALYSIS OF FUELS USED IN PRODUCER TRIALS.

Description of fuel....	PEAT FROM ALFRED									
Producer used.........	KÖRTING.									
Date of sampling	1910 Nov. 14	Dec. 1	Dec. 6-7	Dec. 23	1911 Jan. 12	Feb. 8	Mar. 16	Mar. 17	Mar. 18	Mar. 21
Sample marks....	28	32	38	40	57	69	73	74	75	76
NOTES.			30 hour test		10 hour test		10 hour test at $\frac{3}{4}$ load	10 hour test at $\frac{1}{2}$ load	10 hour test at full load	10 hour test at $\frac{1}{4}$ load
Moisture of peat as fired......	36·6	30·0	29·3	38·2	30·6	35·0	33·3	31·8	35·0	37·5
Proximate analysis of dry fuel... Fixed carbon (by difference) %	....	....	30·0	....	30·2	....	30·7	30·9	30·9	31·2
Volatile Matter %	....	....	64·0	....	63·9	....	62·9	63·1	63·0	62·8
Ash.....%	....	....	6·0	....	5·9	....	6·4	6·0	6·1	6·0
Calorific value of dry fuel B.T.U. per lb.....	....	....	9470	....	9440	....	9440	9460	9500	9460

Average analysis of dry peat from above 5 analyses:	Fixed carbon............	30·8%
	Volatile matter.........	63·1%
	Ash......................	6·1%
	Calorific value..........	9460 B.T.U. per lb.
Ultimate analysis of sample No. 74:	Carbon.................	56·0%
	Hydrogen..............	5·2%
	Ash.....................	6·0%
	Oxygen, nitrogen, and sulphur (by difference)...	32·8%

Trial No. 4, December 6-7, 1910.

During this trial the producer and engine were operated continuously at full load for a period of 30 hours, for the purpose of determining the fuel consumption per brake horse-power hour; the uniformity of the gas; the water consumption for cooling purposes; and the behaviour of the plant in general, during a period of that duration.

Previous to this trial the producer had been standing idle for some time, consequently was comparatively cold when the trial commenced. No pyrometer measurements were made of the gas in the offtakes, hence the rise in temperature of the gas, and the interior of the producer cannot, fortunately, be shown.

During the first ten hours considerable tar was carried past the cleaning system into the mixing and admission valves, and into the cylinder of the engine; but, owing to one of the properties of peat tar—especially of the tar resulting from the distillation of peat at low temperatures, namely, its complete solution in a mixture of oil soap and water—no trouble was experienced which necessitated a reduction of the load. During the remainder of the test the condition of the producer steadily improved, and the operation of the plant throughout the last ten hours was satisfactory; with the exception of the accumulation of tar on the valve seat and spindle of the gas admission valve which caused some sticking. To overcome this, a mixture of oil soap and water was dropped on the valve-spindle. At the termination of the trial the producer was in excellent condition, and the gas contained but little tar. Under these conditions, the plant could have been operated continuously for almost any period.

Table IX, contains all the principal data of the test, an inspection of which will show the uniformity of the gas in composition and in calorific value. The lowest heating values always occurred immediately after poking; but, with very few exceptions, the heating value of the gas never dropped low enough to necessitate a change in the proportion of the mixture of gas and air.

The fuel consumption in pounds per B. H. P. hour is calculated for peat containing 25 per cent moisture, and also for dry peat.

The amounts of water used for cooling the engine and for the cleaning system, calculated per B. H. P. hour, are very low, and, therefore, satisfactory.

The following is a summary of the results of this test:—

Fires cleaned, ashes removed, and hoppers filled....	11.00 a.m. Dec. 6.
Trial started	11.00 “
“ terminated	5.00 p.m. Dec. 7.
Duration of test	30 hrs.
Average volts	109
“ amperes	350
“ watts delivered at switchboard	38200
“ H. P.delivered at switchboard	51·2
“ B. H. P. developed at engine	58·2
Moisture content of fuel	29·3%
Ash in dry fuel	6·0%
Calorific value of dry fuel	9470 B.T.U. per lb.
Total fuel fired	4900 lbs.
Fuel consumption per hour	163 “
“ “ B.H.P. hour as fired	2·81 lbs.
“ “ “ calculated to 25% moisture	2·65 “
“ “ “ calculated dry	1·98 “
Water consumption per B.H.P. hour producer	2·61 gals.
“ “ “ engine	2·14 “
Speed of engine	200 R. P. M.

Trials Nos. 5, 6, 7, and 8.

These tests, run at three-fourths, one-half, one-fourth, and full loads, respectively, were made for the purpose of determining the fuel consumption per B. H. P. hour at these respective loads, and the load at which the producer operated the most satisfactorily. During these tests, with the exception of the one run at one-fourth load, the gas was sampled and analysed every hour. The fuel consumption was determined for every hour, and the temperature of the gas in the offtake observed every fifteen minutes. From this data, and the switchboard observations, were calculated the E. H. P., and the average B. H. P. developed at the engine during each hour; the composition and calorific value of the gas, the temperature of the gas, in the offtake, and the fuel consumption per hour per B. H. P. For all of these tests, the water used in the producer cleaning system and for cooling the engine, was measured. Tables V, VI, VII, and VIII, show the results of the test in detail; while Charts 1, 2, 3, and 4, show the same results graphically.

The average results of the four tests are shown graphically on Chart No. 5.

On this chart the average temperatures in degrees Fahrenheit; the average fuel consumption per B. H. P. hour; heat units in the gas, and the water consumption in gallons per B. H. P. hour—for both the producer and engine—are plotted as ordinates on a base line or abscissa, which, in this case, represents the respective B. H. powers developed during the four tests. The chart is self-explanatory.

The summary of the four tests gives the total averages of all the important items.

Test No. 5, made at 89 per cent full load, was intended to be run at exactly three-fourths load, but during this test it was found necessary to furnish the required power to drive the machinery of the ore concentrating laboratory; which made it impossible to carry a load at the engine precisely equal to three-fourths of the full load rating. Previous to this trial, the producer had been standing practically idle for some time, and, consequently, was not in a hot enough condition to operate at its best. It may be said in passing, that the producer cannot be brought to the proper condition as regards internal temperature conditions, i.e., temperatures of the lining, etc.—which, of course, affects the uniform combustion of the fuel—in a few hours' run.

To obtain the best and most efficient operation of this producer, as well as any other producer, and form a gas as free as possible from tar, the producer should be operated more or less continuously for ten hours during the working days; but such operation is impossible at the Fuel Testing Plant, and since the producer, before starting the engine, is exhausted for only a short period by means of a small fan, driven by a 1 H. P. motor, it is necessary to run the engine, in order to bring the producer into good working condition.

An inspection of Chart No. 1 shows the steady rise in temperature from 320° F. at the beginning of the test, to over 540° F. at the termination. In all the succeeding tests, after the producer had become hot and the temperature conditions more uniform, the high temperature, namely, 540°, was never reached even at full load, when the maximum temperature recorded was only 496° F. This plainly shows that the producer was not at the beginning or termination of Test No. 5 in the best condition for efficient operation.

Test No. 6, at one-half load, was run on March 17, the day following the test at three-fourths load. It will be seen by consulting Chart No.

Table IX.

RESULTS OF OBSERVATIONS.

Calculated Watts, Horse-Power, Fuel Consumption, etc.

Test No. 4, Dec. 6-7, 1910.

Time.	Amperes.	Volts.	Watts.	H. P. delivered at switchboard.	B.H.P. of Engine.	Gas Analysis.										Cal. Value of Gas.		Time of poking Producer.
						No.	Time.	CO_2	O_2	N_2	C_2H_4	CH_4	H_2	CO.	Combustible.	Gross.	Net.	
a.m.							a.m.											
11.00 to 12.00	360	111	39,900	53·5	60·8	1	11.00	8·9	0·9	57·7	0·6	1·9	9·1	20·9	32·5	125	117	12.00
p.m.																		
12.00 to 1.00	365	109	39,960	53·5	60·8	2	Noon. 12.00	10·8	0·5	55·9	0·6	2·3	10·6	19·3	32·8	128	120	
							p.m.											
1.00 to 2.00	363	110	39,790	53·3	60.6	3	1.00	10·8	0·1	57·0	0·3	1·5	10·7	19·6	32·1	117	110	p.m.
2.00 to 3.00	339	111	39,700	50·5	57·4	4	2.00	10·9	0·7	56·5	0·3	1·6	9·7	20·3	31·9	117	110	3.20
3.00 to 4.00	345	108	37,400	50·1	57·0	5	3.00	11·3	0·1	56·8	0·3	1·9	10·4	19·2	31·8	119	111	
4.00 to 5.00	350	107	37,380	50·1	56·9	6	4.10	11·2	0·4	56·4	0·5	1·9	10·2	19·4	32·0	122	114	
5.00 to 6.00	348	108	37,450	50·2	57·0	7	5.05	11·1	1·1	60·9	0·5	1·4	8·1	16·9	26·9	102	96	5·40
6.00 to 7.00	341	109	37,170	49·8	56·6	8	6.00	11·1	0·3	56·1	0·4	2·2	10·6	19·3	32·5	124	116	
7.00 to 8.00	343	110	37,600	50·4	57·3	9	7.35	10·2	0·2	56·6	0·1	1·8	11·3	19·8	33·0	119	112	
8.00 to 9.00	341	110	37,650	50·5	57·3	10	8.30	9·9	0·4	55·7	0·4	1·6	11·2	20·8	34·0	125	117	
9.00 to 10.00	344	110	37,840	50·7	57·6	11	9.15	11·7	0·4	58·3	0·5	2·1	9·6	17·4	29·6	116	108	9.15
10.00 to 11.00	337	109	36,870	49·4	56·1	12	10.00	10·4	0·3	56·1	0·4	1·9	10·4	20·5	33·2	125	117	
11.00 to 12.00	342	108	37,000	49·6	56·4	13	11.00	9·9	0·3	55·7	0·4	2·1	10·2	21·4	34·1	129	121	
						14	12.00	9·3	0·4	56·3	0·5	2·2	9·7	21·6	34·0	130	123	a.m.
a.m.							a.m.											1.00
12.00 to 1.00	350	107	37,440	50·2	57·1													
1.00 to 2.00	350	108	37,780	50·6	57·5	15	1.05	9·4	0·4	55·9	0·4	1·9	10·8	21·4	34·5	129	121	
2.00 to 3·00	350	107	37,380	50·1	56·9	16	2.00	8·6	0·4	57·1	0·3	1·9	9·6	22·1	33·9	125	118	
3.00 to 4.00	356	106	37,800	50·7	57·6	17	3.00	8·7	0·3	57·7	0·3	2·3	8·5	22·2	33·3	126	119	3.30
4.00 to 5.00	359	107	38,480	51·6	58·6	18	4.00	9·0	0·3	56·7	0·4	1·8	9·8	22·0	34·0	126	119	
5.00 to 6.00	362	108	39,090	52·4	59·5	19	5.05	9·3	0·4	56·8	0·3	1·9	9·9	21·4	33·5	124	117	5,40
6.00 to 7.00	354	108	38,370	51·4	58·4	20	6.00	8·9	0·3	57·5	0·3	2·3	8·9	21·8	33·3	126	119	
7.00 to 8.00	345	109	37,670	50·5	57·4	21	7.05	8·8	0·3	56·7	0·4	2·0	9·4	22·4	34·2	128	121	
8.00 to 9.00	343	110	37,660	50·5	57·4	22	8.05	10·5	0·6	58·1	0·4	1·7	8·9	19·8	30·8	116	109	
9.00 to 10.00	344	110	37,860	50·7	57·7	23	9.05	9·9	0·2	58·5	0·7	1·7	8·0	21·0	31·4	121	115	10.20
10.00 to 11.00	350	111	38,750	51·9	59·0	24	10.05	9·1	0·3	59·3	0·3	2·1	9·0	19·9	31·3	119	112	
11.00 to 12.00	351·8	111	39,010	52·3	59·4	25	11.05	8·9	0·1	58·0	0·3	1·8	9·6	21·3	33·0	122	115	
p.m.							p.m.											
12.00 to 1.00	352	111	39,050	52·3	59·5	26	12.05	8·9	0·1	58·0	0·7	3·7	8·3	20·3	33·0	140	131	
1.00 to 2.00	357	110	39,410	52·8	60·0	27	1.10	9·6	0·1	54·5	0·4	2·0	11·0	22·4	35·8	134	126	
2.00 to 3.00	355	110	39,000	52·3	59·4	28	2.05	9·4	0·5	56·3	0·4	2·3	9·9	21·2	33·8	129	121	p.m.
3.00 to 4.00	358	109	38,830	52·0	59·1	29	3.05	8·7	0·1	56·7	0·3	1·7	10·6	21·9	34·5	126	119	
4.00 to 5.00	357	109	38,770	52·0	59·0	30	4.05	11·1	0·2	55·0	0·1	2·4	10·0	21·2	33·7	126	116	5.00
Total ave.	350·4	109	38,202	51·2	58·2			9·9	0·4	56·9	0·4	2·0	9·8	20·6	32·8	124	116	

Water Consumption of Engine, and Producer.		
——	Engine.	Producer.
Gals. for 30 hours.....	3,750	4,563
" per hour........	125	152
" " B.H.P. hour	2·14	2·61
Total fuel fired.................		4,900 lbs.
Average fuel consumption per hour.........................		163 lbs.
Fuel consumption per B.H.P. hour as fired. 29·3% moisture...........................		2·81 lbs.
Fuel consumption per B. H. P. hour calculated for peat containing 25% moisture.........		2·65 lbs.
Fuel consumption per B. H. P. hour calculated for absolutely dry peat......................		1·98 lbs.

2 that the temperature of the gas in the offtake has become very uniform, not reaching during the test a temperature much exceeding 240° F. At this temperature the producer operated most satisfactorily: the gas throughout the entire test being practically free from tar. Moreover, the amount of waste matter passing off with the water in the cleaning system was exceedingly small.

On March 18—the day following the test at one-half load—the test for full-load was run. An inspection of Chart No. 3 will show the temperature conditions prevailing in the gas offtake during this test. At the beginning of the trial the temperature was 380° F. This steadily rose until a temperature of 496° F. was reached, when it steadily dropped to 470° F., which was the temperature at the termination of the trial and for a short time after the test was discontinued. At the termination of this test the producer was in excellent condition. The formation of tar at the final temperature was almost negligible.

Test No. 8—one-fourth load—was run the day following the test at full-load. Chart No. 4 shows the exceedingly low temperature prevailing during this test. The temperature at no time during this run exceeded 155° F., and scarcely varied more than a few degrees from this temperature.

Fuel Consumption.

The fuel consumption for all these tests was most satisfactory, and the hourly rate quite uniform. An inspection of Charts 1, 2, 3, and 4, shows the most noticeable variations to occur at the times of poking the fires of the lower zone.

Composition and Calorific Value of the Gas.

An inspection of the gas analysis in Tables V, VI, VII, and VIII, and the curves representing the calorific values of the gas on Charts 1, 2, 3, and 4, shows that throughout these tests the composition and calorific value of the gas varied but slightly.

The Formation of Tar.

The by-products resulting from the distillation of peat at temperatures obtaining in the producer, consist of heavy and light tars, paraffin-oils, ammonia, etc., and the quantity of such products depends to a very large extent on the moisture content of the peat when fired. As previously explained, most of the heavy tar is condensed and separated in the water cooled pipe which connects the upper and lower zones of the producer. This tar drops into the water seal at the bottom of the pipe, and takes no further part in the formation of the final producer gas.

The remaining by-products—such as lighter tar and paraffin-oils—escape condensation in the water cooled pipe, and pass into the lower zone of the producer. In passing through the hot peat coke—as explained in the foregoing part of this report—some of these light tars and oils interact with carbon, and form permanent gaseous compounds; but the physical and chemical character of a part of these tars and oils is not changed, or at best, very slightly, and they pass with the final producer gas to the cleaning system.

In passing through the coke scrubber, a large amount of the lighter substances is separated out and passes off with the cleaning and cooling water; while a large amount of the products still remaining, is separated out in the tar filter which is continually washed by sprays of hot water. The wet coke scrubber and the tar filter separate the bulk of these products from the gas, and leave it comparatively clean.

According to the temperature conditions obtaining in the producer, and the moisture content of the peat when fired, the gas after it leaves the cleaning system still contains more or less tar carried in a very finely divided state, which gives the gas the appearance of a fog or mist.

It is evident, therefore, that the formation of the final producer gas, or in other words, the gas which leaves the producer, can only be altered by varying either the internal temperature of the producer, or the moisture content of the peat. When the moisture cannot be varied, the temperature can only be increased or decreased by increasing or decreasing the load carried on the engine.

Effect of Temperature on the Formation of Tar.

The temperatures resulting from the different loads carried on the engine during the tests just described are plainly shown on Chart 5. The lowest average temperature occurred in the test of one-fourth load. The peat used during this test contained the highest percentage of moisture, viz., 37·5 per cent; but the tar carried by the gas past the cleaning system was scarcely noticeable, and caused absolutely no inconvenience whatever in the operation of the engine. The distillation products during this test consisted mainly of paraffin-oils; which were either partly separated by the cleaning system before entering the engine, or passed into the engine, there being burned in the combustion chamber along with the permanent gases.

The temperatures prevailing during the one-half and three-fourths loads were considerably higher, while the character of the by-products was noticeably different both physically and chemically, the percentage of light tars being quite predominant. The gas during these two tests was, however, remarkably free from tar.

The greatest amount of tar was formed during the test at full load; the amount of paraffin-oils being comparatively very small. The average temperature during this trial was higher than that obtained during any of the former trials at lower loads.

The tar carried past the cleaning system was, however, at no time serious. The load during this trial was not reduced; and only twice during the ten hours was the piston sprayed with a mixture of oil-soap and water. This occurred during the first two or three hours of the run, after which the gas continually improved up to the end of the run, when the conditions were quite satisfactory.

The colour of the by-products—which are separated out in the cleaning system—varies from a light yellow to a deep dark brown, which at times is almost black, and rapidly changes from the one to the other as the temperature conditions vary in the producer. From experience it has been learned that the light yellow colour of the by-products generally indicates the proper working of the producer, while the darker by-products indicate the opposite.

Effect of Moisture Content of the Peat on the Formation of Tar.

When the percentage of moisture contained in the peat is high, the heavy tar resulting from the distillation carried on in the upper zone of the producer, condenses in very large amounts on the walls of the gas chamber leading to the water cooled pipe, and also in the water cooled pipe itself. When the moisture content of the peat is much in excess of 40 per cent, the tar during a run will often completely choke the above chamber, and the damper boxes on the top end of the pipe. And, when the peat contains moisture much in excess of this amount, the tar produced is

Table X.

RESULTS OF OBSERVATIONS.

Calculated Watts, Horse-Power, Fuel Consumption, etc.

Test No. 5. March 16 = ¾ Load.

Time of taking observations.	Amperes.	Volts.	Watts.	Kilowatts.	H.P. at switchboard.	B.H.P. developed at engine.	Gas Analysis.										Cal. Val. of Gas.		Temperature of gas in offtake.	Fuel consumption per hour.	Fuel consumption per B.H.P.H.	Water Consumption of Engine and Producer.		
							No. of Sample.	Time of taking Sample.	CO_2.	O_2.	N_2.	C_2H_4.	CH_4.	H_2.	CO.	Combustible.	Gross.	Net.				——	Engine.	Producer.
a.m.								a.m.	%	%	%	%	%	%	%				F.	Lbs.				
8.30 to 9.30	314	115	36,160	36·1	48·5	55·1	1	9.30	6·8	1·5	57·5	0·4	1·2	11·2	21·4	34·7	123	116	320	165	3·00	Gals. for 10 hours.....	112·5	3187
9.30 " 10.30	314	111	34,900	34·9	46·8	53·2	2	10·35	7·0	2·2	62·1	0·2	3·4	5·7	19·4	28·7	118	111	332	150	2·82	" per hour.........	112·5	318·7
10.30 " 11.30	309	112	34,590	34·6	46·4	52·7	3	11.35	7·5	1·9	62·0	0·4	2·5	6·7	19·0	28·6	114	107	350	200	3·79	" per B.H.P. hour.	2·1	5·9
p.m.								p.m.																
11.30 " 12.30	305	113	34,350	34·3	46·0	52·3	4	12.35	8·6	0·3	60·8	0·2	4·7	5·8	19·6	30·3	132	124	350	130	2·48			
12.30 " 1.30	304	114	34,490	34·5	46·2	52·5	5	1.40	9·4	0·5	55·8	0·5	1·9	10·9	21·0	34·3	129	121	413	150	2·85			
1.30 " 2.30	300	117	34,950	34·9	46·8	53·2	6	2.30	11·4	0·7	57·3	0·3	2·7	8·2	19·4	30·6	120	113	458	150	2·81			
2.30 " 3.30	299	118	35,140	35·1	47·1	53·5	7	3.30	10·0	0·5	58·8	0·2	3·7	6·3	20·5	30·7	126	119	491	190	3·55			
3.30 " 4.30	299	119	35,510	35·5	47·6	54·1	8	4.30	9·6	0·1	56·8	0·6	3·2	8·8	20·9	33·5	137	128	503	140	2·58			
4·30 " 5.30	301	120	36,150	36·2	48·5	55·1	9	5.30	9·7	0·5	55·8	0·2	3·0	10·6	20·2	34·0	132	123	532	135	2·45			
5.30 " 6.30	297	120	35,520	35·5	47·6	54·1	10..	....	.....	....	......	......	......	......	....	....	....	......	548	170	3·14			
	304	116	35,176	35·16	47·15	53·58			8·8	0·9	58·5	0·3	2·9	8·3	20·2	31·7	125·8	118	430	158	2·95			

of so large an amount as to make the successful operation of the plant under the present conditions, impossible.

Since the plant operates satisfactorily at low loads when the moisture content of the peat is high, it would appear that to operate satisfactorily at high or full loads, with such peat, the capacity of the producer would have to be considerably increased. When operating with peat containing from 25 to 30 per cent moisture, no difficulties are met with when running at loads varying from 0 to full.

In conclusion, it may be stated that a peat gas power plant can be operated continuously under adverse conditions regarding tar without any serious degree of trouble. The main trouble is caused by the deposition of tar on the rings of the piston, and the deposit of carbonized tar at the back of the cylinder. In any case the piston, as well as the back of the cylinder, can be easily and entirely cleaned by injecting into the open end of the cylinder a mixture of oil, soap, and water. This completely dissolves the tar, which is then thrown out by the forward stroke of the piston. Such an operation consumes very little time, and may be resorted to while the engine is in operation without in any way injuring it.

This method of cleaning, however, is always a dirty operation, and the plant should be so improved, that this work could be dispensed with.

The peat gas power plant has a distinct advantage over one utilizing bituminous coal. In the latter case, the accumulation of tar in the valves and cylinder is likely—if deposited in large amounts—to result most seriously, necessitating the shutting down of the engine, removal of the piston, and complete cleaning of the engine; since the cylinder and piston cannot be cleaned by washing with a mixture of oil, soap, and water. When this method of cleaning is tried, the oily matter of the coal tar is dissolved out, leaving behind a stiff sticky mass, somewhat of the nature of pitch, which holds the piston and piston rings so tightly as to make their removal almost impossible. This cleansing, if resorted to while the engine is running, would, probably, result in an accident caused by the 'seizing' of the piston.

Stand-by Loss.

The fuel consumed, while the producer stands idle, has been determined for a period extending over several months. The average consumption has been found to be between 2 and 3 lbs. per hour when the producer stands overnight, and between 1 and 2 lbs. per hour, for longer periods: three days or more.

When preparing the producer for the night, the damper in the waste pipe is not entirely closed, nor are the air flues on the doors of the ash pits of the upper and lower zones; as a consequence, when the weather conditions change during this period, the consumption of fuel is increased or decreased depending upon the increase or decrease in the strength of the wind.

When standing idle for considerably longer periods, the producer can be almost entirely closed, admitting only sufficient air to maintain a small amount of combustion. The damper in the waste pipe must, in any case, always be left slightly open, to allow the gases and smoke resulting from combustion to escape. In this case, the fires of the upper zone are liable to go out, and will have to be relighted when the producer is started again.

Chart Nº 1

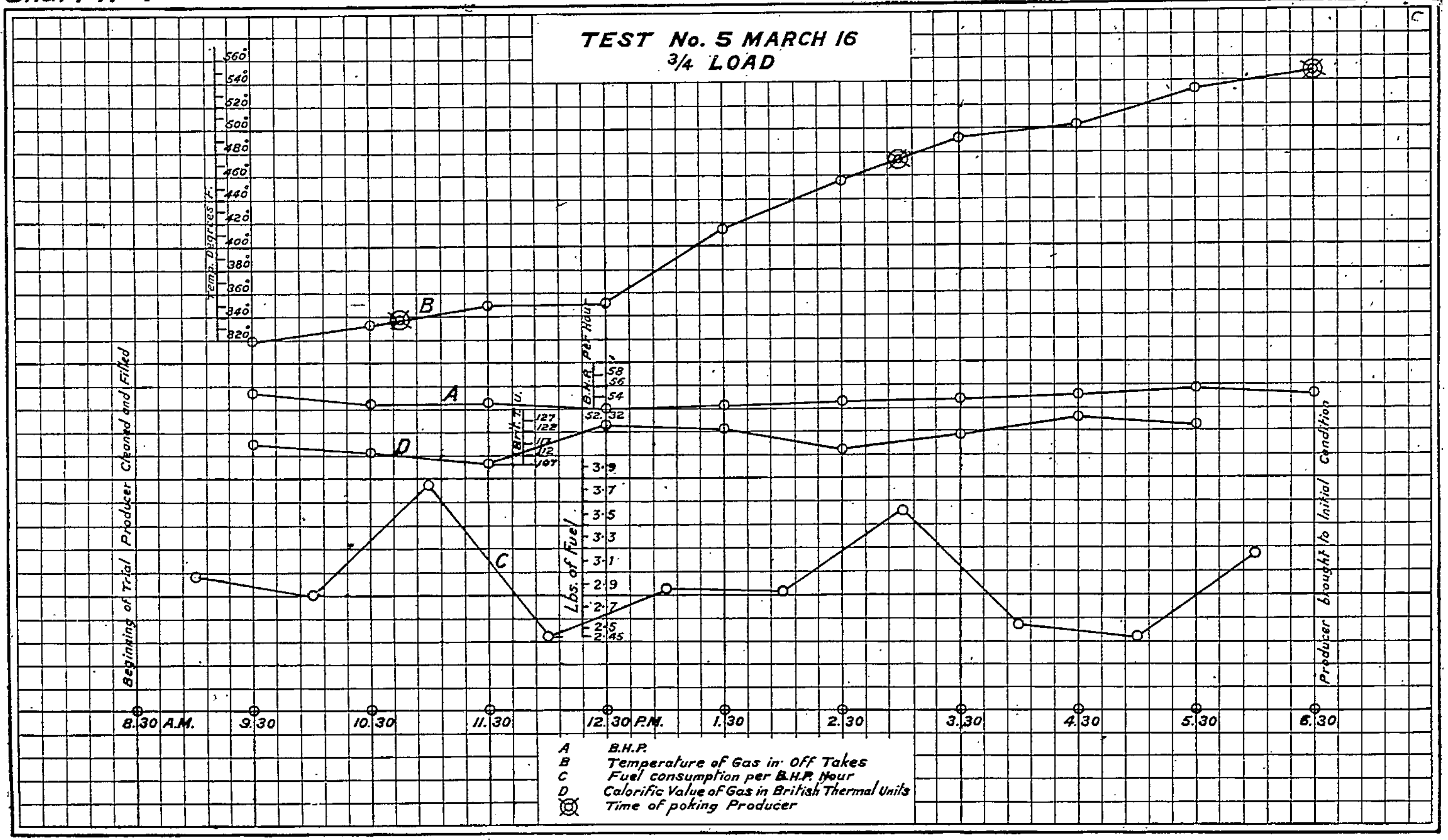

TEST No. 5 MARCH 16
3/4 LOAD
Temp. Degrees F.
560°
540°
520°
500°
480°
460°
440°
420°
400°
380°
360°
340°
320°
B
B.H.P. per Hour
58
56
54
52.32
A
B.T.U.
127
122
117
112
107
D
Lbs. of Fuel
3·9
3·7
3·5
3·3
3·1
2·9
2·7
2·5
2·45
C
Beginning of Trial Producer Cleaned and Filled
Producer brought to Initial Condition
8.30 A.M.
9.30
10.30
11.30
12.30 P.M.
1.30
2.30
3.30
4.30
5.30
6.30
A B.H.P.
B Temperature of Gas in Off Takes
C Fuel consumption per B.H.P. Hour
D Calorific Value of Gas in British Thermal Units
Time of poking Producer

TABLE XI.

RESULTS OF OBSERVATIONS.

CALCULATED WATTS, HORSE-POWER, FUEL CONSUMPTION, ETC.

TEST No. 6. March 17 — ½ Load.

Time of taking observations.	Amperes.	Volts.	Watts.	Kilowatts.	H. P. at switchboard.	B.H.P. developed at engine.	No. of Sample.	Time of taking Sample.	CO_2.	O_2.	N_2.	C_2H_4.	CH_4.	H_2.	CO	Combustible	Cal. Val. of Gas.		Temperature of gas in offtake.	Fuel Consumption per hour.	Fuel Consumption per B.H.P.
																	Gross	Net.			
a.m.								a.m.	%	%	%	%	%						°F.	Lbs.	
8.00 to 9.00	210	118	24,730	24·7	33·1	37·7	1													100	2·66
9.00 “10.00	198	111	21,970	22·0	29·4	33·5	2	10.00	8·00	0·3	57·8	0·2	3·2	8·5	22·0	33·9	133	125	212	100	2·99
10.00 “11.00	187	111	20,810	20·8	27·9	31·7	3	11.00	7·60	0·4	58·6	0·3	3·0	7·8	22·3	33·4	131	124	224	130	4·10
11.00 “12.00	190	110	20,910	20·9	28·0	31·8	4	12.00	8·30	0·3	59·7	0·2	2·5	7·7	21·3	31·7	121	114	230	80	2·51
p.m.								p.m.													
12.00 “ 1.00	190	111	21,090	21·1	28·3	32·1	5	1.00	8·10	0·4	59·3	0·4	3·1	7·3	21·4	32·2	129	122	224	175	5·45
1.00 “ 2.00	193	111	21,270	21·3	28·5	32·4	6	2.10	8·30	0·2	58·9	0·2	3·0	7·7	21·7	32·6	127	120	230	90	2·77
2.00 “ 3.00	190	111	21,020	21·0	28·2	32·0	7	3.00	7·00	0·5	60·5	0·0	3·9	5·4	22·7	32·0	129	122	245	95	2·97
3.00 “ 4.00	191	111	21,300	21·3	28·5	32·4	8	4.00	7·70	0·3	58·8	0·2	4·0	7·0	22·0	33·2	136	128	245	100	3·08
4.00 “ 5.00	191	111	21,170	21·2	28·4	32·2	9	5.00	7·70	0·5	60·6	0·5	2·9	6·6	21·2	31·2	126	119	240	90	2·79
5.00 “ 6.00	188	111	20,830	20·8	27·9	31·7	10	.....	......	....	......	......	.....	......	......	....	......	......	235	100	3·15
Total average.	193	112	21,511	21·5	28·8	32·75			7·8	0·4	59·3	0·3	3·2	7·2	21·8	32·5	129	122	232	106	3·25

WATER CONSUMPTION OF ENGINE AND PRODUCER.		
——	Engine.	Producer.
Gals. per 10 hours.....	875·00	3,375·00
“ per hour........	87·50	337·50
“ per B.H.P. hour	2·60	10·31

Chart No 2

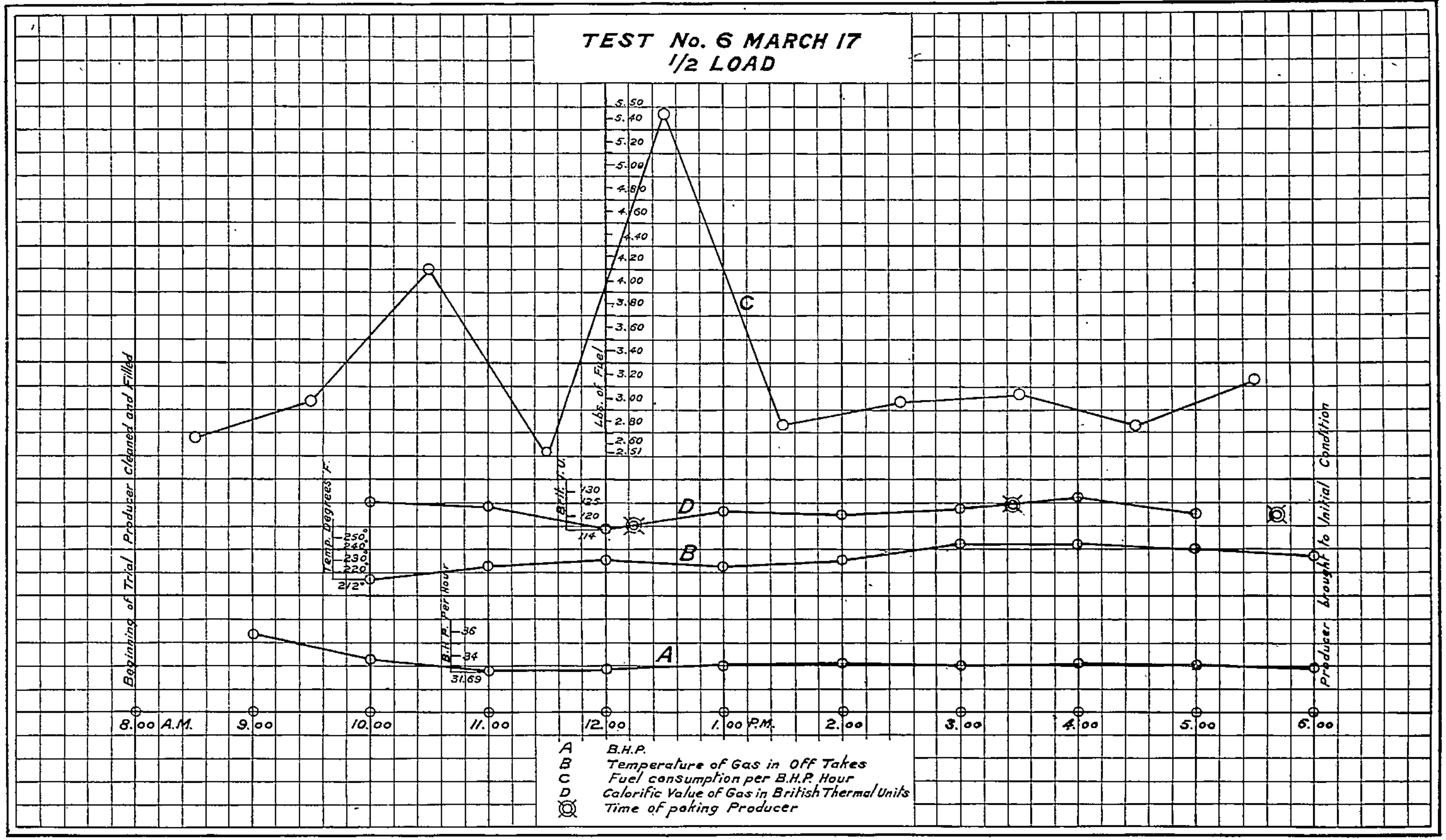

TEST No. 6 MARCH 17
1/2 LOAD
Beginning of Trial Producer cleaned and Filled
Producer brought to Initial Condition
Lbs. of Fuel
5.50
5.40
5.20
5.00
4.80
4.60
4.40
4.20
4.00
3.80
3.60
3.40
3.20
3.00
2.80
2.60
2.51
Brit. T.U.
130
125
120
114
Temp. Degrees F.
250°
240°
230°
220°
212°
B.H.P. Per Hour
36
34
31.69
A
B
C
D
8.00 A.M.
9.00
10.00
11.00
12.00
1.00 P.M.
2.00
3.00
4.00
5.00
6.00
A B.H.P.
B Temperature of Gas in Off Takes
C Fuel consumption per B.H.P. Hour
D Calorific Value of Gas in British Thermal Units
Time of poking Producer

Chart No 3

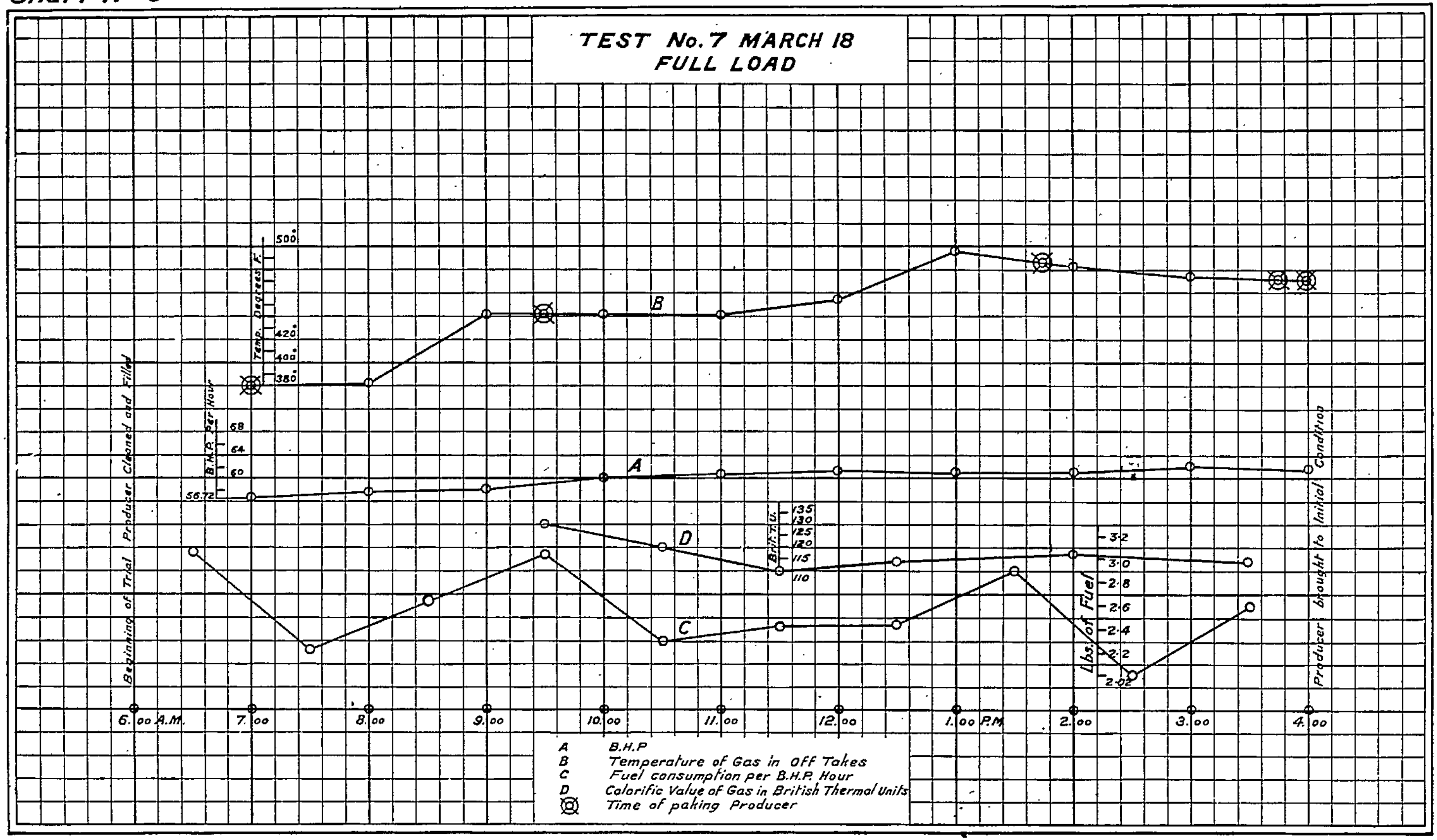

TEST No. 7 MARCH 18
FULL LOAD
Temp. Degrees F.
500°
420°
400°
380°
B.H.P. Per Hour
68
64
60
56.72
Brit. T.U.
135
130
125
120
115
110
Lbs. of Fuel
3.2
3.0
2.8
2.6
2.4
2.2
2.02
A
B
C
D
Beginning of Trial Producer Cleaned and Filled
Producer brought to Initial Condition
6.00 A.M.
7.00
8.00
9.00
10.00
11.00
12.00
1.00 P.M.
2.00
3.00
4.00
A B.H.P
B Temperature of Gas in Off Takes
C Fuel consumption per B.H.P. Hour
D Calorific Value of Gas in British Thermal Units
Time of poking Producer

TABLE XII.

RESULTS OF OBSERVATIONS.

CALCULATED WATTS, HORSE-POWERS, FUEL CONSUMPTION, ETC.

TEST NO. 7. MARCH 18—FULL LOAD.

Time.	Amperes.	Volts.	Watts.	Kilowatts.	H. P. at swichboard.	B. H. P. at engine.	Gas Analysis.										Cal. Val. Gas.		Fuel used per hour.	Fuel used per B.H.P.H.	Temperature gas in offtake.
							No. of Sample	Time of Sampling.	CO_2	O_2	N_2	C_2H_4	CH_4	H_2.	CO.	Combustible.	Gross.	Net.			
a.m.								a.m.	%	%	%	%	%	%	%	%					°F.
6.00 to 7.00	308	121	37,240	37·2	49·9	56·7													175	3·08	380
7.00 " 8.00	308	123	37,930	37·9	50·8	57·8													130	2·24	383
8.00 " 9.00	309	123	38,090	38·1	51·0	58·0	1	9.35	9·3	1·0	57·2	1·4	2·4	9·1	19·6	32·5	138	130	160	2·76	442
9.00 " 10.00	323	123	39,660	39·7	53·2	60·4	2	10.30	10·5	0·4	57·4	0·5	3·4	6·7	20·1	30·7	128	120	185	3·06	442
10.00 " 11.00	323	123	39,790	39·8	53·3	60·6	3	11.30	9·8	0·6	56·4	0·3	0·9	9·5	22·5	33·2	116	110	140	2·31	442
11.00 " 12.00	324	125	40,470	40·5	54·2	61·6													150	2·43	455
p.m.								p.m.													
							4	12.30	9·0	0·5	58·3	0·5	2·1	8·2	20·4	31·2	121	114			
12.00 " 1.00	324	125	40,310	40·3	54·0	61·4	......	......	......	......	......	......	......	......	......	......	......	......	150	2·44	496
1.00 " 2.00	328	123	40,280	40·3	54·0	61·3	5	2.00	9·9	0·2	58·0	0·5	2·3	8·1	21·0	31·9	124	117	180	2·93	482
2.00 " 3.00	328	124	40,690	40·7	54·5	62·0	6	3·30	10·2	0·7	58·5	0·5	2·5	8·5	19·1	30·6	122	114	125	2·02	475
3.00 " 4.00	329	123	40,393	40·4	54·1	61·5	......	......	......	......	......	......	......	......	......	......	......	......	160	2·60	470
Average.......	320	123	39,480	39·5	52·9	60·1			9·8	0·5	57·6	0·6	2·3	8·3	20·5	31·7	125	117·5	155·5	2·59	447

Water Consumption of Engine and Producer.		
	Engine.	Producer.
Gals. for 10 hrs....	1,250	3,000
" per hour......	125	300
" per B.H.P.H	2·08	4·98

TABLE XIII.

RESULTS OF OBSERVATIONS.

CALCULATED WATTS, HORSE-POWER, FUEL CONSUMPTION, ETC.

TEST NO. 8. MARCH 21—¼ LOAD.

Time.	Amperes.	Volts.	Watts.	Kilo-watts.	H. P. of switch-board.	B. H. P. of Engine.	Fuel used per hour. lbs.	Fuel used per B.H.P.H. lbs.	Temperature of gas in offtake. °F.	WATER CONSUMPTION OF ENGINE AND PRODUCER.		
										—	Engine.	Producer
a.m.												
8.00 to 9.00	148	112	16,450	16·45	22·0	25·0	90	3·59	....	Gals. for 10 hrs.........	875	2,687
9.00 " 10.00	90	107	9,640	9·64	12·9	14·7	100	6·81	152	" per hour..........	87·5	268·7
10.00 " 11.00	93	107	9,990	9·99	13·4	15·2	90	5·92	155	" per B.H.P.H.....	5·4	16·6
11.00 " 12.00	95	106	10,100	10·11	13·5	15·4	100	6·50	154			
p.m.												
12.00 " 1.00	94	107	10,020	10·02	13·4	15·3	100	6·55	153			
1.00 " 2.00	91	107	9,740	9·74	13·0	14·8	120	8·09	154			
2.00 " 3.00	93	106	9,870	9·87	13·2	15·0	85	5·65	142			
3.00 " 4.00	94	107	10,130	10·12	13·6	15·4	100	6·48	148			
4.00 " 5.00	94	107	9,980	9·98	13·4	15·2	80	5·26	153			
5.00 " 6.00	94	108	10,080	10·08	13·5	15·4	100	6·51	146			
Average	98	107	10,600	10·60	14·2	16·1	96·5	6·14	151			

Chart No 4

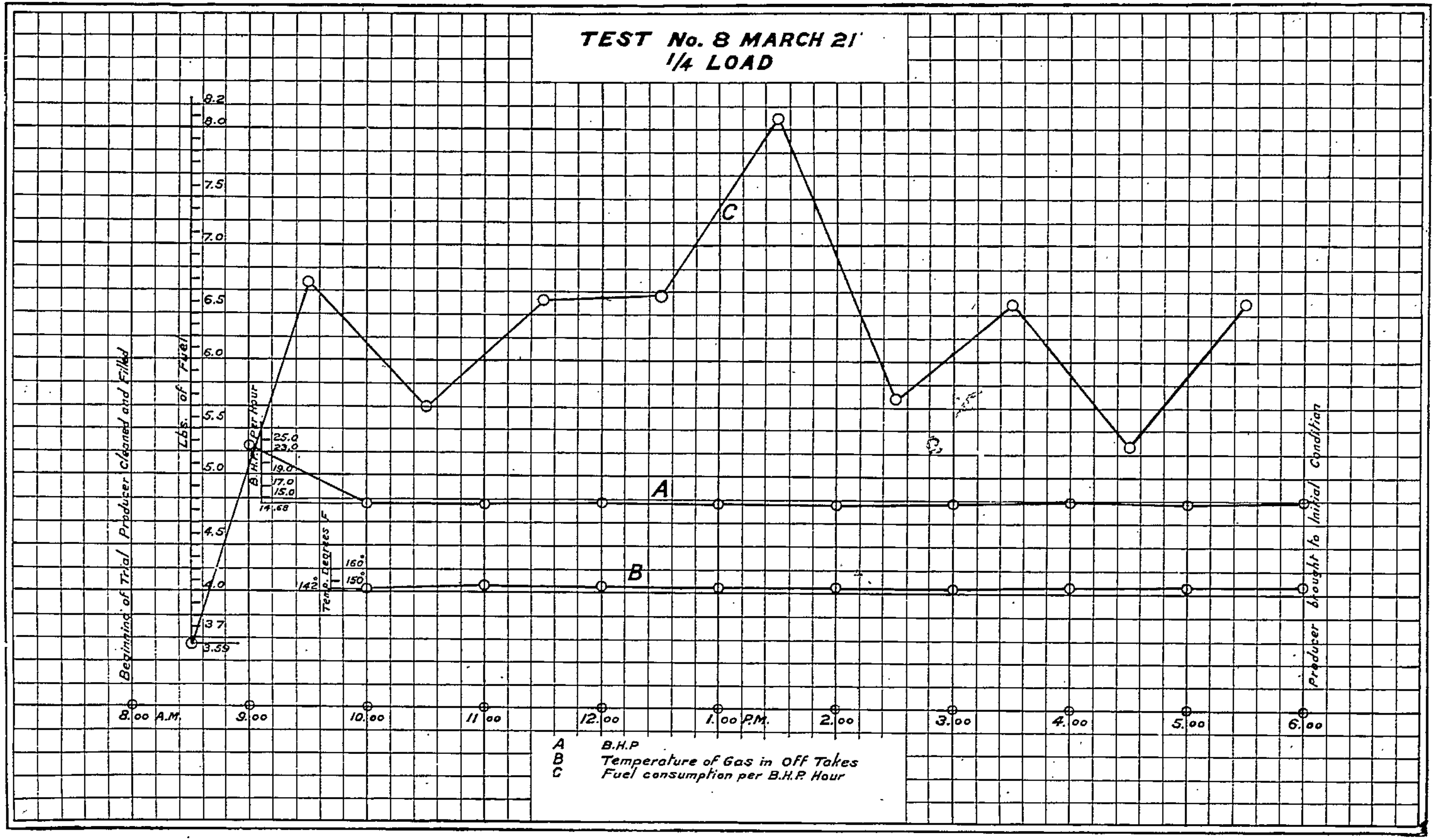

TEST No. 8 MARCH 21'
1/4 LOAD
8.2
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.7
3.59
Lbs. of Fuel
B.H.P. per Hour
25.0
23.0
19.0
17.0
15.0
14.68
Temp. Degrees F
160°
150°
142°
Beginning of Trial Producer Cleaned and Filled
Producer brought to Initial Condition
C
A
B
8.00 A.M.
9.00
10.00
11.00
12.00
1.00 P.M.
2.00
3.00
4.00
5.00
6.00
A B.H.P.
B Temperature of Gas in Off Takes
C Fuel consumption per B.H.P. Hour

TABLE XIV.

SUMMARY OF THE RESULTS OF TESTS NOS. 5, 6, 7, AND 8.

Loads carried on engine	¼	½	¾	Full
Fires cleaned, ashes removed, and hoppers filled	8.00 a.m.	8.00 a.m.	8.30 a.m.	6.00 a.m.
Test started	8.00 "	8.00 "	8.30 "	6.00 "
" terminated	6.00 p.m.	6.00 p.m.	6.30 p.m.	4.00 p.m.
Duration of test, hours	10	10	10	10
Average volts	107·4	111·6	115·7	123·3
" amperes	98·5	192·6	304·1	320·2
" Watts at switchboard	106·00	215·10	351·80	39490
" H.P. at switchboard	14·2	28·8	47·1	52·9
" B.H.P. developed at engine	16·1	32·7	53·6	60·1
" moisture content of fuel, %	37·5	31·8	33·3	35·0
Ash in dry fuel, %	6·0	·6	6·4	6·1
Calorific value of dry fuel, B.T. units per lb	94·60	94·60	94·40	950·0
Total fuel fired, lbs	96·5	10·60	15·80	155·5
Average fuel consumption per hour, lbs	96·5	10·6	1·58	155·5
" " " B.H.P. hour as fired, lbs	6·14	3·25	2·95	2·59
" " " B.H.P. hour as calculated to 25% moisture, lbs	5·12	2·95	2·62	2·24
" " " B.H.P. hour as calculated dry lbs	3·84	2·22	1·97	1·68
Water consunption, gals. per B.H.P. hour, producer	16·6	10·31	5·9	4·98
" " gals. per B.H.P., engine	5·4	2·60	2·1	2·08
Speed of engine, revs. per minute	20·1	2·00	1·98	1·98

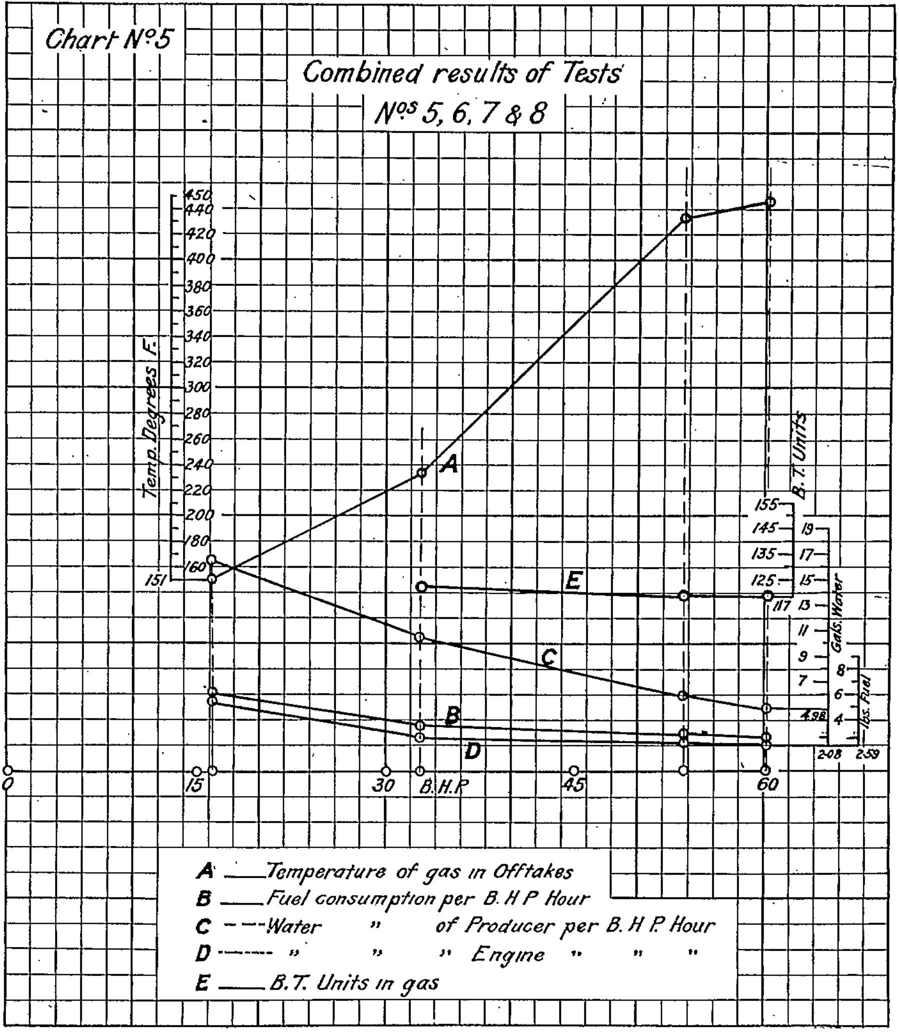


Chart No. 5
Combined results of Tests
Nos 5, 6, 7 & 8
Temp. Degrees F.
450
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
151
A
E
C
B
D
0
15
30
B.H.P.
45
60
B. T. Units
155
145
135
125
117
Gals. Water
19
17
15
13
11
9
7
4.98
lbs. Fuel
8
6
4
2.08
2.59
A ——— Temperature of gas in Offtakes
B ——— Fuel consumption per B.H.P. Hour
C - - - Water " of Producer per B.H.P. Hour
D ········ " " " Engine " " "
E ——— B.T. Units in gas

PART II.

RESULTS OF TRIALS WITH PRODUCER: AS ALTERED BY THE KÖRTING BROTHERS, HANOVER, GERMANY.

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RESULTS OF TRIALS WITH PRODUCER: AS ALTERED BY THE KÖRTING BROTHERS, HANOVER, GERMANY.

INTRODUCTION.

The trials described in part I, demonstrated that, with the producer and cleaning system as originally designed and constructed, it was impossible to obtain a gas sufficiently free from tar to permit the engine to operate many hours without cleaning the cylinder and valves. It was also shown that the operation of cleaning could be performed while the engine was in motion, without in any way interfering with the load; but while the plant could be run for an indefinite period without having to shut down for purposes of cleaning, efforts were made to discover the seat of the trouble, and, if possible, to correct it.

The results of the many trials conducted by the writer and his technical staff, tended to point to a faulty construction of the producer itself; and on the strength of the deductions made from the observations, certain changes in the internal construction of the producer were recommended to Körting Brothers, Hanover, Germany—the manufacturers of the plant.

With a view to assisting them in their efforts to eliminate the tendency to the formation of tar in large quantities, the Mines Branch sent to their works at Hanover, Germany, ten tons of the peat manufactured at the Government peat plant at Alfred. After a lengthy investigation of the behaviour of this peat under varying conditions in a similar producer erected in their shops, they reported as having succeeded in obtaining a gas free from tar, and on which the engine could operate for many months without cleaning.

To accomplish this result, the engineer-in-charge—acting upom the results of our investigation—deemed it advisable to alter the shape of the lining of the producer; because the contracted neck described in the foregoing pages did not offer sufficient resistance to the passage of the gas down through this neck to the offtakes, hence, instead of operating as an up-draft producer, in the upper zone, it acted partially as down-draft.

In order to overcome this difficulty, the contracted neck was made much longer, thus increasing, considerably, the resistance to the passage of the gas through this channel.

The cleaning system was also altered, as will be described later.

But even with these alterations, the producer, though undoubtedly improved, failed to deliver a gas sufficiently free from tar to permit of more than a few hours' operation of the engine before it became necessary to clean the valves and cylinder to prevent sticking; and the old remedy of washing with oil-soap and water had to be resorted to.

The trials made by the producer expert sent by the Körting Brothers from Germany did not prove satisfactory, as regards the generation of a tar-free gas, consequently, a series of tests were conducted by the technical staff of the Fuel Testing Division for the purpose of ascertaining the cause of the trouble, and, if possible, discovering some means of correcting it[1].

During these trials the producer was operated under varying conditions, as regards air openings in the upper and lower zones; the objective being, to ascertain the particular air openings with which the producer delivered the cleanest gas, and, if possible, to balance the two zones. After many trials, the idea of appreciably decreasing the tendency to the formation of tar, by this means, was abandoned; since, even with a large range of air-openings, the composition of the gas was only slightly altered, and the quantity of tar carried past the cleaning system did not vary to any appreciable extent.

As a result of many trials made with the producer in its original and altered state, it was concluded that the tarry components of the gas evolved in the upper zone could not be entirely burned or split-up into permanent combustible gases; and for this reason, a special method of cleaning the gas was resorted to in order to overcome the difficulty.

After considerable experimentation, the writer succeeded in devising a cleaning system which effectively separated the troublesome tarry matter from the gas; so that, irrespective of the behaviour of the producer itself, namely, whether it operated as down-draft or up-draft, with large or small air-openings, the gas at all times was sufficiently clean to offer no obstruction to the normal operation of the gas engine.

While, under the original construction, it was necessary to remove and clean the mixing or admission valves after a few hours' run—and even the piston, after a few days—it is now possible—under the new conditions—to run for many days before it becomes necessary to clean either the mixing or admission valves, and the piston should not require cleaning more than once or twice a year, if the plant is operated continuously. This system of cleaning will be described later.

DESCRIPTION OF THE ALTERATIONS MADE TO THE PEAT GAS PRODUCER AND CLEANING SYSTEM.

The complete details of the alterations made to the shape of the lining of the producer are so clearly shown in Fig. 11 that no detailed description is required. The changes will be better comprehended by comparing Fig. 11 with Fig. 2, page 9.

It will be seen that the principal change consists in the lengthening of the contracted neck, G, Fig. 2; an alteration in construction which involved the necessity of a very thick lining at that section. This increased thickness of lining—which runs from the grates of the upper zone to below the gas offtakes at the lower zone—was taken advantage of for the purpose of decreasing the loss of heat through radiation.

The lining is constructed of silica brick at a, fig. 1, Fig. 11—which shows the vertical, longitudinal section—firebrick at c, and a specially prepared heat insulating material at b, between a and c.

Fig. 2 on the same plate, shows a vertical, transverse section of the producer. The lining at this section is composed of firebrick at c, and a special heat insulating material at b.

The gas offtake of the upper zone has been enlarged, as will be seen by comparing fig. 1, Fig. 11; and Fig. 2, page 9.

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[1] These alterations were made at the expense of the Körting Brothers, who sent one of their experts to Ottawa, to superintend the work.

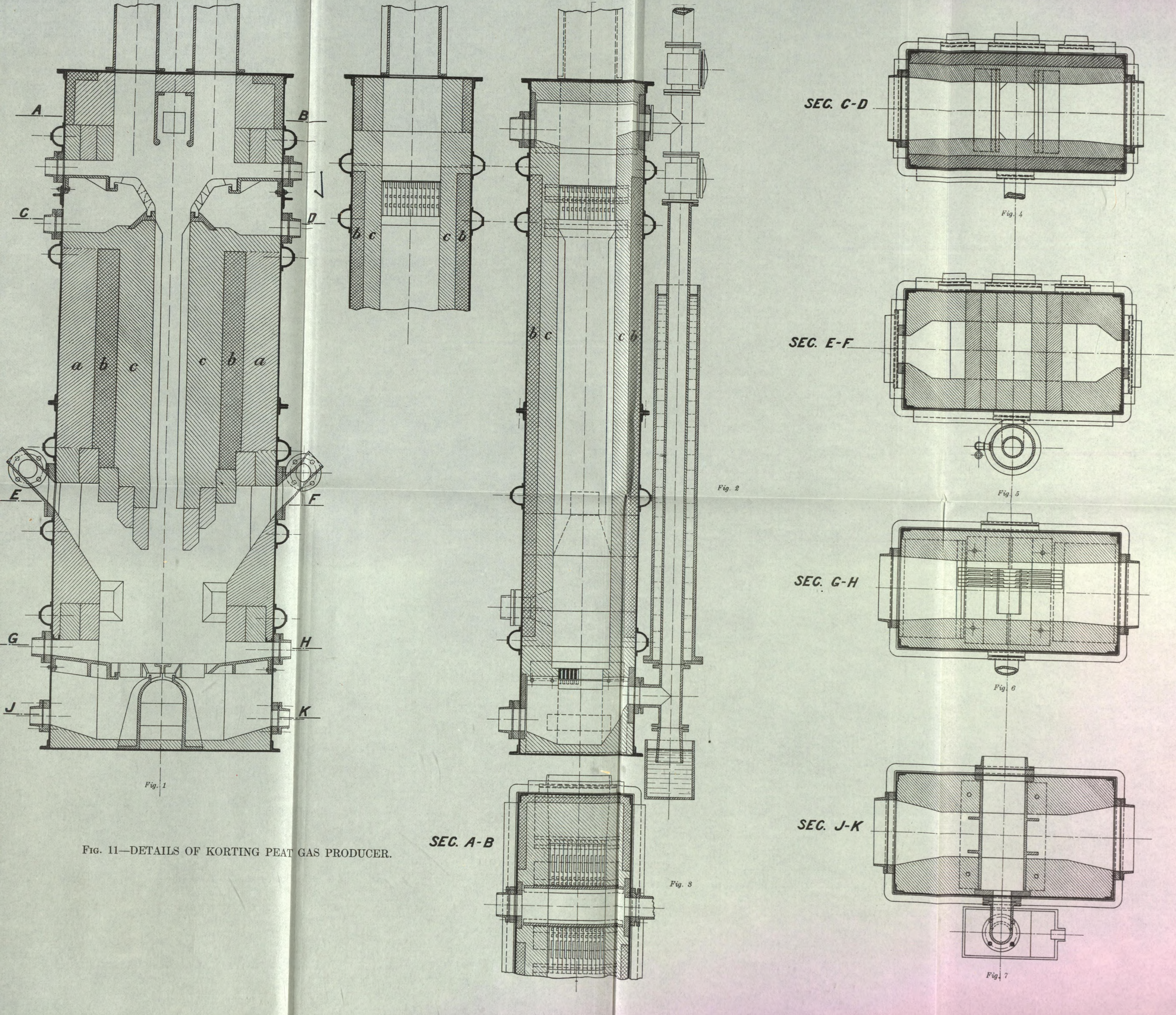


Fig. 11—DETAILS OF KORTING PEAT GAS PRODUCER.

The grate bars of the upper zone were re-designed with larger air-openings; while those of the lower zone are so designed that the gas from the upper zone drawn up through these grates will be deflected away from the centre of the fire. These changes are shown in figs. 1, 2, 3, and 6, Fig. 11.

PURPOSE OF LENGTHENING THE CONTRACTED NECK OR PASSAGE CONNECTING THE UPPER AND LOWER ZONES.

In the producer as originally constructed, the gases evolved in the upper zone were partially drawn down through the contracted neck G, Fig. 2, page 9, to the two gas offtakes, and did not all pass through the incandescent fuel of the lower zone, consequently, the tarry components of the gas were neither burned nor split up into permanent combustible gases. The producer, when operating in this manner, was up-draft in the lower zone, and partially down-draft in the upper zone; the gases generated from both, mixing at the offtakes. The amount of tar formed, or which escaped the producer unchanged, depended on the ratio of the amount of gas passing down through the contracted neck to that passing through the pipe, C-V-U, Fig. 4, page 11. This ratio was varied by the restriction of pipe C-V-U, caused by the adherence of tarry matter to its walls. As originally constructed, therefore, the operation of the producer was irregular, delivering at times a gas comparatively free from tar, and at other times one heavily charged with tarry vapours.

To overcome this difficulty and to ensure the passage of the gas from the upper to the lower zone through the pipe provided for this purpose, the contracted neck was made sufficiently long to increase the resistance necessary to prevent any appreciable quantity of gas from being drawn down through the same. With this new construction, it is probable that all, or very nearly all, of the gases evolved in the upper zone are conducted to the chamber under the grates of the lower zone, where they pass through the grates, and mix with the air admitted through the air-openings in the doors of the ash chamber.

The objective of drawing the gases in this manner through the incandescent peat coke of the lower zone is, either to cause the tarry vapours to burn when mixed with the air, or to be split up into permanent combustible gases. This is realized to a certain extent; but a quantity of the tarry vapours generally escapes combustion or decomposition and must be separated out in the cleaning system.

The bulk of the tarry matter is removed in the coke scrubber and tar filter; but even under the best conditions tar in a very finely divided state is carried in suspension by the gas past the entire cleaning system to the engine. Here, it is deposited on the mixing, admission valves, and in the cylinder, where it becomes partially carbonized, causing the valves and piston to stick. Whenever this occurs, it is necessary, in order to ensure regular operation of the engine, to thoroughly cleanse the cylinder and valves with a mixture of oil-soap and water, as already described.

EFFECTS OF ALTERATIONS TO THE PRODUCER.

While the producer, as now constructed, cannot deliver a gas free from tar, i.e., cannot completely burn or split up into permanent combustible gases all the hydrocarbon vapours evolved in the upper zone, yet the alteration has effected a manifest improvement: its operation is more uniform, and the amount of solid material possessing a high heating value, which it is necessary to separate out in the coke scrubber is materially decreased, and at times scarcely noticeable. The main difficulty, however, still exists, as in the old form of the producer, namely, the formation of a variety of tar: as a thin liquid when condensed, and as finely divided particles carried in a state of suspension after passing through the cleaning system. This objectionable by-product cannot be obviated in the producer itself, but must be separated out mechanically.

To accomplish this, the makers of the plant, who designed and carried out the alterations, devised a special addition to the coke scrubber. But this device, as our many tests have shown, failed to accomplish the desired result; hence, the writer, after considerable experimentation, invented a remedial device which completely removes the troublesome matter from the gas. *The plant, as it now stands, is an unqualified success.*

THE KÖRTING IMPROVED COKE SCRUBBER.

The alterations to the wet coke scrubber (see Fig. 12) consisted of an addition to the top of the old scrubber which was used with the original plant.

The shell of the original coke scrubber, still in place, is designated on Fig. 12 by the letter A, while the addition is indicated by the letter B.

The lower part of the present scrubber consists, as before, of a gas chamber in the lower part, connected by an overflow pipe E, to a water seal, also a cleaning door H, and a gas intake D. The middle part C, is filled with coke, resting on wooden gratings at F, and is fitted with cleaning door G.

At the top of section A immediately above the coke is a settling chamber, which formerly served as the outlet for the gas, and in which was placed the water spray.

Section B—the additional length added to the old scrubber—is 5 feet high. On the lower end of this cylinder is bolted a diaphragm plate S, in the centre of which is a hole 12″ diameter. A perforated metal plate J, covers this hole, and a cylinder, K-K—open at both ends and perforated for about two-thirds of its height—fits inside the flange O-O on the perforated metal plate J, and is held firmly in place by the cover plate, P-P, which presses against it. L is the water spray, and N a relief cock.

The gas from the producer enters at D and passes up through the grating F and coke C into the expansion or settling chamber R, and then through the perforated plate J and perforations in cylinder K-K to the outlet M.

The spray at L impinges against the interior surface of the cylinder K-K and then passes through the plate J and coke C to the bottom of the scrubber, where it flows off through the pipe E.

The gas in passing through the wet coke is cooled, and loses some of its dust and tarry matter, which passes with the cooling water into the seal. In passing through the perforated metal plate J, the velocity of the gas—and consequently, of the particles of tar carried past the coke—is increased, so that when the gas again expands into the chamber surrounding the cylinder K-K, its velocity and also that of the tarry particles, is reduced; and some of the latter—adhering to the inside and outside surface of the cylinder or dropping to the bottom onto the metal plate J—are washed down by the steady flow of spray water, to the overflow at the bottom.

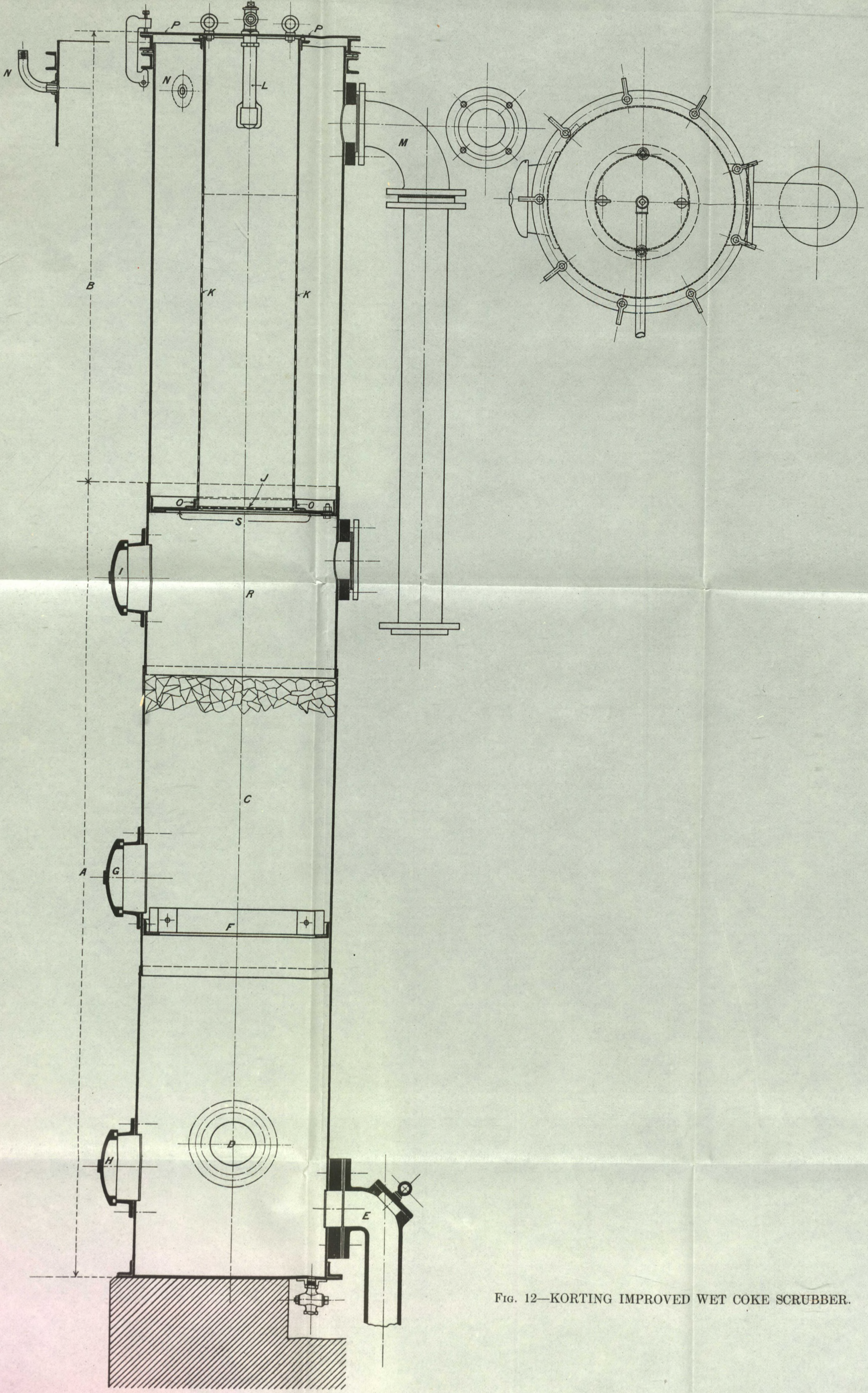


Fig. 12—KORTING IMPROVED WET COKE SCRUBBER.

A considerable quantity of tarry material is separated from the gas in this way; but the particles which are carried in a very finely divided state in suspension by the gas, are not affected by this arrangement, which gives rise to alternate increases and decreases in the velocities of the gas; but pass with it through the entire cleaning system to the engine, where this matter is finally condensed on the walls of the mixing and admission valves, and in the cylinder itself. This gives rise to the troubles previously referred to.

The particles carried in suspension are in such a finely divided state that they give the gas the appearance of a white vapour; in fact, the subdivision of the particles is so minute that, the application of the term vapour, to this phenomenon, may be quite correct.

The alterations to the original coke scrubber were, on the whole, an improvement. There were, however, certain details which might have been further improved: for instance, a portion of the solid matter separated from the gas was washed through the plate J, but that portion which was deposited outside the cylinder K-K, dropped down between the cylinder K-K and the enclosing cylinder, on to the diaphragm plate S, where, in a short time, the accumulation would be quite considerable. Separation of solid matter from the gas again took place at the opening to the outlet M, where the accumulation would, at times, completely choke up the passage during a lengthy run. These defects could, of course, have been easily remedied had this system been satisfactory in other particulars.

Experiments to Ascertain a Method for Effectively Separating the Tar Fog from the Gas.

To determine under what conditions the tar fog present in producer gas would condense or separate out from the gas, and how these conditions could be applied in a simple but effective manner to a cleaning system—with special reference to the one already in place—experiments were undertaken with a view to investigating the effect on the matter held in suspension by the gas, of varying the velocity of the gas by means of different shaped pipes, etc. These experiments will not be described in detail, but only a statement made of the general results obtained.

When a gas heavily charged with the above-described, tar-fog is drawn from a larger to a smaller chamber: for example, through a glass tube of about 1″ diameter at the inlet end, drawn down to a small fraction of an inch at the outlet end, the velocity is very greatly increased; but if this gas is then expanded into a second chamber 1″ diameter—similar to that of the gas inlet end—the following phenomenon may be observed.

In the contracted neck between the two expanded chambers, the tar fog is seen to condense on the glass walls as a brownish, black grease. This, then forms into small globules or pellets, which are shot out with considerable force into the expansion chamber.

This phenomenon may be due to the great resistance set up by the rapidly flowing gas against the glass surface, causing the particles to lose their velocity and thus accumulate; or, it may possibly be due to the crowding together of the stream lines, which affects the deposition of the tar fog on the walls of the channel, or to a combination of the two.

These experiments showed that the tar fog could be separated from the gas in this manner; but the high suctions necessary to draw the gas through the small tubing and the tendency to increased suction due to clogging of the pipes or tubes render such a method impracticable.

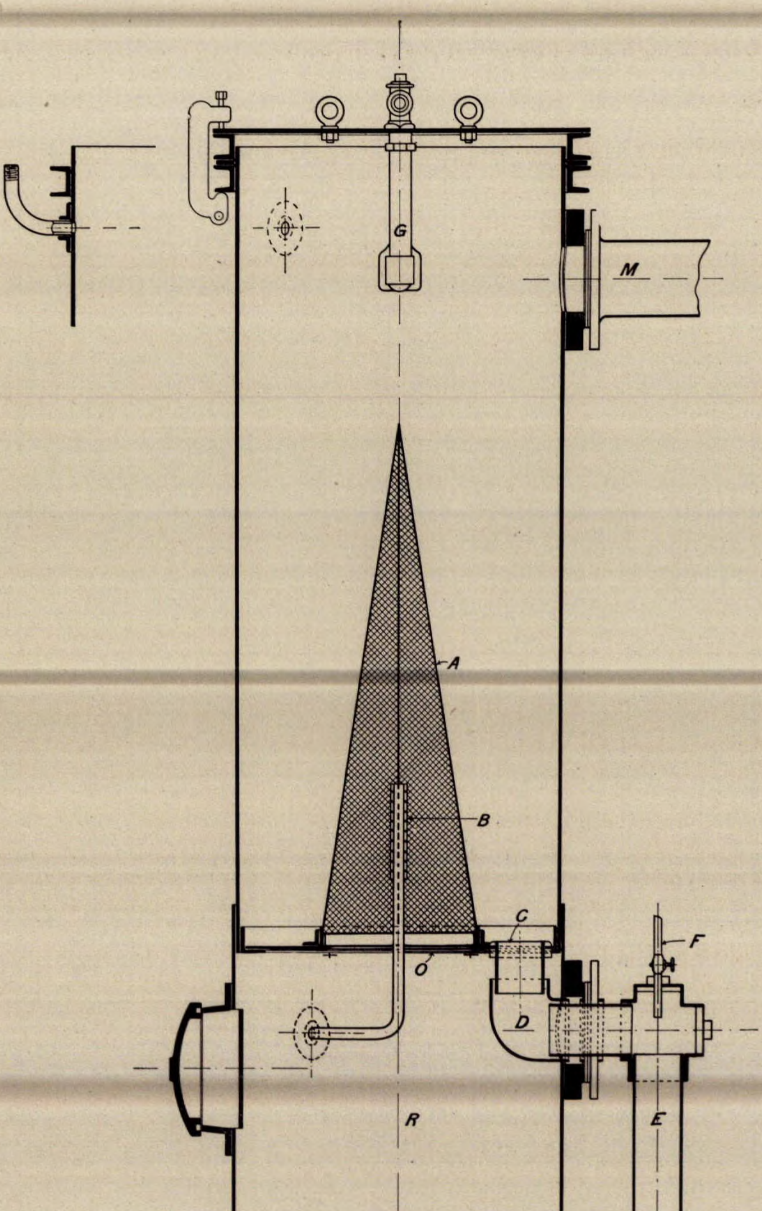


FIG. 13.—Newly devised tar separator.

As a result of the above experiments, a separator was devised, which has proved to be very efficient, entirely dependable, and can operate for any period without clogging, and, therefore, without producing increase of the suction.

DESCRIPTION OF TAR SEPARATOR DEVISED BY B. F. HAANEL.

The system invented by the writer, for the separation of tar and tar fog from producer gas, is shown in sectional elevation, Fig. 13.

The lower part of the coke scrubber has not been altered. The cylinder, K-K, Fig. 12, and perforated plate J, have been removed, and in their place has been substituted the wire mesh cone, A, Fig. 13. At C, an overflow has been provided for the purpose of carrying away the solid matter separated from the gas on the outside of the cone and washed off by the spray G.

A water spray, B, serves the combined function of washing the interior surface of the cone and cooling the gas. At F, a water jet has been provided for sluicing the overflow pipe E, whenever this shows a tendency to clog. This, however, it has never been necessary to use, the overflow pipe remaining absolutely clean.

The water spray, G, which in the old system was supplied with cold water only, is now connected by a two-way cock to the return cooling water from the gas engine. Whenever the suction in the chamber containing the wire mesh cone begins to rise, the cold water at G is shut off and the hot water turned on. By this means the suction, whatever it may be, is brought to normal in about a minute. The cone is made of 40 mesh brass wire screen.

DESCRIPTION OF OPERATION.

The gas passes through the wet coke into chamber R as before. From this chamber the expanded and cooled gas is drawn through the opening O, through the cone screen, and passes out at M.

In passing through the cone screen, some of the particles of the tar-fog still carried by the gas, impinge against the metallic surface of the cone, aggregate into comparatively large drops, and are then washed off by the continuous spray B—dropping into chamber R, through the wet coke, down to the water seal. The particles escaping contact with the metallic surface of the cone, in passing through the fine meshes are crowded together, and are thus caused to coalesce, forming larger drops which either adhere to the outside surface of the cone or drop to the bottom, when the continuous cold water spray G washes this tarry matter to the overflow at C.

It will thus be seen that the action of the cone screen in eliminating the tar fog is twofold: (1) in producing coalescence of the fog particles by impact with the solid parts of the screen; (2) causing coalescence of the fog particles, by crowding together the stream lines as the gas passes through the fine meshes of the screen, and retarding the particles by friction with the internal surface of the meshes.

When the suction shows a tendency to increase, the cold water at G is turned off and the hot water turned on; which thoroughly cleanses the cone in a very short time, at an expenditure of a very small amount of water.

An automatic arrangement is being devised whereby an increase in suction will instantly turn off the cold, and put on the hot water, and *vice-versa*. By this device, the consumption of both hot and cold water can be reduced to a minimum.

In ordinary practice, however, it has not been found necessary to resort to the hot water spray more than two or three times during a ten hours' run. In order to maintain a straight and normal suction curve during the entire period of operation, a simple automatic arrangement for changing from cold to hot water and *vice-versa* would be an advantage. But while this would prove an advantage, it is in no sense a necessity.

The water consumption for cleaning with this new system is not increased over that of the old: which was very small.

The gas, after leaving this cleaning system, is sufficiently free from deleterious material, so that it can be used in the gas engine without any trouble whatever. Moreover, the cleanliness of the gas is not dependent on the perfect operation of the producer itself, but permits of a large variation in the conditions governing its operation. For example, the cleanliness of the gas—its freedom from tarry matter, as it leaves the producer—depends (1) on the moisture content of the peat burned; (2) to some extent on its quality, and (3) quite considerably on the amount of air admitted to the two zones. Close and careful regulation is, therefore, not so essential to the cleanliness of the gas leaving the cleaning system as it was with the former construction, although obviously an advantage in so far as the waste of tarry matter is reduced.

Gas Producer Tests with the Körting Producer: as Altered by the Makers.

Upon the completion of the alterations to the producer and gas cleaning system, twenty-six trials were carried out, fourteen of which are described in detail.

The first three tests described, Nos. 20, 21, and 24, were made with the object of examining the performance of the producer, and were operated according to the instructions of the makers.

The tests 28 to 36 inclusive, were carried out for the purpose of examining the behaviour of the producer under varied conditions, and with a view to decreasing the amounts of tar in the gas leaving the cleaning system.

Throughout the latter series of trials, the engine was run at nearly constant load—thus ensuring a nearly constant demand upon the producer—in order to observe the change in the state of the gas, principally as regards the tar produced, by varying the supply of air to the lower zone. This was done by leaving the air-openings for the upper zone fully open, and altering those for the lower zone.

PERSONNEL OF TECHNICAL STAFF.

In carrying out the series of tests, the writer was assisted by John Blizard, B.Sc, technical engineer; Edgar Stansfield, M.Sc., engineering chemist; and A. W. Mantle, engineer and mechanic. In addition to the above observers, M. F. Connor, B.Sc., assistant chemist in the Mines Branch Laboratories, rendered aid when the duration of particular tests exceeded ten hours.

EQUIPMENT.

In addition to the equipment used during the tests already described, the following instruments were installed and used during these tests: Smith recording gas calorimeter; Bristol recording pyrometer; Thwing three record recording pyrometer; and a Sargent apparatus for determining the amount of tar in a gas.

The recording pyrometers were employed for determining the temperatures of the gases in the offtake of the upper zone, and the two gas offtakes of the lower zone.

The calorific value of the gas was determined throughout the trials by means of a Smith recording gas calorimeter. This calorimeter makes a record of every variation in the gas caused by poking, or the formation of air spaces in the producer, and constitutes a valuable adjunct to the observation instruments usually found in the engine rooms; since the change in the heating value of the gas is perceived at once, and can be rectified by the producer attendant.

The quantity of tar carried in the gas was determined—in the larger number of tests—by means of a Brady tar filter.

Inasmuch as the Smith recording gas calorimeter is the only instrument used which has not been described in technical journals, it has been deemed expedient to give the following description and explanation of the principle upon which its operation is based.

SMITH RECORDING GAS CALORIMETER.

This instrument is manufactured by the Lexington Instrument Works, Lexington, Ohio (See Plate X). No drawings were supplied by the firm to show the construction of the instrument; the following extracts, however, from communications received from them give a good idea of the working of the calorimeter:—

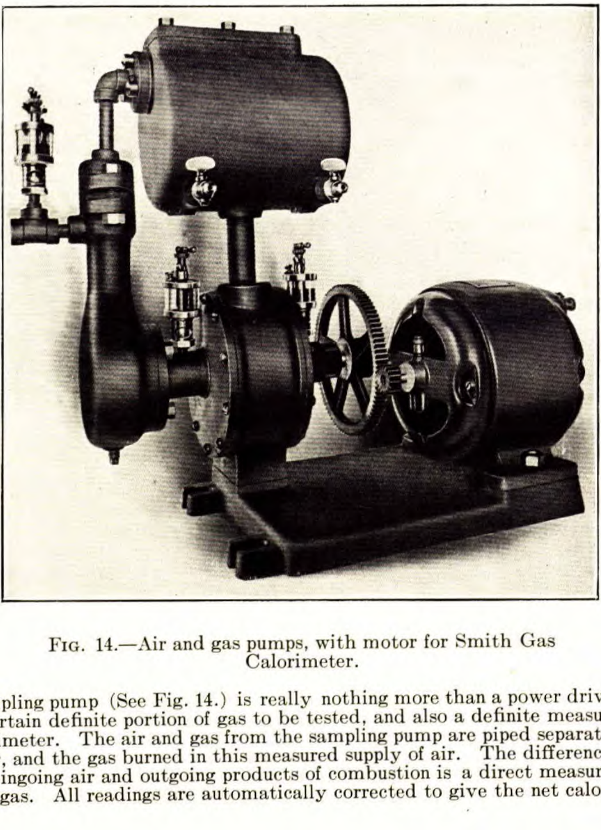
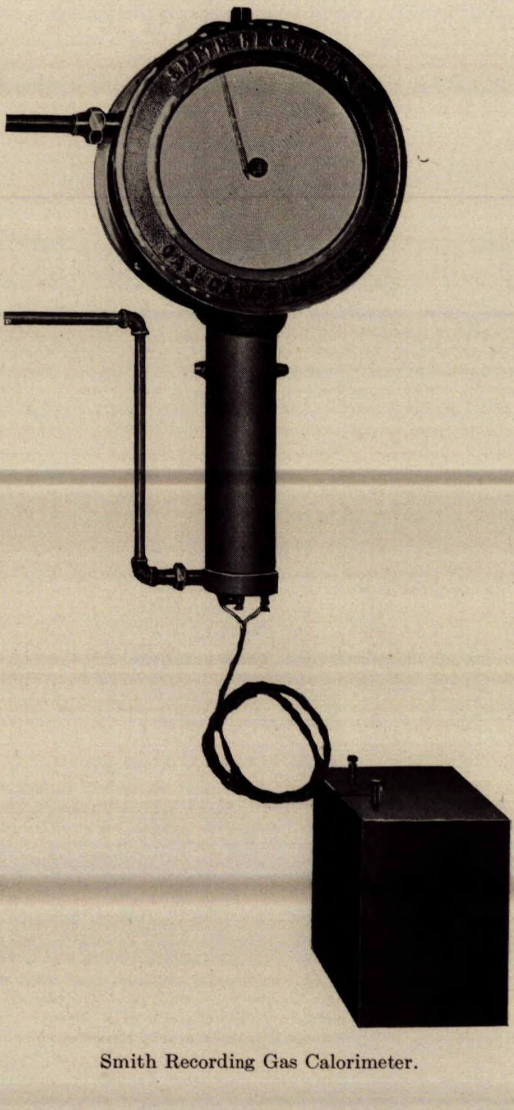


FIG. 14.—Air and gas pumps, with motor for Smith Gas Calorimeter.

"The sampling pump (See Fig. 14.) is really nothing more than a power driven meter, which "delivers a certain definite portion of gas to be tested, and also a definite measured supply of air "for the calorimeter. The air and gas from the sampling pump are piped separately to the calori-"meter proper, and the gas burned in this measured supply of air. The difference in temperature "between the ingoing air and outgoing products of combustion is a direct measure of the calorific "value of the gas. All readings are automatically corrected to give the net calorific value of the

PLATE X.



Smith Recording Gas Calorimeter.

"gas (measured moist), at 60° F. and 30 inches of mercury barometric pressure. The apparatus is "fitted with electrical ignition appliance. The button shown on the side of the calorimeter near "the bottom constitutes the sparking connection for igniting the gas.

"With regard to correction to temperature and pressure standards, the instrument makes "automatic correction only for the variations in gas volume due to temperature and pressure. The "corrections would be made on the assumption that whatever water vapor, if any, contained in "the gas, behaved during cooling to standard in every particular, as though it were a perfectly inert "gas. In other words, whatever water vapor may be in the gas at the time of its passing to the "calorimeter is treated for purpose of correction exactly as though it were so much nitrogen. Of "course, if the gas is dried by chemical means before passing to the instrument, the determinations "would then be for dry gas at 60° F. and 30″ mercury.

"It is not necessary to dry either the gas or air passing to the calorimeter, or to supply them "saturated, unless it is desired that the determinations should be on the basis of dry gas, in which "case the gas sample passing to the instrument should be chemically dried before passing the "sampling pump. It is not necessary to pay any attention whatever to the condition of air with "regard to moisture content. This may sound rather startling, but a brief consideration will show "that the error introduced by the presence of water vapor in the air supply is very small indeed. "It is quite true that the specific heat of water vapor is practically double the specific heat of air "under the same conditions. However, it should be remembered at the same time that this "specific heat is calculated on the basis of weight and while the specific heat of water vapor is practically double that of air, the specific gravity of water vapor is only approximately one-half that "of air. To reduce the matter to concrete figures, if we assume extreme cases, taking absolutely "dry air at 100° F. and comparing its total specific heat with the specific heat of completely saturated air at the same temperature, it will be found that the difference even under these extreme "conditions amounts to only a small fraction of 1%. Accordingly, for all practical purposes we have "assumed this to be negligible, and in all of our experiments we have never been able to detect "any appreciable difference in the readings of the instrument which could be traceable to the "condition of air with respect to moisture content.

"The sampling apparatus furnished with the equipment is designed to draw the gas sample "from gas mains that are under the ordinary suction required for operating a suction gas producer. "Of course, if this suction were extremely high, that is to say, from 14″ to 16″ of water, we would "expect that this would make a slight variation in the readings of the instrument, since for perfectly correct readings the gas and air should both be taken at the same pressure. However, a "brief consideration will make it clear that a small variation would not make any appreciable "difference in the accuracy of the apparatus.

"Any gas that is fit to supply a gas engine can be used through the apparatus without further "purification. The gas pump is supplied with continuous lubrication, which protects the working "parts from any especial interference from the slight tar vapor that is present in gas from bituminous "coal as it is ordinarily supplied to a gas engine after mechanical scrubbing. In any event, all that "would be required would be an occasional cleaning of the gas pump, which is a comparatively "simple operation.

"The established ratio between gas and air in the instrument is 1 to 29. This gives a total "volume of products of combustion of 30 to 1, as compared with the gas supplied which approximates very closely to a rise in the temperature of the products of combustion of 1 degree centigrade for each B.T.U. per cubic foot of standard gas. The large air excess, together with the fact "that the specific heat of nearly all of the products of combustion from the burning of the small "quantity of gas are the same as that of air, renders the instrument practically immune from variation in readings due to variation in the actual composition of the gas. Of course, there is a slight "error, but if the extreme conditions that are likely to be met with in any sample of producer "gas that is capable of combustion be assumed, and a calculation made of the amount of variation "that would result from the extreme change in composition of these elements, it will be seen how "negligible this factor is. The large excess of air which ensures that for all practical purposes the "specific heat of the discharging products of combustion will be that of air is relied upon to reduce "the liability to error in this direction.

"The thermocouple mentioned above is not strictly speaking a thermocouple in the electrical "sense of this term, but rather a mechanical couple consisting of a steel tube, exposed on the outside "to the atmospheric air and on the inside to the supply of atmospheric air—delivered by the sampling pump—which constitutes the zero member of the pair, and a thin steel tape, which is exposed "throughout its length to the outgoing products of combustion, and whose length, as compared with "the length of the zero member of the pair, is taken as a measure of the temperature of the outgoing "gas. The parts taken together constitute a means for indicating the difference in temperature "between the in-going atmospheric air and the outgoing products of combustion. This difference "in length is carried through a simple multiplying gear to the needle carrying the recording pen. "The tape which constitutes the hot member of the couple is made quite thin so as to make it "respond very promptly to any change in temperature, thus making the apparatus highly sensitive "to variation in gas quality.

"The manner in which this instrument gives correct readings is quite obvious. The corrections are to compensate for the change in heating value of the gas, due to volumetric variations "induced by change of temperature and pressure. It is perfectly clear that when the heat absorbing "medium is an elastic gas and when this is handled through the sampling pump under the same conditions of pressure and temperature as air that any condition affecting the calorific intensity of the "gas metered would affect the heat absorbing capacity of air in exactly the same manner. Thus, "under high temperature conditions, the gas would be expanded and would have lower calorific "value per unit volume, but the air supplied would be under the same conditions and would be expanded likewise with a corresponding loss of heat absorbing capacity. Consequently, a definite "volumetric ratio being established and the instrument being calibrated under standard conditions, "no corrections whatever would be required, for deviation in pressure or temperature difference

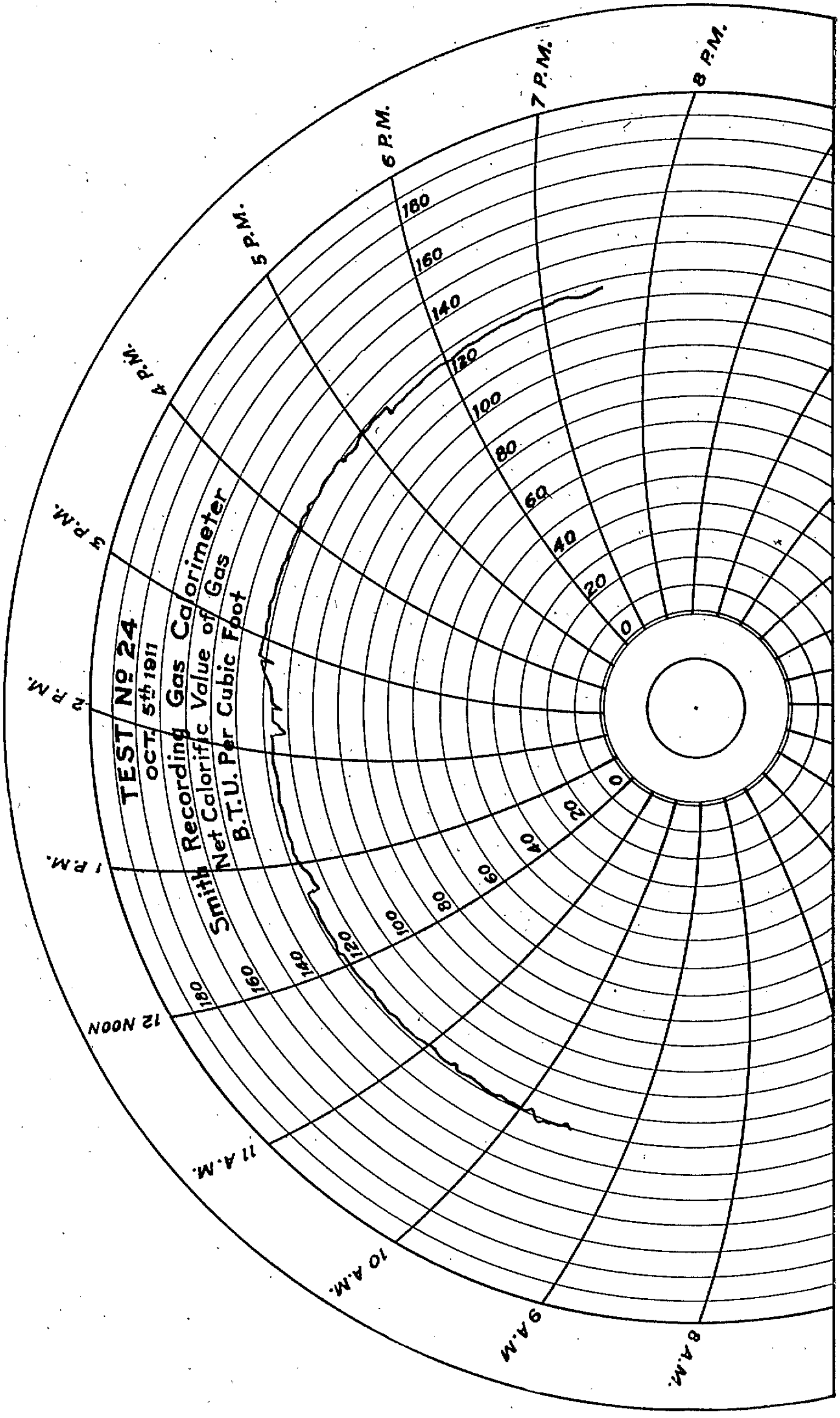


FIG 15.—Sample record from Smith Gas Calorimeter.

"per actual B.T.U. would be exactly the same in any case. This has been borne out in an experi-"mental way to our entire satisfaction, although the correction is not absolutely perfect on ex-"tremely wide ranges. For example, a change in altitude from sea level to 7,000 feet will make an "actual variation in readings of the apparatus of about 1%. It can be seen, however, that the error "that would be introduced from small variations and particularly from the variations that would "occur in any one plant from day to day would be entirely negligible."

The instrument as now built is designed to operate on gas up to 200 B.T.U. per cubic foot. This would include blast furnace and producer gas. The lower limit is somewhere in the neighbourhood of 60 B.T.U. per cubic foot. The cards are calibrated down to O, and readings are shown as long as the instrument can be kept lighted.

The sampling pump and calorimeter were set up in the engine room close to the engine. About 6 feet of $\frac{1}{4}''$ pipe carry the gas from the engine gas receiver to the sampling pump; and about 6 feet of $\frac{1}{4}''$ pipe and 6 feet of $\frac{1}{2}''$ pipe carry the gas and air, respectively, from the pump to the calorimeter.

No tests have, as yet, been made to standardize this calorimeter by means of the Junker's or Boys' calorimeters; but comparison of the readings of the instrument with the calorific values of the gas calculated from the analyses of samples taken at definite times, show that, the former are almost invariably the higher. The difference usually ran from 5 to 10 B.T.U. per cubic foot. The chief value of the instrument for the purpose of the investigations thus far carried out, lay in the prompt indication it gave of the effect of any change made in the working of the producer, upon the calorific value of the gas; and the record it gave of the uniformity or otherwise of the gas whilst the conditions of working remained unchanged. The frequent checking of the instrument by means of analyses of gas samples showed that its relative readings were at least approximately correct. The absolute values were, for the purpose in view, of very little importance.

The specimen record shown (Fig. 15) gives an indication of the sensibility of the instrument.

OBSERVATIONS AND RESULTS.

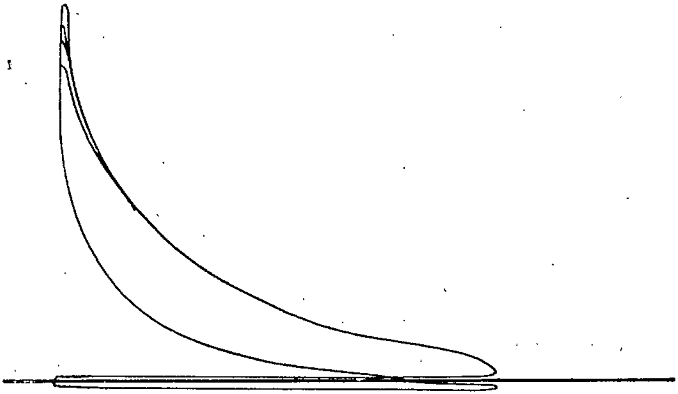
Power.

The brake horse-power of the engine was calculated, as in the previous tests, from the observations of the voltmeter and ammeter on the switchboard and the dynamo efficiency at the output obtained.

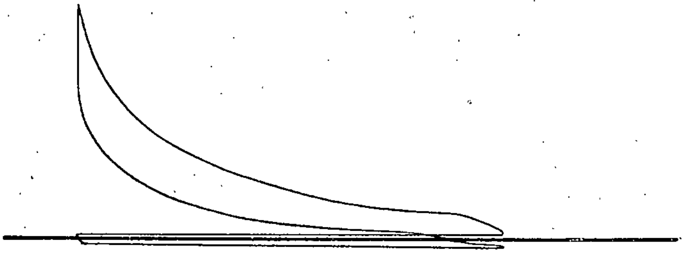
For trial No. 24, a full set of indicator cards was taken; but for the remainder of the trials an occasional card was taken in order to be certain that the timing of the ignition was correct, and that the valves operated properly. Fig. 16 shows 3 diagrams taken while running at different horsepowers.

Temperature of the Gas.

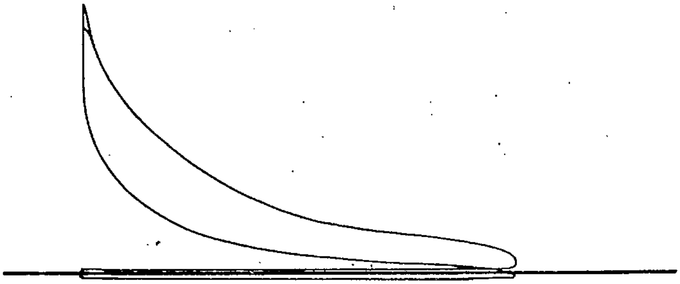
For trials 19 and 20, the temperature of the gas was taken at No. 1 offtake (Fig. 4, page 11.) This temperature was recorded by means of a Stansfield electrical pyrometer. For trial No. 24 this pyrometer was re-



M.E.P. 39.1 Lbs. Sq. In. R.P.M. 199 I.H.P. 19.2
Scale, 1" = 120 Lbs. Sq. In.



M.E.P. 49 3 Lbs Sq. In. R.P.M. 193 I.H.P. 51.8
Scale, 1" = 240 Lbs. Sq. In.



M.E.P. 62 Lbs. Sq. In. R.P.M. 191 I.H.P. 65
Scale, 1" = 240 Lbs. Sq. In.

Fig. 16.—Indicator diagrams taken from Körting Gas Engine.

placed by a Bristol recording pyrometer; and for the series of trials Nos. 28 to 36 inclusive, a Thwing pyrometer—which recorded three temperatures—was used. One fire end—No. 3—was placed in the gas offtake of the upper zone, and the other two—Nos. 1 and 3—in the gas offtakes for the final gas of the lower zone. (See Figs. Nos. 2, 3, and 4, pages 9, 10, and 11.) Fig. 17 shows a chart taken from the Bristol recording pyrometer.

PREPARATION OF THE PRODUCER BEFORE BEGINNING A TRIAL.

On the day of the test, the producer—which had been banked for the night—was first opened up to permit the fires to brighten under the action of the natural-draft. The gas exhauster was then started and kept running until the gas was of good quality—as indicated by a pilot flame and the recording calorimeter. The engine was then started.

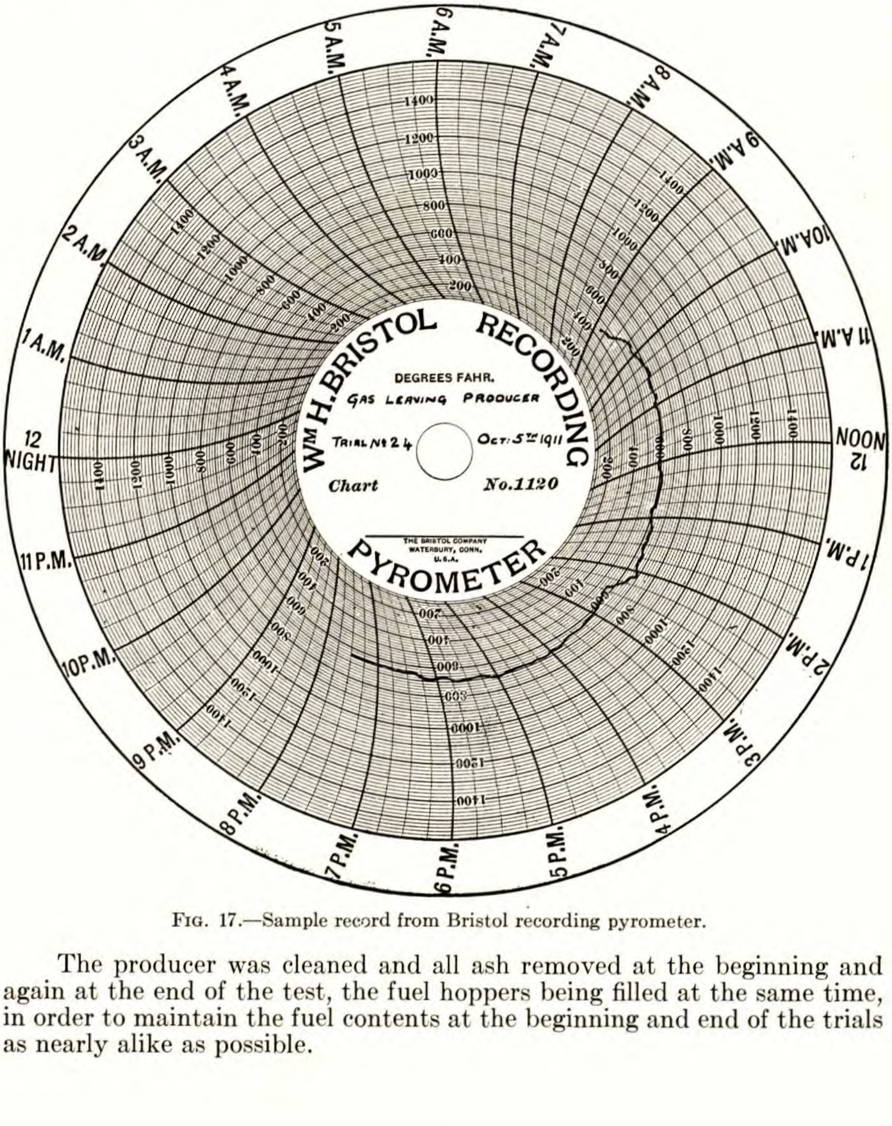


FIG. 17.—Sample record from Bristol recording pyrometer.

The producer was cleaned and all ash removed at the beginning and again at the end of the test, the fuel hoppers being filled at the same time, in order to maintain the fuel contents at the beginning and end of the trials as nearly alike as possible.

At regular intervals during the test the producer was filled, the amount of fuel fed into the hoppers being carefully weighed, and recorded.

A record was kept of any operation carried out on the producer, such as poking, cleaning, or alteration of the air-supply.

HUMIDITY.

The method of obtaining the humidity was by means of a sling type of wet and dry bulb thermometer, from the readings of which the dew-point could be found from tables.

CALORIFIC VALUE OF GAS.

This value is given in British thermal units per cubic foot at 60° F., and 30 inches of mercury pressure.

RESULTS DEDUCED FROM FUEL AND GAS ANALYSES.

For trials 20, 21, and 24—for which complete gas analyses were determined—some additional calculations were made.

From the gas analyses the pounds of nitrogen per pound of carbon are calculated. It is assumed that this nitrogen is obtained solely from the air, whence we may obtain the pounds of air per pound of carbon in the gas. It is assumed that the combustible in the refuse contains 80 per cent of fixed carbon; and neglecting the quantity of carbon which passes off as tar and dust with the gas, the pounds of carbon in the gas per pound of peat charged are determined, from which figures the pounds of air per pound of dry peat are found. Similarly, using the gas analyses to calculate the cubic feet of gas (at 60° F., and 30 inches of mercury) per pound of carbon, and multiplying this figure by the pounds of carbon in the gas per pound of dry peat charged, the quantity of gas per pound of dry peat charged was determined.

The water supplied per pound of peat includes the moisture taken in with the air supply and the moisture contained in the peat as charged.

PRODUCER EFFICIENCY.

This is taken as the ratio of the product of the cubic feet of gas produced per pound of peat and its net calorific value to the calorific value of a pound of peat.

RESULTS OF THE TESTS.

The results of the tests are set forth in the following charts and summaries, and in the complete test logs placed in the appendix. All the computations for the construction of the charts and those entering into the summaries were made by John Blizard, B.Sc. The gas analyses and analyses of samples of peat were made by Edgar Stansfield, M.Sc.

Trial 20, September 19, 1911.

This trial—No. 20—was the first made after the reconstruction of the producer.

Since the makers of the producer sent one of their experts to carry out the alterations, the manipulation of this and the succeeding trial was left entirely under his direction.

The trial was started at 11.30 a.m. and finished at 9.30 p.m.—a period of ten hours. Owing to the presence of tar in the gas, which deposited on the walls of the cylinder, causing the piston to pound, it was found necessary to wash the cylinder with a mixture of oil-soap and water at 2.15 p.m., and again at 7.20 p.m. For a similar reason the cylinder was well oiled at 8.00 p.m.

At the end of the trial the valves were examined and found to be fairly clean. Before replacing, they were thoroughly cleaned.

The area of the air-openings of the lower zone are given in the summary of this trial.

During the entire trial, the wash from the coke scrubber remained conspicuously clean. It was discovered later, however, that a considerable amount of the solid matter carried by the gas and separated out by the sieve in the scrubber was deposited between the cylindrical sieve and the enclosing shell of the scrubber. Apart from the deposit of tar in the cylinder of the engine—which necessitated the washing of the cylinder and piston—the operation was quite satisfactory. The results of this test are shown graphically on Chart No. 6, and in the summary No. 20.

Trial 21, September 20, and 21.

This trial was run under precisely similar conditions to the preceding trial; but was of twice the duration. It will be noticed from summary No. 21 and Chart No. 7, that there was practically no change in the results: the economic figures obtained in both trials being almost identical.

The trial lasted from 10.10 a.m. September 20, until 6.10 a.m. September 21.

As in the previous trial, trouble was experienced with tar in the cylinder, which caused the piston to pound. To remove the deposit in the cylinder, washing with oil-soap and water was resorted to at 10.15 a.m ; 6.10 p.m.; 10.30 p.m., and 5.00 a.m.

The valves were removed at the end of the trial, and were found to be covered with a thin, tarry deposit, which, however, did not cause them to stick during the run.

See summary No. 21, and Chart No. 7.

Trial No. 24, October 5.

This trial was run at $\frac{2}{3}$ load, or 40 H.P., with the peat manufactured at the bog of the Industrial Peat Company, Limited, Farnham, Que. Ten tons of this peat were shipped by that Company to the Fuel Testing Plant for the purpose of investigating its behaviour in a gas producer.

The peat sent to Ottawa by this Company to be tested in the producer was of excellent quality, and the moisture content—27·8 per cent—was within the limits prescribed by the makers.

This peat was manufactured by a machine which the Company was experimenting with in order to test the durability of a newly designed mechanical excavator. The machine was operated on a part of the bog underlain by a ridge of partially decomposed rock, carrying iron. This rock, which was easily broken, passed through the mascerating or pulp mill and entered into the composition of the finished peat.

When burned in the producer, the ferruginous rock material contained in the peat formed bad clinkers—whenever the internal temperatures became very high. Since no arrangement existed for introducing steam into the lower zone, the clinkers could not be made sufficiently soft to facilitate their removal during operation; consequently, during a part of the tria the operation of the producer was not as uniform as could be desired.

The trial was commenced at 9.30 a.m. and completed at 7.30 p.m.

The air openings in the doors of the lower zone were varied from time to time in order to observe the effect on the formation of tar. From the beginning of the trial until 2.50 p.m., the sum of the areas of the openings in the bottom doors amounted to 2·8 square inches; which was increased at 2.00 p.m. to 6·6 square inches, and at 5.30 p.m., to 10·8 square inches.

The cylinder was washed out before starting, and again at 1.00 p.m., in order to free it from tar. Upon stopping the trial, the cylinder was found to be clean.

The rise in suction at the producer exit towards the end of the trial was due to a layer of clinkers of about 1″ thick, which had formed over the grate bars.

Trial No. 28.

For this trial, the coke scrubber was provided with a special addition in the form of a cheese-cloth cone about 3 feet high, and of a diameter at the base just large enough to cover the hole at the lower end of the perforated cylinder. This cone was placed inside the cylinder and held firmly in position so that all the gas passing from the producer through the coke had to pass through the cone before leaving the coke scrubber.

This test is the first of a series of nine carried out with the engine running with a load of approximately 45 brake horse-power, having the air openings to the top zone wide open, and those in the lower zone varied from time to time.

The air-openings in the lower zone during this test corresponded to the ¾ load mark on the gauge supplied by the expert who was sent by the makers to carry out the alterations to the producer. The ¾ load mark on this gauge gave an air opening of 2·8 square inches.

From 9.30 a.m. to 2.45 p.m. the fire was not very bright on the lower bars: particularly on the south side where No. 3 fire end of the pyrometer was inserted; but was quite bright on a level with the poke hole on the back of the producer.

At 2.45 p.m. no flame was visible below the bars. The gases from the top zone—which are drawn up through the grate of the lower zone—were observed during test No. 24, and thereafter, to be deflected downward into the ash chamber on either side and then to burn, and the flames of the burning gas then passed up through the hot coke above the grates. This phenomenon occurred when the air openings of the lower zone were in the vicinity of ¾ gauge, or 2·8 square inches, and ceased when the openings were increased or decreased to any extent, or when clinkers rested on the grate bars.

At 2.45 p.m. the fires were poked, and several hard bits of clinkers removed. Similar bits of clinkers were taken out when the fires were cleaned at the end of the trial.

It will be seen from the curves (Chart No. 9) that after poking the fires of the lower zone, the gas temperatures and suction were lowered and that the calorific value of the gas was raised.

The wash from the scrubber was of a bright yellow colour from 9.30 a.m. to 1 p.m., after which it changed to a black colour.

During this trial it was not necessary to wash the cylinder, since no trouble was experienced with tar. The valves, however, did not operate as smoothly as was desired, and an inspection at the termination of the test revealed a deposit of soft tar on the mixing and admission valves.

During the first few hours the gas appeared to be very clean; it then suddenly changed, the tar in the gas increasing in amount. The cheese-cloth cone on examination was found to be buckled; this allowed part of the gas to pass through without being cleaned, which explained the presence of tar during the latter part of the run.

At the end of the trial the cylinder was washed out with oil-soap and water, in order to bring the engine into proper condition for the succeeding trial.

Trial No. 29.

Before running this trial, the cheese-cloth cone was replaced by one of the same dimensions made of fine wire gauze, which was washed with the cold water spray already in place at the top of the scrubber.

The air-openings used during this test were the same as for the preceding test.

The analysis of a sample of gas taken from the standpipe connecting the upper and lower zones, showed only 3 per cent of carbon dioxide, and as much as 17·6 per cent oxygen. This was found, at the end of the trial, to be due to a stoppage in the standpipe caused by a large piece of waste carelessly dropped in by the producer attendant while cleaning the damper.

Owing to this restriction, the gases formed in the upper zone, instead of passing through the standpipe to the lower zone and up through the hot coke, were drawn down through the contracted neck and fuel to the lower gas offtake. The tarry matter carried by the gas was, therefore, neither burned nor decomposed. Notwithstanding these adverse conditions, the coke scrubber separated the tar from the gas so efficiently that, no trouble was experienced with the engine, and on stopping, it was found unnecessary to clean the valves. This is due to the modification made to the coke scrubber by the writer and the technical staff.

The wire gauze cone was covered on the inside with a deposit of tar, which tended to clog the cone, and, consequently, to greatly increase the suction. A cold water spray was, therefore, added for spraying the inside of the cone. This was put in place before the succeeding trial.

The wash from the coke scrubber during the run carried a large amount of solid matter of a bright yellow colour. For further information see Chart No. 10, and summary No. 29, and detailed information the complete log for trial No. 29 in the appendix.

Trial No. 30.

The conditions under which the producer and engine were operated were the same for this trial as for trials Nos. 28 and 29.

On account of an imperfection in the cleaning system—which was later altered—tar found its way into the engine, which necessitated the cleaning of the valves at the end of the run. See Chart No. 10, and summary No. 29.

Trial No. 31.

The air-openings in the lower zone were increased to the full load mark on the gauge, namely, 3·3 square inches.

The gas from the upper zone was observed to be burning beneath the grates of the lower zone; some of the tarry matter in the gas from the upper zone was thus destroyed.

The wash from the coke scrubber was abundant, and carried matter of a yellow colour.

The engine ran extremely well and the valves were in good condition at the end of the day's run; when it was found to be unnecessary to clean the valves. See Chart No. 10 and summary No. 29.

Trial No. 32.

The air-openings in the lower zone were enlarged after test No. 31.

As the generator was supplying the ore concentrating laboratory with power, it was impossible to maintain as steady a load as desired. And owing to the large amount of water used by the concentrating machinery, the water supply for cooling the engine and gas cleaning system was insufficient, thus causing the suction to rise.

The wash from the coke scrubber contained a smaller quantity of solid matter than in the preceding trials. This substance was of a light brown colour.

The gas from the upper zone burned freely beneath the bars of the lower zone.

At the end of the test the valves and cylinder of the engine were in excellent condition.

Trial No. 33.

The area of the air-openings for this trial was increased.

The solid matter in the wash from the coke scrubber was of small amount and of a light yellow colour.

The gas drawn from the upper zone was observed to be burning beneath the grate bars of the lower zone throughout the entire trial; with the exception of one hour, from 2 to 3 p.m., when no flames could be seen.

The valves and cylinders were clean at the end of the run.

The material removed by the gauze cone collected on its outer surface and filled the space between the cone and the perforated cylinder surrounding it. This caused the suction to rise. See Chart No. 14 and summary No. 33.

Trial No. 34.

The air-openings during this trial were not changed from the previous day's run.

A small amount of tar got into the cylinder almost immediately after starting; but this quickly disappeared. The operation of the engine throughout the day, and its condition when closing down at the end of the test, were excellent. The wash contained a small amount of solid matter of a yellow colour.

Trial No. 35.

Previous to this test the coke scrubber had been permanently altered, as shown in detail on Fig 13. The perforated cylinder was removed and the wire gauze cone fitted with an iron ring and bolts for clamping it in position over the hole. An overflow was provided, as shown on Fig. 13; for carrying off the solid matter separated from the gas by the cone. An arrangement was also provided for spraying the interior of the cone with the hot return cooling water from the engine, whenever the suction rose very high.

The producer was operated during the day's run on two different air-openings. From 9.00 a.m. until 12.25 p.m. an opening of 2·2 square inches was used. From 12.25 p.m. to the end of the run the area of the air-openings was increased to 3·3 square inches—the full load gauge openings. It will be seen from an inspection of the charts and log sheets, Chart No.

16 and summary No. 35, (p. 101) that this increase was accompanied by a reduction of the suction at the engine and producer, and of the temperature of the gas leaving the upper zone. The calorific value of the final gas and temperature of the gas leaving the producer were increased. From the gas analysis of a sample of gas taken from the upper zone it will be seen that as a result of this change in the air-openings—the increase in the areas of the openings—the carbon dioxide was increased; and that the carbon monoxide and hydrogen were decreased in the gas from the upper zone; while for the final gas the carbon dioxide and hydrogen were decreased, and the carbon monoxide increased.

The engine finished in excellent condition, with clean valves and piston.

Trial No. 36.

The air-openings of the lower zone during this trial corresponded to the full load mark on the gauge, namely, 3·3 square inches.

From Chart No. 17 and summary No. 36, it will be perceived that the suction increased considerably. This was due to a deposit on the gauze cone in the coke scrubber. In order to reduce the suction when it shows a tendency to increase, and for the purpose of maintaining the suction as nearly normal as possible throughout a day's run, a hot water spray has been provided which can be operated intermittently or whenever required. By this means the suction can be reduced in a very short time, seldom exceeding a minute.

At the end of the trial the engine was in excellent condition. No trouble was experienced with tar during this or the preceding run.

NOTES ON OPERATION OF PRODUCER FROM RESULTS OF PROGRESSIVE TRIALS.

Before proceeding with the comparative examination of the trials 28 to 36, in which progressive air-openings were used, a brief consideration of the principles involved in the operation of the producer is necessary.

The gas finally leaving the producer may be regarded as being derived from three sources:—

(a) Gases formed in the upper combustion zone of the producer which pass down through the contracted neck directly to the offtake.

(b) Gases formed by the reaction between the gases and moisture, which pass down the stand-pipe from the upper zone, and the incandescent fuel in the lower zone through which they pass.

(c) Gases formed by passing air through the fuel bed of the lower zone.

The relative quantities of the gases obtained from the above sources will depend upon the following factors:—

(1) The resistance to the entrance of air to the upper zone.

(2) The resistance offered to the passage of the gas (a) through the upper fuel zone, and down through the contracted neck to the offtake.

(3) The resistance of the gas (b) in its passage through the upper fuel zone, and down through the stand-pipe into the lower fuel zone.

(4) The resistance of the lower fuel zone.

(5) The resistance offered to the flow of air into the lower zone.

Using the figures and letters above, it will be seen that increasing the resistance (1) increases the flow of gas c; an increase in (2) increases b and c; an increase in (3) increases a and c; an increase in (4) increases a; an increase in (5) increases a and b.

Resistances (1) and (5), may be directly altered by an attendant, and the others moderated, to some extent, by poking and cleaning.

The effect of increasing the air-opening of the lower zone as seen above, is to decrease the flow of gas down the stand-pipe. The only source of supply of moisture to the incandescent fuel of the lower zone—with the exception of the small quantity introduced with the air supply—is, the gases and vapours from the upper zone; which moisture can only find its way to the lower zone of combustion by passing down the stand-pipe. This supply is obviously decreased by enlarging the lower air-openings. That is to say, that a small proportion of the moisture from the peat passes up through the lower fuel bed; the remaining quantity of moisture, therefore, passes down through the narrow neck directly to the final offtake. As a consequence, there is very little probability of it reacting with carbon. The effect of this is shown in the trials. For instance, in trial 29—when the stand-pipe was inadvertently plugged up, and consequently no moisture was passed up through the lower zone—the hydrogen content was as low as 4·7 per cent; whereas, with the small air-openings in trials 30 and 31 the hydrogen contents were 10·6 and 10·9, which were reduced with increased air openings to 7·4. In trial 35, in which the air-openings were changed during the trial, the effect of an enlargement of the air-openings was to reduce the hydrogen from 9·9 to 7·8 per cent.

A further tendency, due to enlargement of the air-openings of the lower zone—as appears, from the gas analyses—is, to decrease the CO_2, and to increase the CO found in the final gas, with an increase in its calorific value; this increase in the CO constituent, and decrease in the CO_2, would appear to be due to an increase in the temperature of the lower combustion zone, consequent upon a larger portion of air being admitted to that zone. No connexion can be traced, however, between the temperature of the final gases and any condition of working of the producer other than the character of the tar deposit from the scrubbers. These temperatures can not give a direct indication of the conditions in the lower fuel bed; for the temperature of the final gas must be considerably modified by the layer of fuel through which it has to pass, and by that portion of the moisture and gases given off by the peat in the upper zone, which pass down through the contracted neck directly to the final exit.

In trial 35 the enlargement of the air-openings in the lower zone was attended by a rise in temperature in the final gas; an increase in the carbon monoxide; and a decrease in the carbon dioxide.

While the gas analyses are not sufficient in number to warrant an accurate deduction as to the efficiency of the producer; the efficiencies calculated from the analyses at our disposal, show a manifest increase when the air-openings to the lower zone are enlarged.

FUEL CONSUMPTION, TRIALS 28 TO 36.

The pounds of dry peat consumed per hour per brake horse-power, in these trials—in which the engine was run at ¾ load—varied from 1·77 to 2·16 pounds; while the average consumption was 2 pounds.

If a plant were run for 10 hours, at ¾ load, and then closed down for 14 hours, the total consumption per B.H.P.H., including the fuel used for banking—which has been found to be about 3 pounds per hour—would amount to 2·09 pounds.

The figure used for the fuel consumed during the hours the producer was standing idle, was obtained from a special test, previously referred to—page 53. The figure given for the quantity used in trials 28 to 36 is higher than that; since it includes the fuel used for the preliminary generation of gas before it was deemed advisable to start the trial.

GENERAL DEDUCTIONS AND CONCLUSIONS.

The tests carried out and described in the foregoing pages are divided into two parts:—

PART I.

Part I describes the tests carried out with the producer as originally constructed. This series of tests showed a good fuel economy, but left something to be desired as regards the cleanliness of the gas delivered to the engine. The deposition of tar in the gas main, and on the valves, cylinder, and piston of the engine, necessitated the cleaning of the parts affected. At the close of the run it was generally found necessary to remove the valves for cleaning, and to wash the cylinder and piston from time to time during the running of the engine. The operation of cleaning was accomplished by syringing the cylinder and piston with a mixture of oil-soap and water; and while the continuity of the running of the engine was at no time endangered by the presence of tar, the operation of cleaning occupied more of the engineer's time than was considered desirable.

In order to obviate this trouble, such as it was, the makers at their own expense had the producer reconstructed.

PART II.

Part II of the report deals with the tests carried out with the producer as reconstructed by the makers, and with the modification introduced by the technical staff of the Fuel Testing Station.

Upon scrutinizing the first of this series of tests it will be perceived that tar still reached the engine—in spite of the change in construction; and although a manifest improvement was discerned, it was found necessary from time to time to wash the cylinder and piston as in the previous series of tests.

Further tests were conducted in order to observe the effect which changes in the distribution of the air admitted to the upper and lower combustion zones would have upon the production of tar. The results of these tests led, on the one hand, to the abandonment of the idea of totally destroying all the tarry matter within the producer itself, and on the other hand, to the necessity of separating the tar from the gas in the cleaning system.

After some preliminary experimentation, a solution of the problem was found by placing a gauze cone in the top chamber of the coke scrubber. After the inclusion of this cone in the cleaning system no further trouble with tar was experienced, *and the operation of the plant, as it now stands, may be pronounced as entirely satisfactory.*

The results of the investigation may be summarized as follows:—

RELIABILITY.

The peat producer-gas power plant, as now constructed, may be pronounced thoroughly reliable. Its operation may be carried on continuously for a week or more without having to shut down for the purpose of cleaning the valves of the engine. The engine has been operated for a period of 150 hours without removing either the admission or mixing valves for cleaning.

It should not be found necessary in commercial practice, to remove the piston for the purpose of cleaning, more than once in six months.

The operation of the producer is uniform, and the gas delivered to the engine varies only slightly during a ten hours run. The removal of ashes, and the cleaning of the fires, can be done without interfering with the operation of the engine; due to a change in the quality of the gas.

ATTENDANCE.

A peat-producer-gas-power-plant of the size installed in the Fuel Testing Station can safely be left in the hands of an intelligent labourer after he has received, for a week or so, instructions in the handling of the plant, from a competent engineer. The services of only one man are required to run this plant when it is operated on day shift work only.

CLEANING OF GAS PIPES, MAINS, VALVES, ETC.

It is recommended that the gas pipes leading from the producer to the cleaning system and the tar filter be cleaned once a week, if possible, when the plant is run ten hours a day during the working days of the year. If this is done, very little will be required to keep the plant in good condition. The admission and mixing valves of the engine will not require cleaning for two weeks or more.

FUEL CONSUMPTION.

The consumption of fuel per brake horse-power hour—including stand-by losses—is for *full load, 1·7 lbs. of dry peat, or 2·3 lbs. of peat containing 25 per cent moisture; for $\frac{3}{4}$ load,* the fuel consumption—including stand-by losses—is *2·1 lbs. of dry peat or 2·8 lbs. of peat containing 25 per cent moisture.*

COST OF FUEL.

In estimating fuel costs, the assumption is made that peat with a moisture content of 25 per cent can be delivered to the producer for $2 per ton. In order, however, to take advantage of this, or a lower cost for fuel, the power plant will have to be situated at or near the bog where the peat fuel is manufactured. For small plants of the type and capacity described in the foregoing pages this might not prove feasible in many cases; but will prove entirely feasible and practicable when the plants are of large capacity and when the energy developed is transmitted, in the form of electricity, to neighbouring towns and villages, for lighting, power, and other purposes.

Since the fuel burned in the producer does not require to be of the best quality, the fuel cost may be considerably reduced, since the broken peat bricks and considerable fines—which always occur in the manufacture of peat and otherwise represent a loss—can be efficiently utilized in the producer. Assuming, however, that peat can be delivered to the plant for $2 per ton, and that the plant is run with a power factor of 75 per cent for 3,000 hours, the fuel costs would be $8.40 per B.H.P. year, including stand-by losses.

PLANT COSTS.

The first cost of a plant of this type, in comparison with that of other types, should be left for the consideration of those interested in particular cases, by obtaining competitive prices from manufacturers. Local conditions, capacity of plant, etc., changes the first cost so considerably that any figures quoted here might prove misleading.

BY-PRODUCT RECOVERY PLANTS.

In various plants at present utilizing peat for the production of power, the net cost of developing power is considerably reduced by the sale of sulphate of ammonia and tar; which are recovered as by-products. This recovery is attempted only in plants of larger size than the one ~~described~~ ~~in the foregoing pages.~~ used,

TABLE XV.

TRIALS WITH ALFRED PEAT, AIR OPENING FOR FULL LOAD ON GAUGE

1.	No. of trial	20	21	
2.	Date of trial	Sept. 19	Sept. 20 and 21	1911.
3.	Time of starting	11.30 a.m.	10.10 a.m.	
4.	Time of stopping	9.30 p.m.	6.10 a.m.	
5.	Duration	10	20	hrs.
6.	Total peat charged during trial	1250	2450	lbs.
7.	Total ash and clinker drawn during trial	60	116	“
8.	Total peat used for banking and starting	....	431	“
9.	Total peat used during trial and for banking and starting	....	2881	“
	PARTICULARS OF PEAT USED.			
10.	Moisture % in peat as charged	31·4	30·2	
	Proximate analysis of dried peat as charged.			
11.	Fixed carbon	29·5	30·0	%
12.	Volatile matter	64·8	64·6	%
13.	Ash	5·7	5·4	%
14.	Calorific value of dry peat	9470	9450	B.T.U. per lb.
15.	Calorific value of peat as charged	6500	6600	
16.	Combustible matter in refuse withdrawn during trial	53·4	29·7	per cent.
17.	Barometer reading	29·85	29·88	inches
18.	Wet bulb (in producer room)	....	59·2	°F
19.	Dry bulb “	....	67·1	°F
20.	Humidity “	....	64·8	per cent.
21.	Average suction at producer exit	0·6	0·5	in. of water
22.	“ “ after coke scrubber	4·3	2·6	
23.	“ “ “ tar filter	4·7	4·7	“
24.	“ “ “ dry scrubber	5·7	5·4	“
25.	Temperature of gas leaving producer in No. 1 exit	469	475	°F
	ENGINE AND GENERATOR.			
26.	Average revolutions per minute of engine	190	190	
27.	Temperature of outlet cooling water	111	115	°F.
28.	Average kilowatts delivered to switchboard	35·3	35·2	
29.	Average electrical horse-power	47·3	47·2	
30.	Efficiency of dynamo	0·88	0·88	
31.	Average brake horse-power of engine	53·8	53·7	

TABLE XV—*Concluded.*

TRIALS WITH ALFRED PEAT, AIR OPENING FOR FULL LOAD ON GAUGE—*Concluded.*

		10 samples	20 samples	
	GAS ANALYSIS, per cent by volume Sample taken after passing tar filter.			
32.	Carbon dioxide	10·8	9·9	per cent.
33.	Ethylene	0·5	0·4	"
34.	Oxygen	0·5	0·3	"
35.	Carbon monoxide	17·7	20·2	"
36.	Methane	2·4	2·4	"
37.	Hydrogen	10·2	10·3	"
38.	Nitrogen	57·9	56·5	"
39.	Inflammable gas	30·8	33·3	"
40.	Calorific value from analysis (gross)	122	128	B.T.U. per cub. ft.
41.	" " " " (net)	113	120	
42.	Average net calorific value from recording gas calorimeter	123	127	
	RESULT OF TESTS.			
43.	Total peat charged during trial	1250	2450	lbs.
44.	Total dry peat charged during trial	858	1710	"
45.	Total ash and clinker drawn during trial	60	116	"
46.	Ash and clinker drawn per cent of peat charged	4·8	4·7	
47.	Ash and clinker drawn per cent of dry peat charged	7·0	6·8	
48.	Average kilowatts delivered to switchboard	35·3	35·2	
49.	Average brake horse-power of engine	53·8	53·7	
	HOURLY QUANTITIES.			
50.	Lbs. of peat charged	125	122	
51.	" dry peat charged	86	86	
	ECONOMIC RESULTS.			
52.	Peat charged per K.W. hour	3·54	3·47	lbs.
53.	Dry peat charged per K.W. hour	2·44	2·44	"
54.	Peat charged per B.H.P. hour	2·32	2·27	"
55.	Dry peat charged per B.H.P. hour	1·6	1·6	"
56.	Overall thermal efficiency of engine and producer	16·8	16·9	"
	RESULTS DEDUCED FROM FUEL AND GAS ANALYSES.			
57.	Air supplied to producer per lb. of dried peat charged	39·2	37·6	cub. ft.
58.	Water supplied to producer per lb. of dried peat charged	0·47	0·46	lbs.
59.	Cubic feet of gas produced per lb. of dried peat charged	53·4	52·6	
60.	Heat equivalent of gas produced per lb. of dried peat charged	6040	6310	B.T.U.
61.	Producer efficiency	63·8	66·8	per cent.
62.	Cubic feet of gas delivered to engine per per hour	4590	4520	
63.	Cubic feet of gas delivered per B.H.P. per hour	85	84	
64.	Heat equivalent of gas delivered per B.H.P. per hour	9660	10100	B.T.U.
65.	Thermal efficiency of engine (B. H. P. basis)	26·3	25·2	per cent.

Chart Nº 6

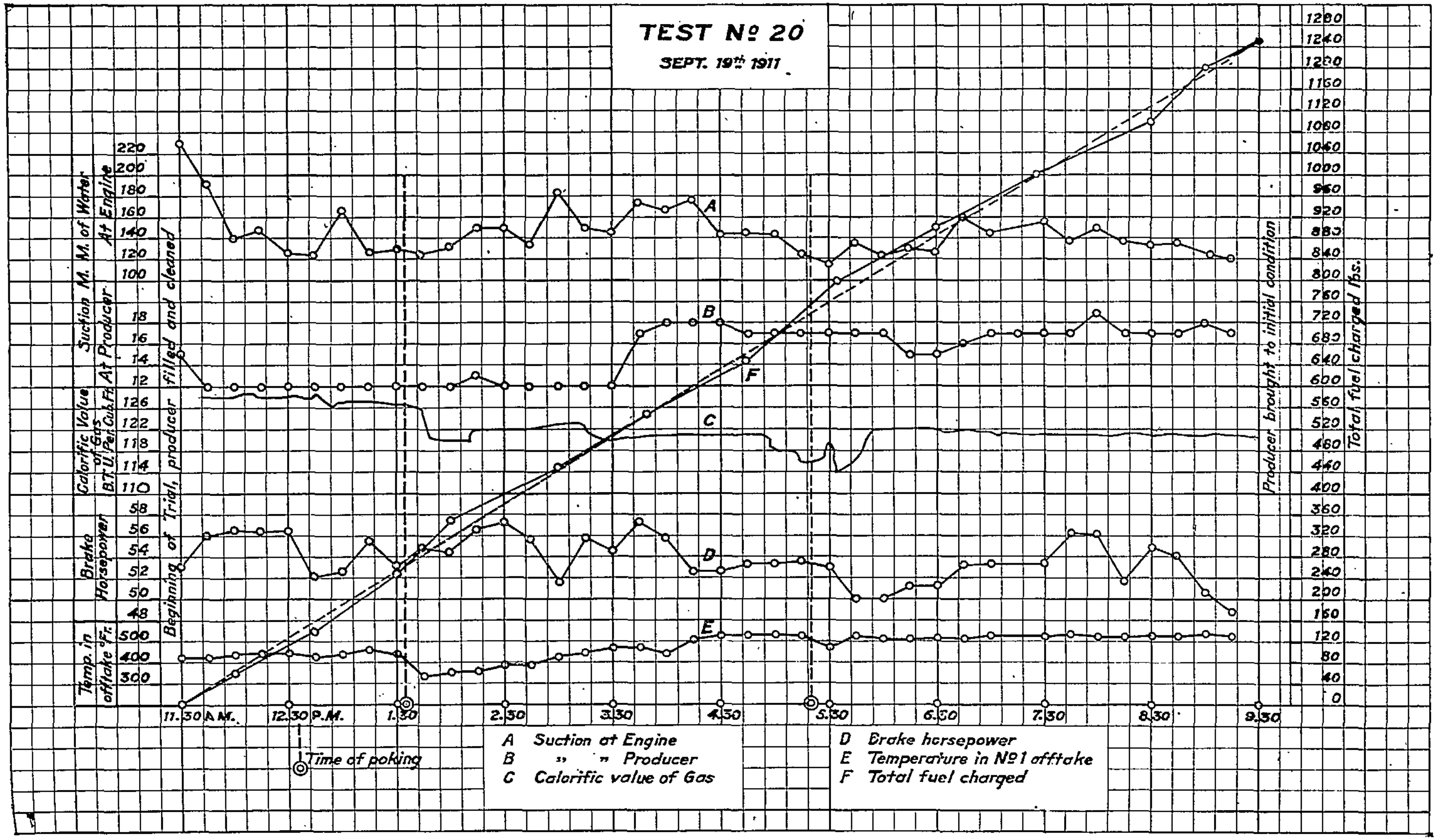

TEST Nº 20
SEPT. 19th 1911
Suction M. M. of Water
At Engine
220
200
180
160
140
120
100
At Producer
18
16
14
12
Calorific Value of Gas B.T.U. Per Cub. Ft.
126
122
118
114
110
Brake Horsepower
58
56
54
52
50
48
Temp. in offtake °F.
500
400
300
Beginning of Trial, producer filled and cleaned
11.30 A.M.
12.30 P.M.
1.30
2.30
3.30
4.30
5.30
6.30
7.30
8.30
9.30
Time of poking
Producer brought to initial condition
Total fuel charged lbs.
1280
1240
1200
1160
1120
1080
1040
1000
960
920
880
840
800
760
720
680
640
600
560
520
480
440
400
360
320
280
240
200
160
120
80
40
0
A
B
C
D
E
F
A Suction at Engine
B " " Producer
C Calorific value of Gas
D Brake horsepower
E Temperature in Nº 1 offtake
F Total fuel charged

Chart Nº 7

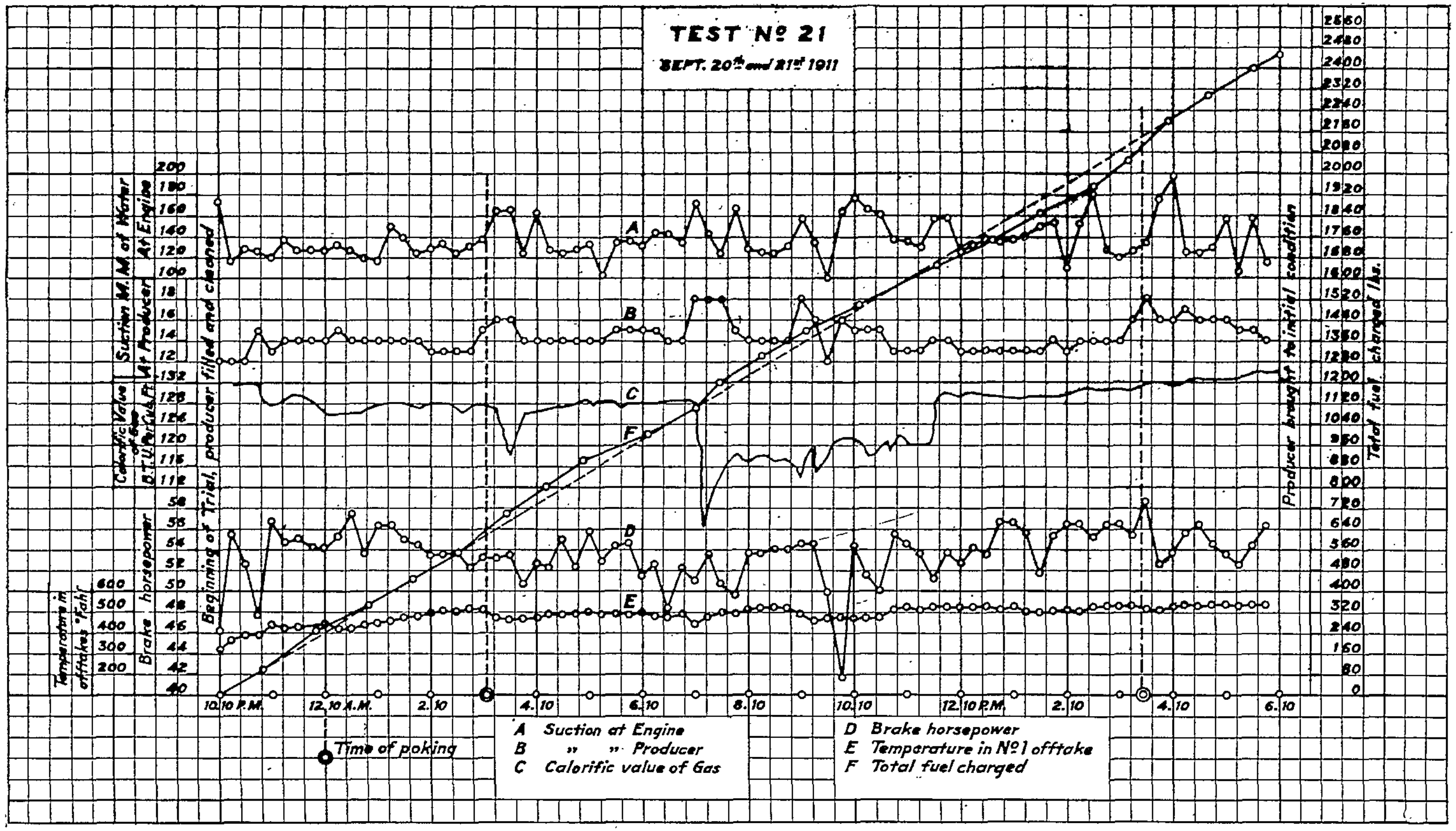

TEST Nº 21
SEPT. 20th and 21st 1911
Suction M.M. of Water
At Engine
At Producer
Calorific Value of Gas B.T.U. Per Cu. Ft.
Brake horsepower
Temperature in offtakes °Fahr.
Beginning of Trial, producer filled and cleaned
Producer brought to initial condition
Total fuel charged lbs.
200
180
160
140
120
100
18
16
14
12
132
128
124
120
116
112
58
56
54
52
50
48
46
44
42
40
600
500
400
300
200
2560
2480
2400
2320
2240
2160
2080
2000
1920
1840
1760
1680
1600
1520
1440
1360
1280
1200
1120
1040
960
880
800
720
640
560
480
400
320
240
160
80
0
10.10 P.M.
12.10 A.M.
2.10
4.10
6.10
8.10
10.10
12.10 P.M.
2.10
4.10
6.10
A
B
C
D
E
F
Time of poking
A Suction at Engine
B " " Producer
C Calorific value of Gas
D Brake horsepower
E Temperature in Nº 1 offtake
F Total fuel charged

TABLE XVI.

TRIAL WITH FARNHAM PEAT; AIR OPENING FOR ¾ LOAD ON GAUGE

1. No. of trial	24	
2. Date of trial	Oct. 5	1911
3. Time of starting	9.30 a.m.	
4. Time of stopping	7.30 p.m.	
5. Duration	10–00	hrs.
6. Total peat charged during trial	1,102	lbs.
7. Total ash and clinker drawn during trial	125	"
8. Total peat used for banking and starting	155	"
9. Total peat charged, including that used for banking and starting	1,257	"
PARTICULARS OF PEAT USED.		
10. Moisture % in peat as charged	27·8	
Proximate analysis of dried peat as charged.		
11. Fixed carbon	29·9	per cent.
12. Volatile matter	65·1	"
13. Ash	5·0	"
14. Calorific value of dry peat	9730	B.T.U. per lb.
15. Calorific value of peat as charged	7020	
16. Combustible matter in refuse	43·1	per cent.
17. Barometer reading	30·00	inches
18. Wet bulb thermometer	51	°F.
19. Dry bulb thermometer	62	"
20. Humidity	46	per cent
21. Average suction at producer exit	0·4	inches of water
22. " " after coke scrubber	2·8	
23. " " " tar filter	5·5	
24. " " " dry scrubber	6·2	
25. Average temperature of gas at producer exit No. 1	621	°F.
26. Initial reading of water meter for producer and scrubber	3792	cub. ft.
27. Final " " "	4482	"
28. Difference	690	"
29. Time between readings	10	hrs.
ENGINE AND GENERATOR.		
30. Average revolutions per minute	194	
31. Average temperature of outlet cooling water	113	°F.
32. " indicated horse-power (gross)	52·2	
33. Average kilowatts delivered to switchboard	27·1	
34. " electrical horse-power	36·3	
35. Efficiency of dynamo	0·88	
36. Average brake horse-power of engine	41·3	
37. Mechanical efficiency	79·0	per cent
38. Initial reading of water meter for engine	8964	cub. ft.
39. Final " " "	9312	"
40. Difference	348	"
41. Time between readings	10	hrs.

TABLE XVI—*Concluded.*

TRIAL WITH FARNHAM PEAT; AIR OPENING FOR ¾ LOAD ON GAUGE—*Concluded.*

Gas Analysis per cent.		
By volume, sample taken after passing tar filter, average of 10 samples.		
42. Carbon dioxide	8·5	per cent
43. Ethylene	0·4	"
44. Oxygen	0·3	"
45. Carbon monoxide	22·4	"
46. Methane	2·1	"
47. Hydrogen	10·0	"
48. Nitrogen	56·3	"
49. Inflammable gas	34·9	"
50. Calorific value from analysis (gross)	132	B.T.U. per cub. ft.
51. Calorific value from analysis (net)	124	
52. Net calorific value from recording gas calorimeter	129	
Results of Tests.		
53. Total peat charged during trial	1102	lbs.
54. Total dry peat charged during trial	794	"
55. Total ash and clinker drawn during trial	125	"
56. Ash and clinker drawn per cent of peat charged	11·3	
57. Ash and clinker drawn per cent of dry peat charged	15·7	
58. Average kilowatts delivered to switchboard	27·1	
59. Average brake horse-power of engine	41·3	
Hourly quantities—		
60. Lbs. of peat charged	110	
61. " " dry peat charged	79	
62. Cub. ft. of water to producer	69·0	
63. " " " engine	34·8	
64. Gallons of water to producer	430	
65. " " " engine	216	
66. Peat charged per K.W. hour	4·06	lbs.
67. Dry peat charged per K.W. hour	2·91	"
68. Peat charged per B.H.P. hour	2·66	lbs.
69. Dry peat charged per B.H.P. hour	1·91	"
70. Overall thermal efficiency of engine and producer	13·7	per cent.
71. Gallons of water used per B.H.P. hour, by producers and scrubbers	10·4	
72. By engine	5·23	
Results Deduced from Fuel and Gas Analysis.		
73. Air supplied to producer per lb. of dried peat charged	34·8	cub. ft.
74. Water supplied to producer per lb. of dried peat charged	0·40	lbs.
75. Cubic feet of gas produced per lb. of dried peat charged	48·6	
76. Heat equivalent of gas produced per lb. of dried peat charged	6030	B.T.U.
77. Producer efficiency	62·0	per cent
78. Cubic feet of gas delivered to engine per hour	3840	
79. Cubic feet of gas delivered per B.H.P. per hour	93	
80. Cubic feet of gas delivered per I.H.P. per hour	74	
81. Heat equivalent of gas delivered per B.H.P. per hour	11500	B.T.U.
82. Thermal efficiency of engine (B.H.P. basis)	22·1	per cent
83. Heat equivalent of gas delivered I.P.H. per hour	9160	B.T.U.
84. Thermal efficiency of engine (I.H.P. basis)	27·9	per cent

Chart No. 8.

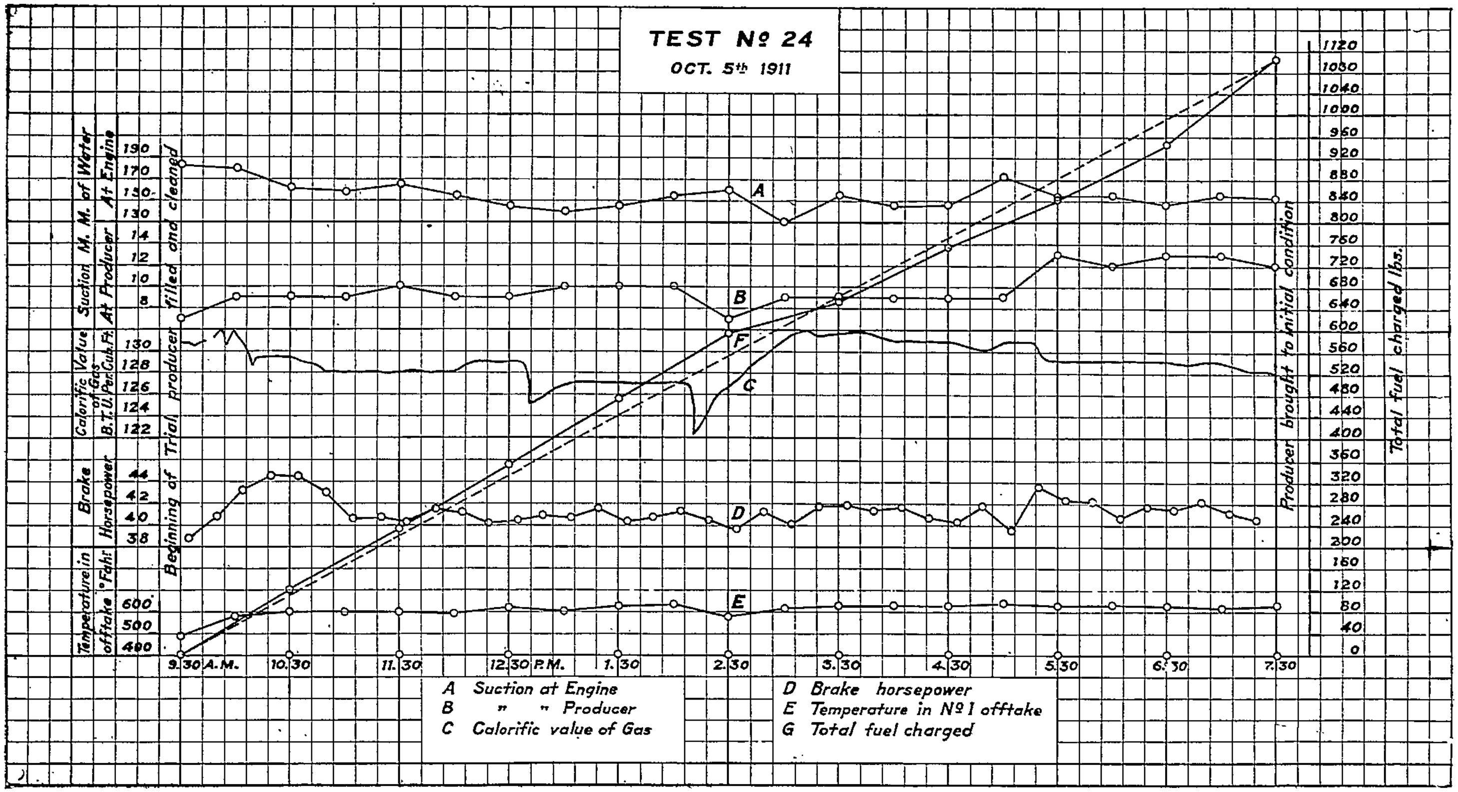

TEST No. 24
OCT. 5th 1911
Suction M. M. of Water
At Engine
190
170
150
130
At Producer
14
12
10
8
Calorific Value of Gas B.T.U. Per Cub. Ft.
130
128
126
124
122
Brake Horsepower
44
42
40
38
Temperature in offtake °Faht.
600
500
400
Beginning of Trial producer filled and cleaned
A
B
F
C
D
E
9.30 A.M.
10.30
11.30
12.30 P.M.
1.30
2.30
3.30
4.30
5.30
6.30
7.30
Producer brought to initial condition
Total fuel charged lbs.
1120
1080
1040
1000
960
920
880
840
800
760
720
680
640
600
560
520
480
440
400
360
320
280
240
200
160
120
80
40
0
A Suction at Engine
B " " Producer
C Calorific value of Gas
D Brake horsepower
E Temperature in No 1 offtake
G Total fuel charged

Chart No. 9.

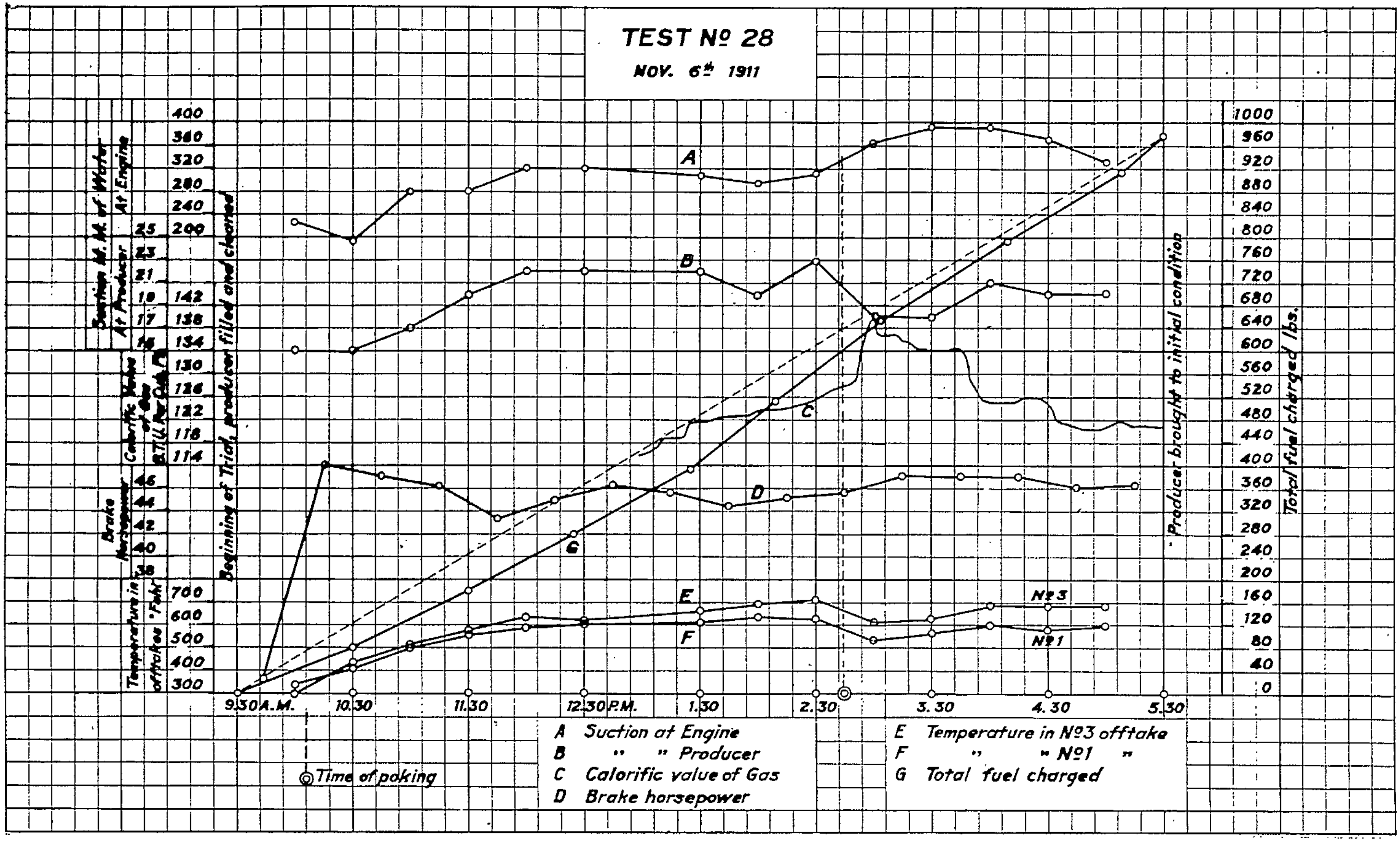

TEST No 28
NOV. 6th 1911
Suction M.M. of Water
At Producer
At Engine
Calorific Value of Gas B.T.U. Per Cub. Ft.
Brake Horsepower
Temperature in offtakes °Fahr.
400
360
320
280
240
200
25
23
21
19
17
15
142
138
134
130
126
122
118
114
46
44
42
40
38
700
600
500
400
300
Beginning of Trial, producer filled and cleaned
9.30 A.M.
10.30
11.30
12.30 P.M.
1.30
2.30
3.30
4.30
5.30
A
B
C
D
E
F
G
No 3
No 1
Producer brought to initial condition
Total fuel charged lbs.
1000
960
920
880
840
800
760
720
680
640
600
560
520
480
440
400
360
320
280
240
200
160
120
80
40
0
Time of poking
A Suction at Engine
B " " Producer
C Calorific value of Gas
D Brake horsepower
E Temperature in No 3 offtake
F " " No 1 "
G Total fuel charged

Table XVII.

TRIALS AT $\frac{3}{4}$ LOAD WITH PROGRESSIVE AIR OPENINGS, WITH PEAT FROM ALFRED, ONT.

Air Openings to Top Zone kept constant throughout.

1. No. of trial.	28.	29.	30.	31.	32.	33.	34.	35.	36.	——
2. Date of trial......	Nov. 5.	Nov. 9.	Nov. 10.	Nov. 13.	Nov. 14.	Nov. 16.	Nov. 17.	Nov. 23.	Nov. 24.	1911.
3. Air opening for bottom zone........	2·8	2·8	2·8	3·3	4·1	5·1	5·1	2·2 & 3·3	4·1	square inches.
4. Time of starting...	9.30 a.m.	9.45 a.m.	10.40 a.m.	9.45 a.m.	8.00 a.m.	9.00 a.m.	9.15 a.m.	9.00 a.m.	9.00 a.m.	
5. Time of stopping..	5.30 p.m.	5.45 p.m.	6.40 p.m.	5.45 p.m.	4.00 p.m.	5.00 p.m.	5.15 p.m.	5.00 p.m.	5.00 p.m.	
6. Duration..........	8	8	8	8	8	8	8	8	8	hrs.
7. Total peat charged during trial......	974	1,030	1,040	1,055	933	838	868	857	958	lbs.
8. Total dry peat charged during trial.	750	792	796	807	714	652	675	667	746	lbs.
Particulars of peat used. 9. Moisture per cent in peat as charged.	23·1	23·1	23·5	23·5	23·5	22·2	22·2	22·2	22·2	per cent.
Proximate analysis of dried peat. 10. Fixed carbon......	31·3	31·3	30·0	30·0	30·0	30·4	30·4	30·4	30·4	per cent.
11. Volatile matter....	64·8	64·8	65·3	65·3	65·3	64·8	64·8	64·8	64·8	per cent.
12. Ash..............	4·9	4·9	4·7	4·7	4·7	4·8	4·8	4·8	4·8	per cent.
13. Calorific value of dried peat.......	9,450	9,450	9,500	9,500	9,500	9,400	9,400	9,400	9,400	B.T.U. per lb.
14. Cal. value of peat as charged.......	7,270	7,270	7,270	7,270	7,270	7,310	7,310	7,310	7,310	B.T.U. per lb.
15. Barometer.........	29·84	30·33	30·06	29·89	30·16	29·9	30·05	29·92	29·55	inches.
16. Wet bulb..........	51	48·5	59	47·5	46·5	49·5	37	46	52	°F.
17. Dry bulb..........	61	59·0	74	58·0	57·5	61·0	45·5	57	65·5	°F..
18. Humidity per cent	50	45	40	44	41	42	42	41	38	per cent.
19. Average suction at producer exit....	0·8	0·8	0·7	0·7	0·5	0·5	0·5	0·7	0·7	in. of water.
20. Average suction after coke scrubber	8·0	5·4	6·2	5·8	5·3	7·4	11·0	8·9	10·1	in. of water.
21. Average suction after tar filter.....	11·1	9·8	10·8	10·7	9·9	10·2	14·4	13·1	17·3	in. of water.
22. Average suction after dry scrubber.	12·2	10·9	11·9	11·6	10·5	11·3	15·0	13·8	18·3	in. of water.
23. Average temperature of gas at top exit (No. 2)......	246	260	257	283	262	250	252	266	230	°F.
24. Average temperature of gas at final exit (No. 1).....	555	615	525	581	650	590	601	526	500	°F.
25. Average temperature of gas at final exit (No. 3)......	601	660	781	727	755	750	818	742	820	°F.
Engine and Generator. 26. Average kilowatts delivered to switchboard..............	29·5	30·0	31·1	30·8	30·3	30·3	29·6	30·1	30·0	
27. Average electrical horse-power.....	39·5	40·2	41·7	41·3	40·6	40·2	39·6	40·3	40·2	
28. Efficiency of dynamo.............	0·88	0·88	0·88	0·88	0·88	0·88	0·88	0·88	0·88	
29. Average brake horse-power of engine	45·0	45·7	47·4	46·9	46·2	45·8	45·1	45·9	45·8	
Analysis of gas in stand-pipe, per cent by volume..............	....	1 sample.	2 samples.	3 samples.	3 samples.	3 samples.	3 samples.	2 samples.	3 samples.	
30. Carbon dioxide....	....	3·0	11·2	10·8	10·8	12·3	12·6	13·3	15·3	per cent.
31. Ethylene..........	....	0·1	0·9	1·1	0·8	0·8	0·8	0·9	1·0	per cent.
32. Oxygen...........	....	17·6	1·4	3·2	4·9	2·4	4·3	0·5	0·4	per cent.
33. Carbon monoxide.	....	0·1	19·7	17·4	13·1	15·6	11·6	18·3	16·0	per cent.
34. Methane..........	....		3·5	7·4	2·9	3·5	3·1	3·5	3·9	per cent.
35. Hydrogen.........	....	....	8·4	3·1	5·7	6·3	4·6	8·6	6·8	per cent.
36. Nitrogen..........	....	....	54·9	57·0	61·8	59·1	63·0	54·9	56·6	per cent..........
37. Inflammable gas...	....	....	32·6	29·0	22·5	26·2	20·1	31·3	27·7	per cent.
38. Calorific value from analysis (gross)..	....	....	139	127	102	118	95	136	128	B.T.U. per cub. ft.
39. Calorific value fron analysis (net)....	....	....	131	119	96	110	89	127	120	B.T.U. per cub. ft.
Analysis of final gas after tar filter per cent, by volume	....	2 samples.	2 samples.	2 samples.	2 samples.	3 samples.	2 samples.	2 samples.	3 samples.	
40. Carbon dioxide....	....	5·1	9·0	9·9	6·55	5·9	4·8	8·3	6·5	per cent.
41. Ethylene..........	....	0·4	0·1	0·4	0·15	0·4	0·2	0·3	0·5	per cent.
42. Oxygen...........	....	0·4	0·2	0·4	0·25	0·2	0·5	0·4	0·7	per cent.
43. Carbon monoxide..	....	26·8	20·7	19·3	24·65	26·3	26·9	22·4	24·4	per cent.
44. Methane..........	....	1·7	1·9	2·4	2·05	1·9	2·0	2·0	2·9	per cent.
45. Hydrogen.........	....	4·7	10·6	10·9	8·85	9·1	7·4	8·8	7·5	per cent.
46. Nitrogen..........	....	60·9	57·5	56·7	57·5	56·2	58·2	57·8	57·5	per cent.
47. Inflammable gas...	....	33·6	33·3	33·0	35·7	37·7	36·5	33·5	35·3	per cent.
48. Calorific value from analysis (gross)..	....	124	121	128	130	139	133·5	125	138	B.T.U. per cub. ft.
49. Calorific value from analysis (net)....	....	120	114	120	123	132	127·5	118	131	B.T.U. per cub. ft.
50. Net calorific value from recording gas calorimeter	126	130	121	124	130	138	133	127	134	B.T.U. per cub. ft.
51. Grams of tar per 1,000 cub. ft. of final gas.........	....	7·1	13·8	21·6	25·1	24·6	23·6	12·7	7·6	
Economic results of tests 52. Average kilowatts delivered to switchboard..............	29·5	30·0	31·1	30·8	30·3	30·0	29·6	30·1	30·0	
53. Average brake horse-power at engine...........	45·0	45·7	47·4	46·9	46·2	45·8	45·1	45·9	45·8	
Hourly quantities. 54. Lbs. of peat charged..............	122	129	130	132	117	104	108	107	120	Lbs.
55. Lbs. of dry peat charged.........	94	99	99	101	89	81	84	83	93	Lbs.
56. Peat charged per K.W. hour.......	4·14	4·30	4·18	4·29	3·86	3·47	3·65	3·55	4·0	Lbs.
57. Dry peat charged per K.W. hour..	3·19	3·30	3·18	3·28	2·94	2·70	2·84	2·76	3·10	Lbs.
58. Peat charged per B.H.P. hour.....	2·71	2·82	2·74	2·81	2·53	2·27	2·40	2·33	2·62	Lbs.
59. Dry peat charged per B.H.P. hour.	2·09	2·16	2·09	2·15	1·93	1·77	1·86	1·81	2·03	Lbs.
60. Overall thermal efficiency........	12·9	12·5	12·8	12·5	13·9	15·3	14·6	14·9	13·3	per cent.

Chart No 10

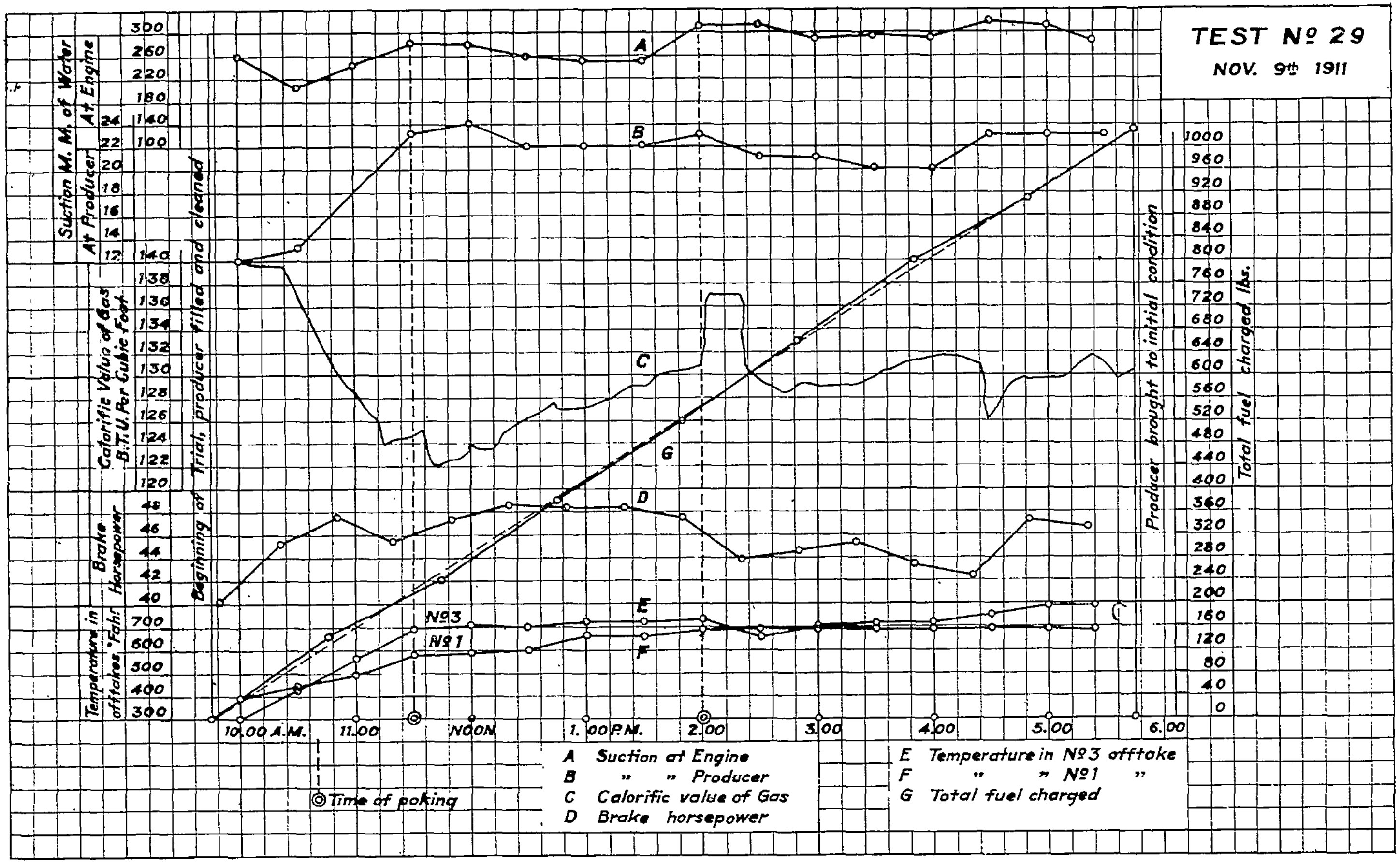

TEST No 29
NOV. 9th 1911
Suction M. M. of Water
At Engine
At Producer
300
260
220
180
140
100
24
22
20
18
16
14
12
Calorific Value of Gas B.T.U. Per Cubic Foot
140
138
136
134
132
130
128
126
124
122
120
Brake Horsepower
48
46
44
42
40
Temperature in offtakes °Fahr.
700
600
500
400
300
Beginning of Trial, producer filled and cleaned
Producer brought to initial condition
Total fuel charged lbs.
1000
960
920
880
840
800
760
720
680
640
600
560
520
480
440
400
360
320
280
240
200
160
120
80
40
0
10.00 A.M.
11.00
NOON
1.00 P.M.
2.00
3.00
4.00
5.00
6.00
A
B
C
D
E
F
G
No3
No1
◎ Time of poking
A Suction at Engine
B " " Producer
C Calorific value of Gas
D Brake horsepower
E Temperature in No3 offtake
F " " No1 "
G Total fuel charged

Chart No. II

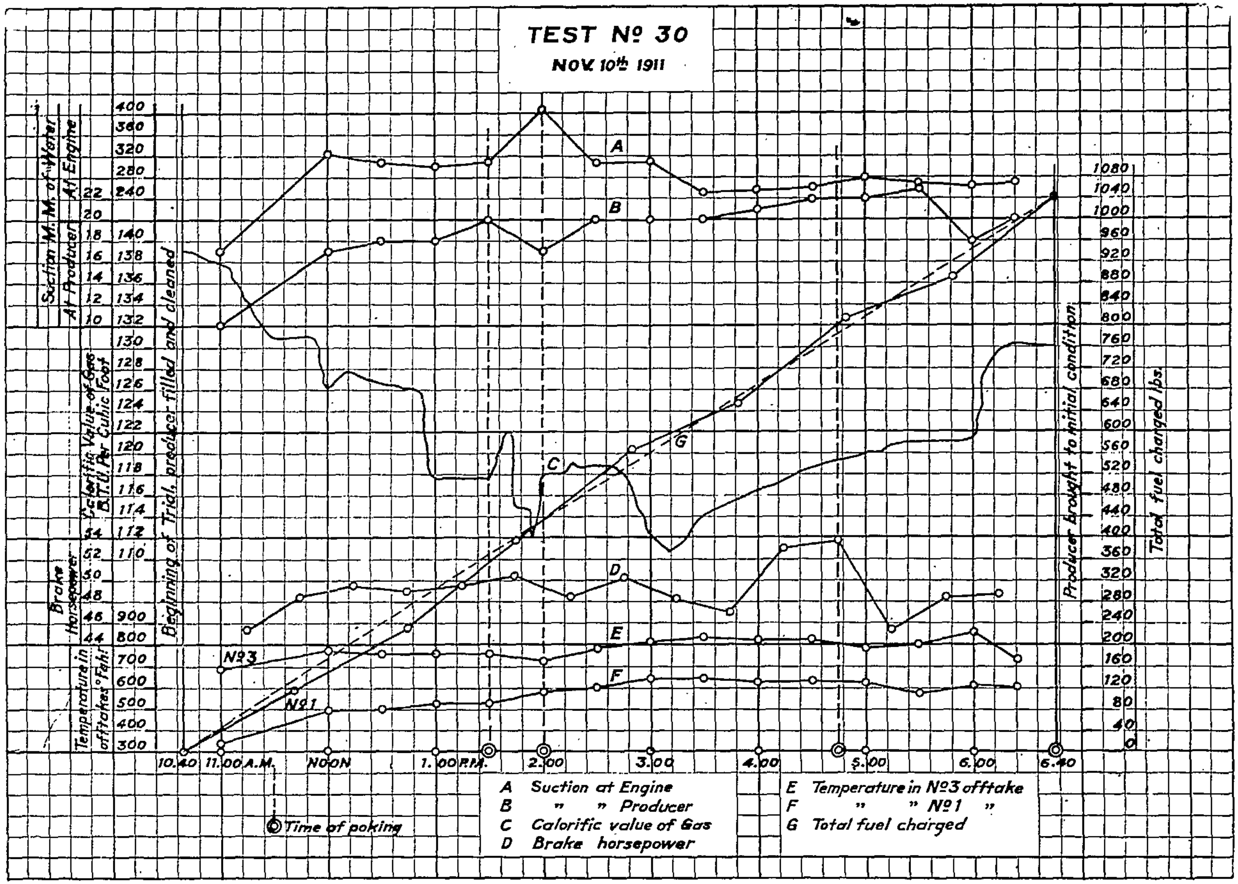

TEST No 30
NOV. 10th 1911
Suction M.M. of Water
At Producer
At Engine
Calorific Value of Gas B.T.U. Per Cubic Foot
Brake Horsepower
Temperature in offtakes °Fahr.
Beginning of Trial, producer filled and cleaned
Producer brought to initial condition
Total fuel charged lbs.
A
B
C
D
E
F
G
No 3
No 1
10.40
11.00 A.M.
NOON
1.00 P.M.
2.00
3.00
4.00
5.00
6.00
6.40
Time of poking
A Suction at Engine
B " " Producer
C Calorific value of Gas
D Brake horsepower
E Temperature in No 3 offtake
F " " No 1 "
G Total fuel charged

Chart No. 12

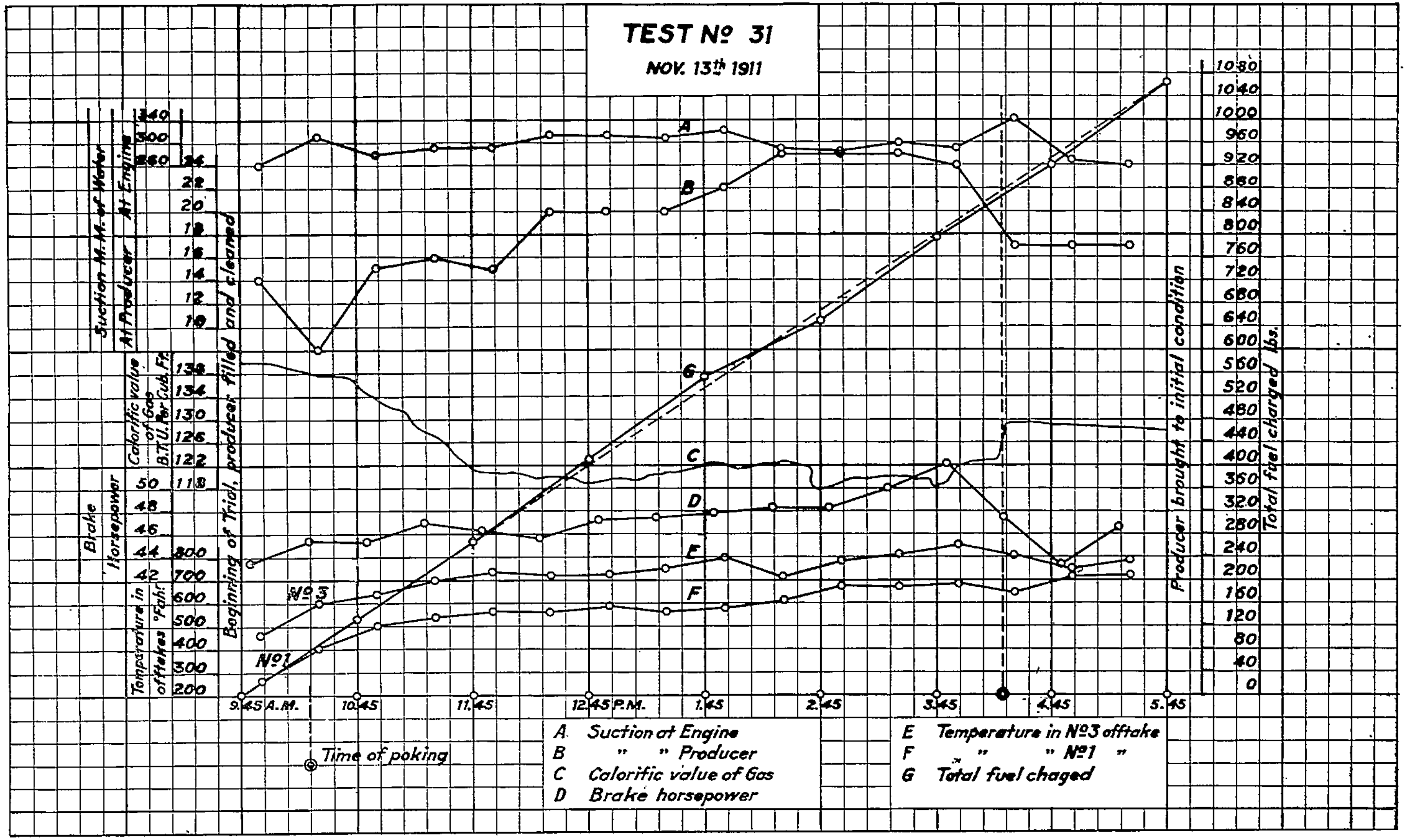
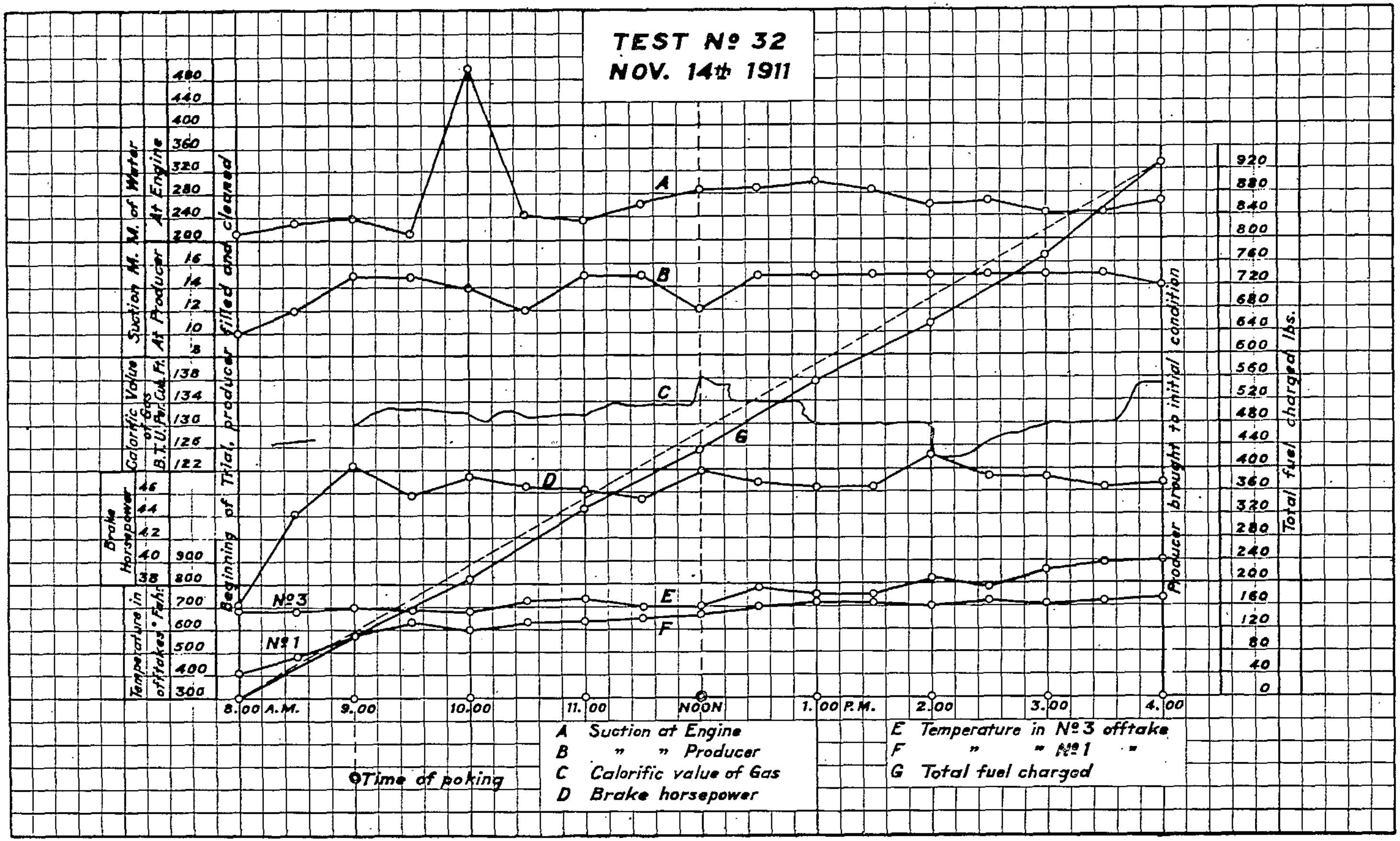

TEST No. 31
NOV. 13th 1911
Suction M.M. of Water
At Producer
At Engine
340
300
260
24
22
20
18
16
14
12
10
Calorific value of Gas B.T.U. Per Cub. Ft.
138
134
130
126
122
118
Brake Horsepower
50
48
46
44
42
Temperature in offtakes °Fahr.
800
700
600
500
400
300
200
Beginning of Trial, producer filled and cleaned
Producer brought to initial condition
Total fuel charged lbs.
1080
1040
1000
960
920
880
840
800
760
720
680
640
600
560
520
480
440
400
360
320
280
240
200
160
120
80
40
0
9.45 A.M.
10.45
11.45
12.45 P.M.
1.45
2.45
3.45
4.45
5.45
A
B
C
D
E
F
G
No. 3
No. 1
Time of poking
A Suction at Engine
B " " Producer
C Calorific value of Gas
D Brake horsepower
E Temperature in No. 3 offtake
F " " " No. 1 "
G Total fuel chaged

Chart № 13



TEST № 32
NOV. 14th 1911
Suction M. M. of Water
At Engine
At Producer
Calorific Value of Gas B.T.U. Per Cub. Ft.
Brake Horsepower
Temperature in offtakes ° Fah.
480
440
400
360
320
280
240
200
16
14
12
10
8
138
134
130
126
122
46
44
42
40
38
900
800
700
600
500
400
300
Beginning of Trial, producer filled and cleaned
Producer brought to initial condition
Total fuel charged lbs.
920
880
840
800
760
720
680
640
600
560
520
480
440
400
360
320
280
240
200
160
120
80
40
0
A
B
C
D
E
F
G
№ 3
№ 1
8.00 A.M.
9.00
10.00
11.00
NOON
1.00 P.M.
2.00
3.00
4.00
Time of poking
A Suction at Engine
B " " Producer
C Calorific value of Gas
D Brake horsepower
E Temperature in № 3 offtake
F " " № 1 "
G Total fuel charged

21256—8

Chart No. 14

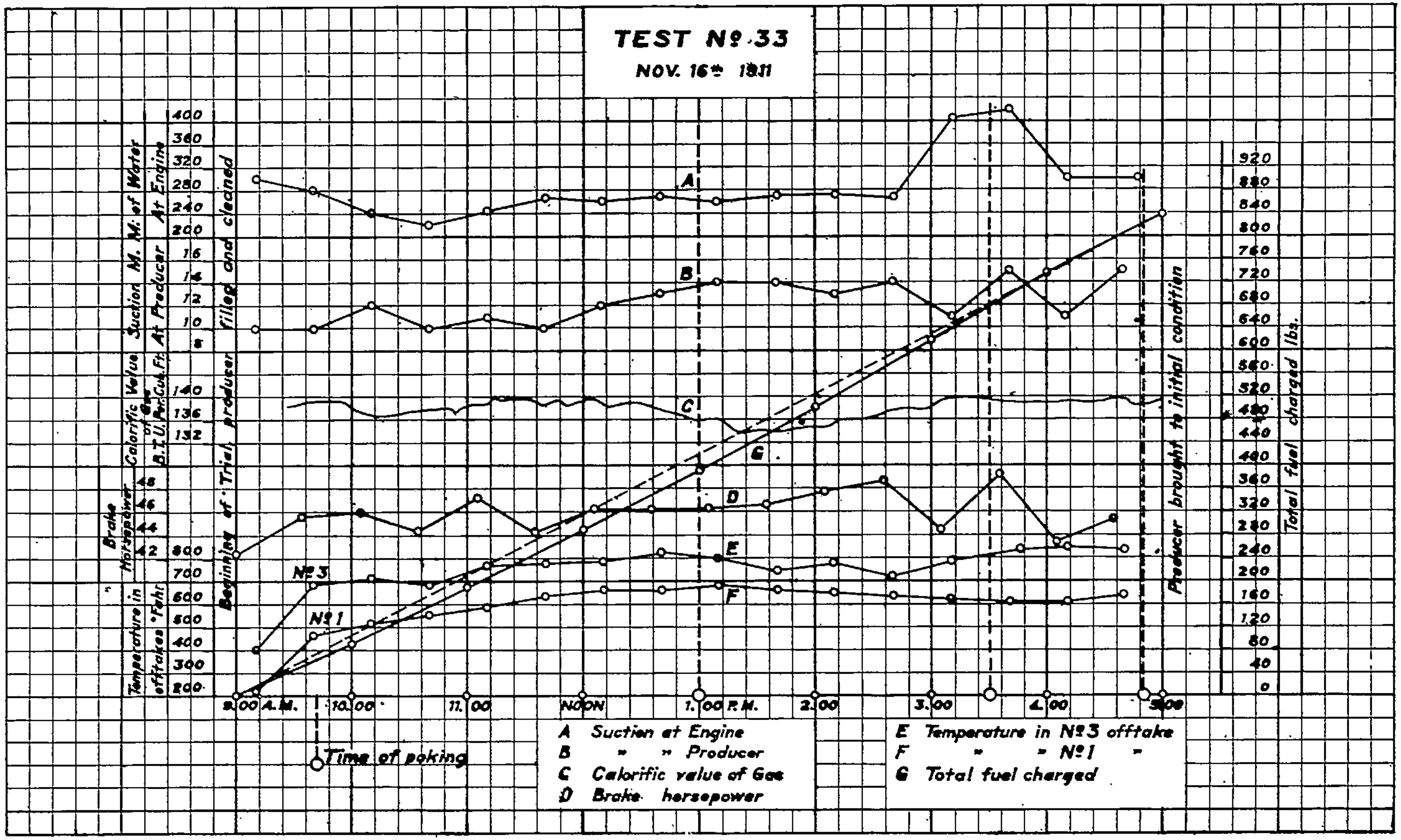


Chart Nº 15

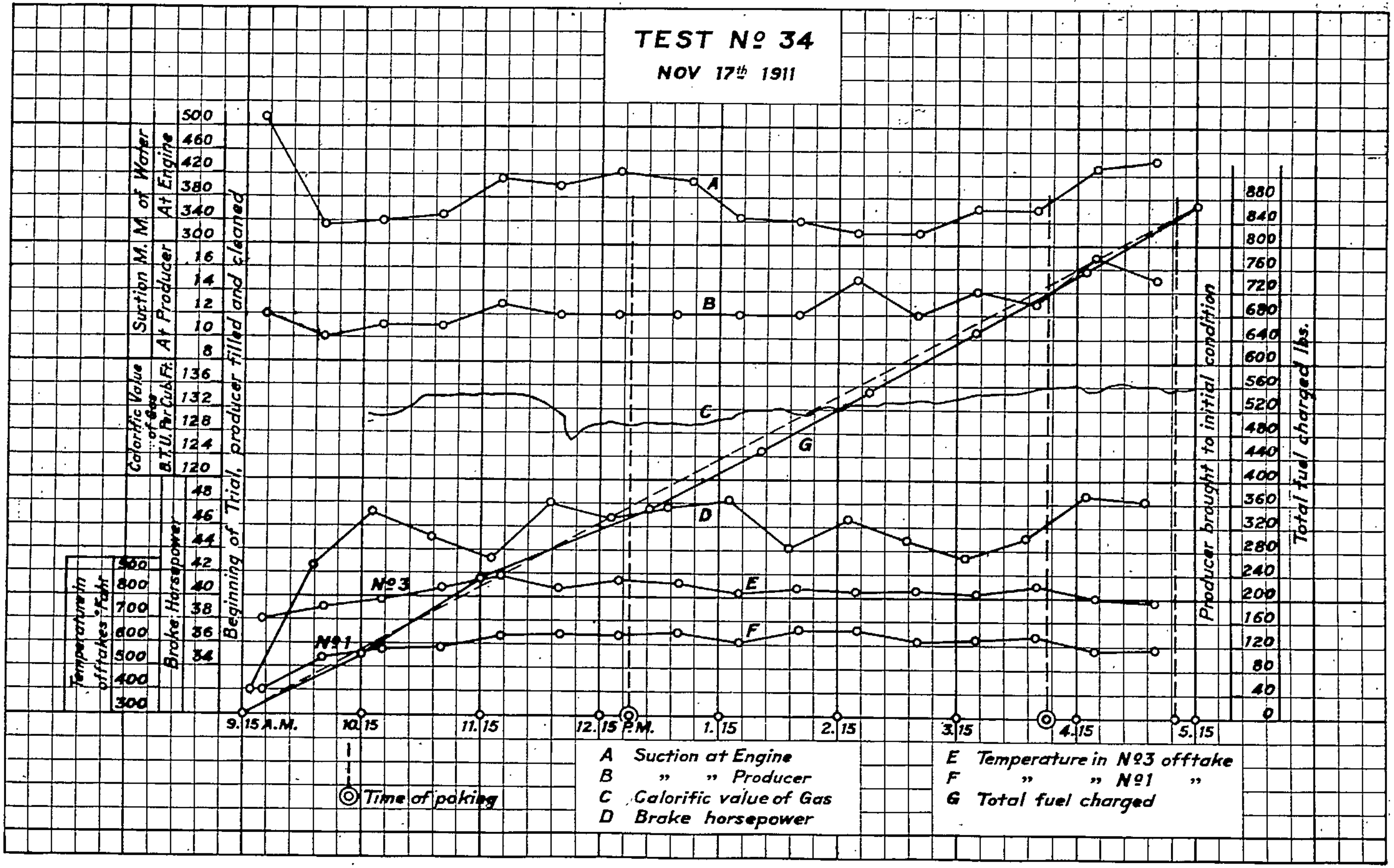

TEST Nº 34
NOV 17th 1911
Suction M. M. of Water
At Engine
At Producer
500
460
420
380
340
300
16
14
12
10
8
Calorific Value of Gas B.T.U. Per Cub. Ft.
136
132
128
124
120
Brake Horsepower
48
46
44
42
40
38
36
34
Temperature in offtakes °Faht
900
800
700
600
500
400
300
Beginning of Trial, producer filled and cleaned
A
B
C
D
E
F
G
Nº 3
Nº 1
9.15 A.M.
10.15
11.15
12.15 P.M.
1.15
2.15
3.15
4.15
5.15
Time of poking
Producer brought to initial condition
Total fuel charged lbs.
880
840
800
760
720
680
640
600
560
520
480
440
400
360
320
280
240
200
160
120
80
40
0
A Suction at Engine
B " " Producer
C Calorific value of Gas
D Brake horsepower
E Temperature in Nº3 offtake
F " " Nº1 "
G Total fuel charged

Chart Nº 16

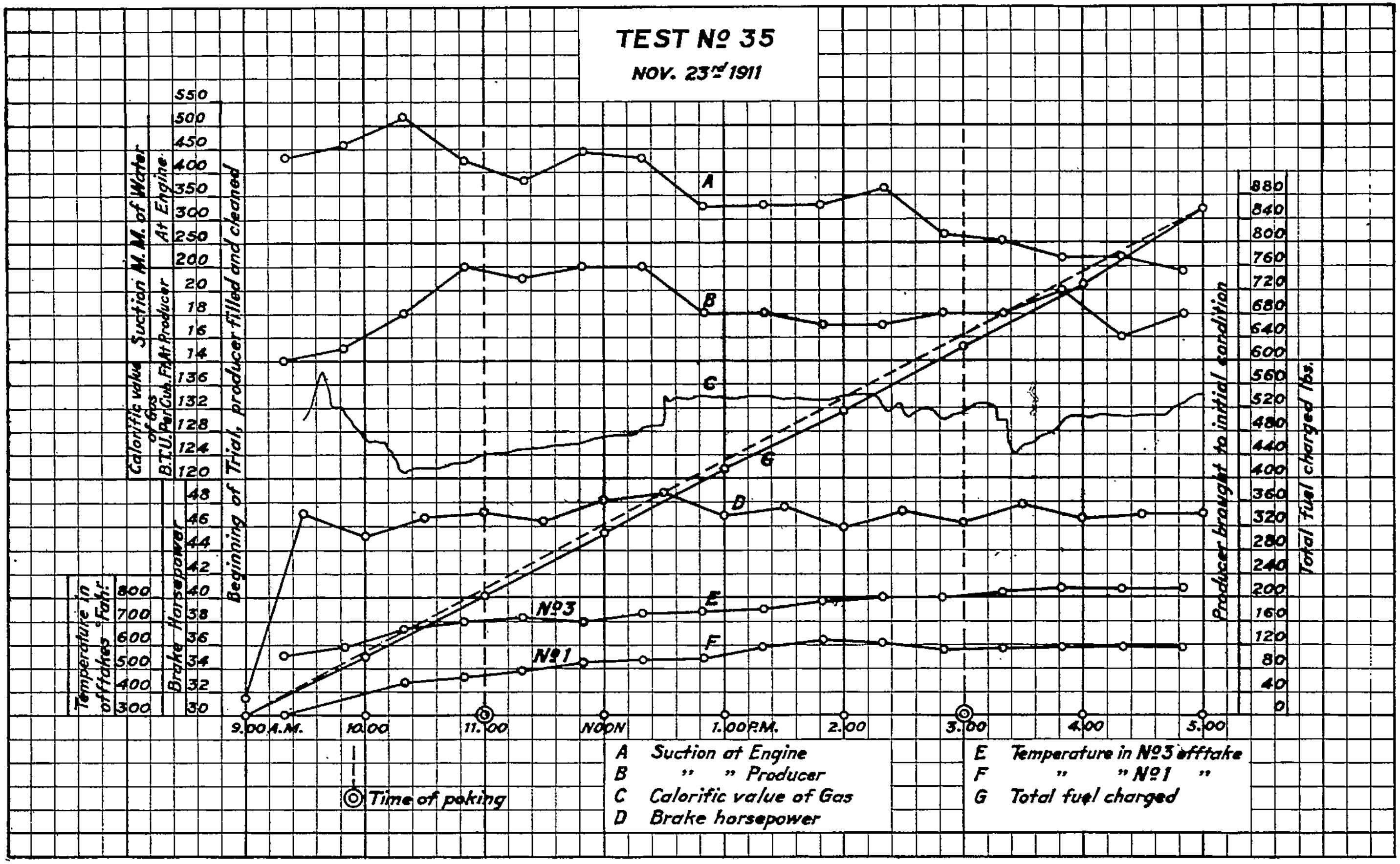

TEST Nº 35
NOV. 23rd 1911
Suction M.M. of Water
At Engine
At Producer
Calorific value of Gas B.T.U. Per Cub. Ft.
Brake Horsepower
Temperature in offtakes °Fahr.
Beginning of Trial, producer filled and cleaned
Producer brought to initial condition
Total fuel charged lbs.
550
500
450
400
350
300
250
200
20
18
16
14
136
132
128
124
120
48
46
44
42
40
38
36
34
32
30
800
700
600
500
400
300
880
840
800
760
720
680
640
600
560
520
480
440
400
360
320
280
240
200
160
120
80
40
0
9.00 A.M.
10.00
11.00
NOON
1.00 P.M.
2.00
3.00
4.00
5.00
A
B
C
D
E
F
G
Nº3
Nº1
Time of poking
A Suction at Engine
B " " Producer
C Calorific value of Gas
D Brake horsepower
E Temperature in Nº3 offtake
F " " Nº1 "
G Total fuel charged

Chart No. 17

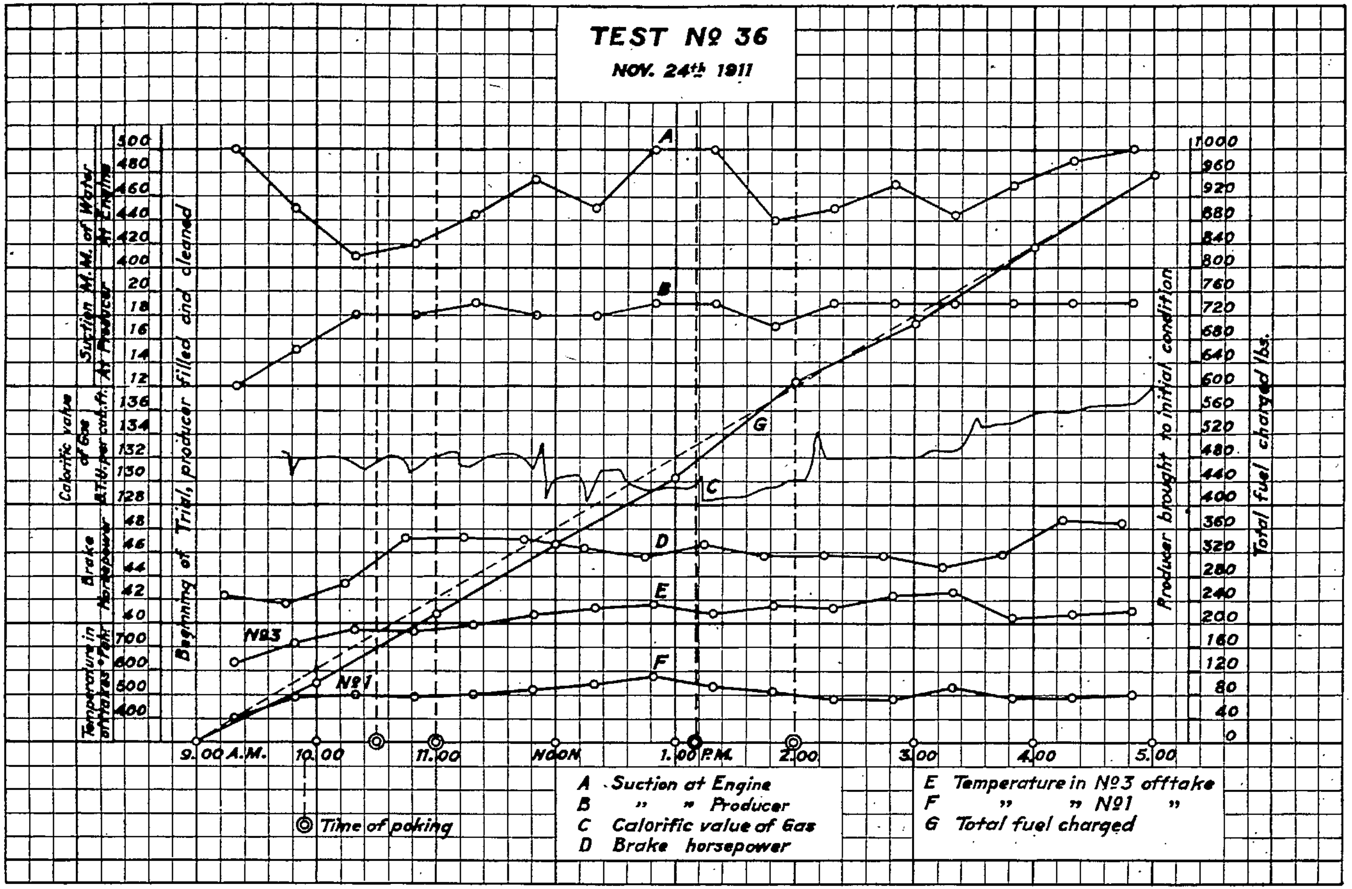

TEST No. 36
NOV. 24th 1911
Suction M.M. of Water
At Engine
At Producer
Calorific value of Gas B.T.U. per cub. ft.
Brake Horsepower
Temperature in offtakes °Fahr.
500
480
460
440
420
400
20
18
16
14
12
136
134
132
130
128
48
46
44
42
40
700
600
500
400
Beginning of Trial, producer filled and cleaned
Producer brought to initial condition
Total fuel charged lbs.
1000
960
920
880
840
800
760
720
680
640
600
560
520
480
440
400
360
320
280
240
200
160
120
80
40
0
A
B
C
D
E
F
G
No. 3
No. 1
9.00 A.M.
10.00
11.00
NOON
1.00 P.M.
2.00
3.00
4.00
5.00
Time of poking
A Suction at Engine
B " " Producer
C Calorific value of Gas
D Brake horsepower
E Temperature in No. 3 offtake
F " " No. 1 "
G Total fuel charged

TABLE XVIII.

OBSERVATIONS OF FUEL CHARGED TO PRODUCER DURING TRIAL.

TRIAL NO. 20. DATE, SEPT. 19, 1911.

Time of Charging.	Gross, Lbs.	Tare, Lbs.	Net, Lbs.	Total Charged, Lbs.	Time of Poking.
12.00 Noon........	57	7	50	50	
12.45 p.m.........	....	....	100	150	
1.30 "	....	....	100	250	1.35 p.m.
2.00 "	....	....	100	350	
3.00 "	....	....	100	450	
3.50 "	....	....	100	550	
4.45 "	....	....	100	650	
5.35 "	....	....	150	800	5.20 p.m.
6.30 "	....	....	100	900	
7.25 "	....	....	100	1000	
8.30 "	....	....	100	1100	
9.00 "	....	....	100	1200	
9.30 "	....	....	50	1250	

Fuel for banking from 6 p.m., Sept. 18, to time of opening up producer at 7 a.m., Sept. 19	250 lbs.
Fuel used from 7.00 a.m. to 11.30..	350 "
Ashes and refuse removed during trial..	60 "

TABLE XIX.

OBSERVATIONS OF GAS ENGINE AND GENERATOR.

NO. OF TRIAL, 20. DATE, OCT. 5, 1911.

Stroke of engine, 24″. Cylinder diameter, 15⅛″.
Cylinder constant, 0·0054.

Time.	Temperature of outlet cooling water. °F.	Revolutions per minute.	Volts.	Amps.	Brake horse-power.
11.30 a.m.	95	192	121	288	53·1
11.45 "	115	......	122	301	56·0
12.00 "	116	193	123	301	56·5
12.15 p.m.	111	......	123	300	56·3
12.30 "	113	192	123	300	56·3
12.45 "	115	......	117	293	52·2
1.00 "	111	192	122	283	52·7
1.15 "	115	......	124	294	55·6
1.30 "	118	192	122	285	53·1
1.45 "	118	......	122	295	54·9
2.00 "	118	194	122	293	54·5
2.15 "	109	193	127	293	56·8
2.30 "	108	......	127	295	57·2
2.45 "	109	192	127	288	55·8
3.00 "	106	......	119	285	51·7
3.15 "	106	189	126	291	55·9
3.30 "	104	......	122	288	53·6
3.45 "	100	178	116	325	57·5
4.00 "	104	187	121	303	55·9
4.15 "	111	......	118	293	52·7
4.30 "	111	186	118	293	52·7
4.45 "	111	......	119	294	53·4
5.00 "	109	187	119	294	53·4
5.15 "	115	......	119	295	53·6
5.30 "	113	189	125	278	53·0
5.45 "	109	......	118	278	50·0
6.00 "	111	192	118	278	50·0
6.15 "	113	......	122	275	51·2
6.30 "	113	188	122	275	51·2
6.45 "	117	192	120	291	53·2
7.00 "	118	198	122	286	53·2
7.30 "	117	......	122	286	53·2
7.45 "	117	193	124	298	56·3
8.00 "	117	......	124	298	56·3
8.15 "	113	190	117	291	51·9
8.30 "	115	193	124	291	55·0
8.45 "	115	......	122	291	54·2
9.00 "	111	191	120	278	50·9
9.15 "	109	188	118	272	48·9

TABLE XX.

OBSERVATIONS OF TEMPERATURES AND PRESSURES AND WATER CONSUMPTION OF PLANT.

No. OF TRIAL, 20. DATE, SEPT. 19, 1911.

Time.	Temperature of gas leaving No. 1 exit. °F.	Suction in gas mains. Millimetres of water.			
		Leaving producer.	Leaving coke scrubber.	Leaving tar filter.	Before engine.
11.30 a.m.	419	15	62	200	230
11.45 “	419	12	46	160	192
12.00 “	430	12	47	120	140
12.15 p.m.	436	12	52	129	149
12.30 “	447	12	51	108	126
12.45 “	430	12	48	98	124
1.00 “	447	12	47	148	168
1.15 “	458	12	62	110	128
1.30 “	441	12	58	103	130
1.45 “	340	12	48	102	127
2.00 “	352	12	54	104	132
2.15 “	362	13	58	128	150
2.30 “	385	12	65	118	150
2.45 “	385	12	55	107	135
3.00 “	425	12	64	153	184
3.15 “	447	12	63	121	150
3.30 “	464	12	62	108	147
3.45 “	469	17	80	144	174
4.00 “	441	18	75	143	169
4.15 “	503	18	72	142	178
4.30 “	520	18	52	111	144
4.45	531	17	55	112	145
5.00 “	531	17	57	110	144
5.15 “	525	17	57	102	127
5.30 “	464	17	58	100	117
5.45 “	526	17	65	113	138
6.00 “	509	17	58	100	123
6.15 “	503	15	64	104	130
6.30 “	503	15	59	102	128
6.45 “	509	16	61	133	170
7.00 “	526	17	78	121	145
7.30 “	520	17	69	140	157
7.45 “	537	17	70	125	138
8.00 “	520	19	75	132	150
8.15 “	520	17	70	120	138
8.30 “	531	17	66	126	134
8.45 “	520	17	67	127	135
9.00 “	531	18	67	117	123
9.15 “	520	17	66	101	120

TABLE XXI.

REPORT OF GAS ANALYSIS.

TRIAL No. 20. Sept. 19, 1911.

Source of samples.	No. of sample.	Time of sampling.	PER CENT BY VOLUME.								CALORIFIC VALUE. B.T.U. PER CUB. FT.	
			Carbon dioxide	Oxygen	Ethylene	Carbon monoxide	Methane.	Hydrogen	Nitrogen	Inflammable gas.	Gross.	Net.
After tar washer.........	1	11.30 a.m.	10·1	0·2	0·3	18·2	2·2	10·3	58·7	31·0	118	110
	2	12.30 p.m.	9·7	1·3	0·8	18·8	1·8	10·6	57·0	32·0	125	117
	3	1.30 "	9·6	0·6	0·3	18·9	....	....	....	....	....	....
	4	2.30 "	10·4	0·3	0·2	19·1	2·7	10·3	57·0	32·3	125	116
	5	3.30 "	12·1	0·2	0·2	17·6	1·1	11·9	56·9	30·8	109	102
	6	4.30 "	10·9	0·3	0·7	18·1	2·6	9·5	57·9	30·9	126	117
	7	5.30 "	12·7	0·6	0·6	13·4	3·4	8·3	61·0	25·7	113	105
	8	6.30 "	10·6	0·3	0·4	17·1	3·5	9·0	59·1	30·0	125	117
	9	7.30 "	10·3	0·3	0·5	18·3	2·6	10·4	57·6	31·8	126	118
	10	8.30 "	11·5	0·7	0·9	17·6	2·0	11·2	56·1	31·7	127	118

TABLE XXII.

OBSERVATIONS OF FUEL CHARGED TO PRODUCER DURING TRIAL.

No. of Trial, 21. Date, Sept. 20 and 21, 1911.

Time of charging.	Gross, Lbs.	Tare, Lbs.	Net, Lbs.	Total charged, Lbs.	Time of poking.
11.00 a.m.	107	7	100	100	
12.00 Noon	....	....	150	250	
1.00 p.m.	....	....	100	350	
1.50 "	....	....	100	450	
2.40 "	....	....	100	550	3.15 p.m.
3.35 "	....	....	150	700	
4.20 "	....	....	100	800	
5.5 "	....	....	100	900	
6.15 "	....	....	100	1,000	
7.10 "	....	....	100	1,100	7.15 p.m.
7.35 "	....	....	100	1,200	
8.25 "	....	....	100	1,300	
9.15 "	....	....	100	1,400	
10.15 "	....	....	100	1,500	
11.45 "	....	....	150	1,650	
12.45 a.m.	....	....	100	1,750	
1.40 "	....	....	100	1,850	
2.40 "	....	....	100	1,950	
3.20 "	....	....	100	2,050	3.35 a.m.
4.5 "	....	....	150	2,200	
4.50 "	....	....	100	2,300	
5.40 "	....	....	100	2,400	
6.10 "	....	....	50	2,450	

Fuel used for banking and starting from previous day's run........................431 lbs.
Ashes and refuse removed during trial..116 "

TABLE XXIII.

OBSERVATIONS OF GAS ENGINE AND GENERATOR.

No. of Trial, 21. Date, Sept. 20 and 21, 1911.

Stroke of engine, 24″. Cylinder diameter, $15\frac{1}{8}$″
Cylinder constant, 0·0054.

Time.	Temperature of outlet cooling water. °F.	Revolutions per minute.	Volts.	Amps.	Brake horse-power.
10.00 a.m	100	194	112	271	46·3
10.25 "	118	194	122	298	55·4
10.40 "	118	....	118	293	52·7
10.55 "	111	193	111	281	47·5
11.10 "	111	193	124	301	56·8
11.25 "	115	194	122	295	54·9
11.40 "	111	....	123	293	55·0
11.55 "	111	192	121	293	54·1
12.10 p.m	109	192	121	293	54·1
12.25 "	108	....	122	297	55·2
12.40 "	108	191	121	311	57·4
12.55 "	109	....	120	294	53·8
1.10 "	109	192	122	303	56·4
1.25 "	115	....	122	303	56·4
1.40 "	111	192	123	293	55·0
1.55 "	115	....	122	293	54·5
2.10 "	111	192	122	288	53·6
2.25 "	115	....	122	288	53·6
2.40 "	113	189	122	288	53·6
2.55 "	113	....	121	283	52·2
3.10 "	109	192	117	298	53·1
3.25 "	109	....	121	288	53·1
3.40 "	115	192	122	288	53·6
3.55 "	111	....	121	274	50·6
4.10 "	111	188	117	295	52·6
4.25 "	111	....	119	288	52·3
4.40 "	111	192	123	293	55·0
4.55 "	108	....	117	293	52·3
5.10 "	104	190	121	303	55·9
5.25 "	108	....	119	292	53·0
5.40 "	106	190	120	297	54·4
5.55 "	111	....	121	296	54·6
6.10 "	111	183	115	293	51·4
6.25 "	109	....	120	288	52·7
6.40 "	108	184	114	278	48·3
6.55 "	109	....	119	287	52·1
7.10 "	113	191	116	288	51·0
7.25 "	113	....	122	288	53·6
7.40 "	115	192	120	278	50·9
7.55 "	113	....	117	278	49·6
8.10 "	113	189	122	288	53·6
8.25 "	113	....	122	288	53·6
8.40 "	113	190	123	288	54·0
8.55 "	113	....	123	288	54·0
9.10 "	113	184	122	293	54·5
9.25 "	113	....	124	288	54·5
9.40 "	113	183	116	282	49·9
9.55 "	115	169	104	263	41·7
10.10 "	115	192	124	287	54·3
10.25 "	111	....	118	287	51·6
10.40 "	111	183	114	288	50·1
10.55 "	115	193	122	298	55·4
11.10 "	117	....	122	293	54·5
11.25 "	115	191	121	291	53·7
11.40 "	115	....	116	289	51·1
11.55 "	111	188	120	294	53·8
Sept. 21.					
12.10 a.m	108	....	119	291	52·8
12.25 "	115	191	122	291	54·1
12.40 "	115	....	121	291	53·7

TABLE XXIII—*Continued.*

Time.	Temperature of outlet cooling water. °F.	Revolutions per minute.	Volts.	Amps.	Brake horse-power.
12.55 a.m............	115	189	123	302	56·6
1.10 "	115	....	123	302	56·6
1.25 "	115	190	121	302	55·7
1.40 "	115	181	116	293	51·8
1.55 "	115	189	120	302	55·3
2.10 "	118	189	122	303	56·4
2.25 "	115	189	122	303	56·4
2.40 "	115	....	120	301	55·1
2.55 "	117	188	122	303	56·4
3.10 "	117	....	122	303	56·4
3.25 "	115	188	120	303	55·4
3.40 "	115	....	123	313	58·7
3.55 "	115	181	116	298	52·1
4.10 "	115	....	117	301	53·7
4.25 "	117	188	122	304	56·6
4.40 "	117	....	124	305	57·6
4.55 "	117	188	120	304	55·6
5.10 "	118	187	118	298	53·6
5.25 "	118	....	117	294	52·5
5.40 "	118	188	118	302	54·4
5.55 "	122	189	122	302	56·2

TABLE XXIV.

OBSERVATIONS OF TEMPERATURES AND PRESSURES AND WATER CONSUMPTION OF PLANT.

NO. OF TRIAL, 21. SEPT. 20 and 21, 1911.

Time.	Temperature of gas leaving No. 1 exit. ° F.	Suction in gas mains. Millimetres of water.			
		Leaving producer.	Leaving coke scrubber.	Leaving tar filter.	Before engine.
10.10 a.m.	319	12	51	135	173
10.25 "	357	12	48	98	116
10.40 "	381	12	56	96	129
10.55 "	386	15	48	111	128
11.10 "	436	13	48	100	120
11.25 "	419	14	54	124	138
11.40 "	425	14	50	108	128
11.55 "	425	14	51	104	128
12.10 p.m.	430	14	52	102	128
12.25 "	419	15	58	104	132
12.40 "	419	14	60	102	128
12.55 "	436	14	48	94	120
1.10 "	447	14	54	106	118
1.25 "	452	14	58	134	150
1.40 "	469	14	60	120	130
1.55 "	475	14	68	106	126
2.10 "	491	13	64	112	128
2.25 "	503	13	62	118	133
2.40 "	503	13	70	114	124
2.55 "	515	13	62	102	130
3.10 "	503	15	70	114	137
3.25 "	469	16	70	136	165
3.40 "	458	16	68	134	167
3.55 "	464	14	60	116	123
4.10 "	469	14	68	140	162
4.25 "	475	14	58	114	128
4.40 "	485	14	58	118	124
4.55 "	485	14	62	112	128
5.10 "	497	14	68	122	132
5.25 "	491	14	58	92	102
5.40 "	485	15	72	124	134
5.55 "	485	15	75	127	136
6.10 "	485	15	54	118	130
6.25 "	479	15	68	134	144
6.40 "	469	14	76	128	142
6.55 "	491	14	72	118	134
7.10 "	447	18	78	148	172
7.25 "	474	18	74	126	142
7.40 "	497	18	58	110	123
7.55 "	491	15	68	148	168
8.10 "	509	14	66	118	128
8.25 "	515	14	68	118	126
8.40 "	515	14	62	118	124
8.55 "	515	14	66	119	130
9.10 "	491	18	74	134	158
9.25 "	458	16	72	123	134
9.40 "	464	12	58	96	100
9.55 "	475	16	68	142	162
10.10 "	469	15	70	152	178
10.25 "	464	15	72	154	168
10.40 "	464	15	76	150	162
10.55 "	503	13	68	126	138
11.10 "	515	13	72	118	135
11.25 "	503	13	78	118	130
11.40 "	520	14	80	140	158
11.55 "	520	14	66	122	158
Sept. 21.					
12.10 a.m.	515	13	62	110	126
12.25 "	515	13	64	120	132

TABLE XXIV—*Concluded.*

Time.	Temperature of gas leaving No. 1 exit. ° F.	Suction in gas mains. Millimetres of water.			
		Leaving producer.	Leaving coke scrubber.	Leaving tar filter.	Before engine.
Sept. 21.					
12.40 p.m.	526	13	64	120	138
12.55 "	509	13	68	120	135
1.10 "	520	13	70	122	138
1.25 "	497	13	70	122	140
1.40 "	497	13	76	141	150
1.55 "	503	14	72	134	154
2.10 "	503	13	62	100	110
2.25 "	520	14	62	142	152
2.40 "	531	14	70	164	180
2.55 "	542	14	62	112	128
3.10 "	520	14	66	112	120
3.25 "	526	16	63	112	126
3.40 "	509	18	74	124	134
3.55 "	503	16	66	166	176
4.10 "	515	16	72	188	198
4.25 "	520	17	68	116	126
4.40 "	515	16	69	117	126
4.55 "	531	16	68	116	130
5.10 "	537	16	72	141	158
5.25 "	531	15	58	92	106
5.40 "	531	15	62	122	158
5.55 "	537	14	57	100	115

TABLE XXV.

REPORT OF GAS ANALYSIS.

TRIAL No. 21, 20 HOUR TRIAL. SEPT. 20, 1911.

Source of Samples.	No. of Sample.	Time of Sampling.	PER CENT BY VOLUME.								CALORIFIC VALUE B.T.U. PER CUB. FT.		
			Carbon dioxide.	Oxygen.	Ethylene.	Carbon monoxide.	Methane.	Hydrogen.	Nitrogen.	Inflammable gas.	Gross.	Net.	
After tar washer.	1	10.15 a.m.	10.6	0·3	0·0	20·1	2·4	10·5	56·1	33·0	122	114	
	2	11.15 "	10·3	0·2	0·4	20·0	1·9	9·5	57·7	31·8	120	113	
	3	12.15 p.m.	10·4	0·6	0·2	18·5	2·8	10·1	57·4	31·6	123	115	
	4	1.15 "	9·6	0·2	0·3	20·8	1·9	12·0	55·2	35·0	129	121	
	5	2.15 "	10·2	0·3	0·4	19·6	2·0	11·7	55·8	33·7	127	118	Fires cleaned
	6	3.15 "	12·7	0·4	0·2	13·9	3·1	9·9	59·8	27·1	111	102	
	7	4.15 "	9·7	0·4	0·3	20·7	1·4	11·6	55·9	34·0	122	115	
	8	5.15 "	9·3	0·2	0·4	20·7	3·2	9·6	56·6	33·9	136	127	
	9	6.15 "	9·6	0·3	0·3	20·8	2·5	9·3	57·2	32·9	126	119	
	10	7.15 "	11·8	0·4	0·6	16·1	3·2	10·4	57·5	30·3	127	117	Fires cleaned.
	11	8.15 "	9·3	0·2	0·4	21·6	2·8	9·7	56·0	34·5	135	127	
	12	9.15 "	12·2	0·3	0·4	16·1	2·9	9·6	58·5	29·0	118	110	Fires poked.
	13	10.15 a.m.	9·4	0·3	0·3	21·0	2·5	10·9	55·6	34·7	132	124	
	14	11.15 "	9·1	0·4	0·5	21·8	1·8	10·8	55·6	34·9	131	123	
	15	12.15 p.m.	8·8	0·1	0·5	22·5	1·8	10·0	56·3	34·8	130	123	
	16	1.15 "	9·2	0·2	0·4	21·9	2·3	9·9	56·1	34·5	131	123	
	17	2.20 "	9·5	0·2	0·6	21·4	2·6	9·6	56·1	34·2	135	127	
	18	3.20 "	8·9	0·2	0·6	20·9	2·5	10·2	56·7	34·2	134	126	
	19	4.15 "	9·6	0·1	0·5	21·7	2·1	10·3	55·7	34·6	132	124	
	20	5.15 "	8·4	0·3	0·6	23·0	1·9	10·6	55·2	36·1	136	128	

TABLE XXVI.

OBSERVATIONS OF FUEL CHARGED TO PRODUCER DURING TRIAL.

NO. OF TRIAL, 24. DATE, OCT. 5, 1911.

Time of charging.	Gross, Lbs.	Tare, Lbs.	Net, Lbs.	Total. charged, Lbs.
10.30 a.m.	127	7	120	120
11.30 "	117	2	115	235
12.30 p.m.	117	2	115	350
1.30 "	122	2	120	470
2.30 "	129	3	126	596
3.30 "	62	1	61	657
4.30 "	102	2	100	757
5.30 "	87	2	85	842
6.30 "	102	2	100	942
7.30 "	162	2	160	1102

Fuel used for banking and starting .... 155 lbs.
Ashes and refuse removed during trial .... 125 "

TABLE XXVII.

OBSERVATIONS OF GAS ENGINE AND GENERATOR.

TRIAL No. 24. DATE, OCT. 5, 1911.

Stroke of engine, 24″. Cylinder diameter, 24″.
Cylinder constant, ·0054.

Time.	Mean effective pressure lbs. per sq. in.	Revolutions per minute.	Indicated horse-power	Outlet cooling water temperature °F.	Volts.	Amps.	Brake horse-power.
9.35 a.m.				106	107·5	237	38·9
9.45 “	50·3	194	52·9	106			
9.50 “					112·5	238	40·8
10.05 “				111	109	259	43·1
10.15 “	57·2	194	60·3				
10.20 “					109·5	267	44·6
10.35 “				122	109·5	267	44·6
10.45 “	49·4	196	52·5				
10.50 “					111·5	247	42·0
11.05 “				118	110	242	40·6
11.15 “	48·2	195	51·0				
11.20 “					109·5	244	40·8
11.35 “				115	109	242	40·2
11.45 “	50·0	195	53·0				
11.50 “					114·5	237	41·4
12.05 p.m.				115	114·5	235	41·1
12.15 “	48·8	194·5	51·5				
12.20 “					113·5	232	40·2
12.35 “				111	114	232	40·3
12.45 “	48·2	194·5	50·9				
12.50 “					114·5	234	40·9
1.05 “				113	115·5	232	40·8
1.15 “	48·2	196	51·3				
1.20 “					115·5	235	41·4
1.35 “				118	114	233	40·4
1.45 “	49·5	194	52·2				
1.50 “					114·5	234	40·9
2.05 “				111	116·5	232·5	41·3
2.15 “	45·7	194	48·2				
2.20 “					114·5	232	40·5
2.35 “				113	114·5	227	39·6
2.45 “	46·9	194	45·5				
2.50 “					116	232	41·1
3.05 “				113	114	231	40·1
3.15 “	49·3	193	51·8				
3.20 “					115·5	237	41·7
3.35 “				113	117·5	234	41·9
3.45 “	51·1	194	53·9				
3.50 “					117·5	230	41·2
4.05 “				118	115·5	237	41·7
4.15 “	51·2	193·5	53·8				
4.20 “					115·5	231	40·7
4.35 “				117	116·0	227	40·1
4.45 “	51·1	195	54·2				
4.50 “					116·5	236	41·9
5.05 “				113	114·5	227	39·6
5.15 “	46·9	194	49·5				
5.20 “					116·5	245	43·5
5.35 “				113	115·5	240	42·2
5.45 “	50·0	194	52·8				
5.50 “					113·5	243	42·1
6.05 “				102	111·5	240	40·8
6.15 “	48·2	193·5	50·6				
6.20 “					113·5	242	41·9
6.35 “				111	113·5	240	41·5
6.45 “	50·0	193·5	52·6				
6.50 “					114	242	42·1
7.05 “				109	111·5	242	41·2
7.15 “	49·2	193·5	51·8				
7.20 “				108	111·5	239	40·7

Table XXVIII.

OBSERVATIONS OF TEMPERATURES AND PRESSURES AND WATER CONSUMPTION OF PLANT.

No. of trial, 24. Date, Oct. 5, 1911.

Time.	Temperature of gas leaving No. 1 exit. °F.	Suctions in gas mains. Millimetres of water.				Readings of water-meters, in cubic feet.	
		Leaving producer.	Leaving coke scrubber.	Leaving tar filler	Before engine.	For scrubbers.	For engine.
9.30 a.m.	490	7	33	179	182	3,792	8,964
10.00 "	570	9	76	175	180	....	
10.30 "	600	9	65	142	163	....	
11.00 "	600	9	85	142	159	....	
11.30 "	600	10	65	135	164	....	9,033
12.00 "	590	9	75	133	155	....	
12.30 p.m.	615	9	60	125	145	3,988	
1.00 "	600	10	55	125	140	....	
1.30 "	640	10	77	140	145	....	9,101
2.00 "	670	10	95	145	155	....	
2.30 "	560	7	77	135	160	4,126	
3.00 "	615	9	70	125	130	....	
3.30 "	640	9	75	143	155	....	
4.00 "	660	9	65	134	145	....	
4.30 "	650	9	73	138	146	....	
5.00 "	690	9	95	153	172	4,294	
5.30 "	680	13	82	140	155	....	9,238
6.00 "	660	12	65	137	155	....	
6.30 "	640	13	65	143	148	....	
7.00 "	630	13	90	155	167	....	
7.30 "	650	12	59	130	163	4,482	9,312

Table XXIX.

REPORT OF GAS ANALYSIS.

Trial No. 24. Oct. 5, 1911.

Source of samples.	No. of sample.	Time of sampling.	Per Cent by Volume.								Calorific Value B. T. U. per Cub. Ft.	
			Carbon dioxide.	Oxygen.	Ethylene.	Carbon monoxide.	Methane.	Hydrogen	Nitrogen.	Inflammable gas.	Gross.	Net.
After tar washer............	1	9.45 a.m.	11·0	0·4	0·5	19·2	2·6	10·1	56·2	32·4	128	120
	2	10.45 "	10·2	0·2	0·5	20·6	1·9	10·0	56·6	33·0	125	118
	3	11.45 "	10·6	0·1	0·6	20·5	2·6	9·6	56·0	33·3	132	124
	4	12.45 p.m.	10·8	0·1	0·6	19·3	2·6	9·8	56·8	32·3	129	121
	5	1.45 "	10·0	0·2	0·9	20·2	2·1	11·9	54·7	35·1	138	129
	6	2·45 "	7·3	0·5	0·3	23·8	2·3	11·7	54·1	38·1	142	133
	7	3.45 "	6·5	0·3	0·1	24·7	1·8	11·1	55·5	37·7	134	127
	8	4.45 "	6·5	0·3	0·2	24·7	1·8	9·6	56·9	36·3	131	124
	9	5.45 "	5·8	0·1	0·2	25·6	1·7	8·5	58·1	36·0	130	123
	10	6.45 "	5·9	0·5	0·2	25·6	1·6	7·8	58·4	35·2	126	120

TABLE XXX.

OBSERVATIONS OF FUEL CHARGED TO PRODUCER DURING TRIAL.

NO. OF TRIAL, 28. DATE, Nov. 6, 1911.

Time of charging.	Gross, Lbs.	Tare, Lbs.	Net, Lbs.	Total charged, Lbs.	Time of poking.
10.30 a.m.	81	1	80	80	
11.30 "	114	14	100	180	
12.25 p.m.	114	14	100	280	
1.25 "	129	14	115	395	
2.15 "	120	1	119	514	
3.5 "	142	2	140	654	2.45
4.10 "	142	2	140	794	
5.10 "	122	2	120	914	
5.30 "	61	1	60	974	

TABLE XXXI.

OBSERVATIONS OF POWER OF ENGINE.

NO. OF TRIAL, 28. DATE, Nov. 6, 1911.

Time.	Volts.	Amps.	Brake horse-power of engine.
9.45 a.m.	111·5	172	29·3
10.15 "	111·5	282	48·0
10.45 "	107·5	287	47·0
11.15 "	107·5	282	46·2
11.45 "	106·5	267	43·4
12.15 p.m.	108·5	272	45·0
12.45 "	111·5	272	46·3
1.15 "	112·5	267	45·8
1.45 "	113·5	257	44·5
2.15 "	115·5	257	45·2
2.45 "	114·5	262	45·7
3.15 "	111·5	277	47·1
3.45 "	111·5	277	47·1
4.15 "	111·5	277	47·1
4.45 "	111·5	271	46·1
5.15 "	113·5	267	46·2

TABLE XXXII.

OBSERVATIONS OF TEMPERATURES AND PRESSURES.

No. of Trial, 28. Date, Nov. 6, 1911.

Time.	Temperature of gas, °F.			Suction in gas mains. Millimetres of water.			
	Final gas leaving No. 1 exit.	Leaving upper zone of producer.	Final gas leaving No. 2 exit.	Leaving producer.	Leaving coke scrubber.	Leaving tar filter.	Leaving dry scrubber.
10.00 a.m.	345	345	300	15	120	220	225
10.30 "	410	280	430	15	120	190	195
11.00 "	500	266	510	17	190	270	280
11.30 "	560	250	575	20	180	270	280
12.00 Noon	590	240	640	22	220	300	320
12.30 p.m.	600	230	630	22	180	280	320
1.30 "	610	230	660	22	186	290	310
2.00 "	640	240	690	20	187	270	295
2.30 "	630	240	710	23	215	290	310
3.00 "	540	235	610	18	272	330	365
3.30 "	570	232	620	18	261	330	390
4.00 "	600	225	680	21	275	330	390
4.30 "	580	215	680	20	215	310	350
5.00 "	600	210	680	20	240	270	330

TABLE XXXIII.

OBSERVATIONS OF FUEL CHARGED TO PRODUCER DURING TRIAL.

No. of Trial, 29. Date, Nov. 9, 1911.

Time of charging.	Gross, Lbs.	Tare, Lbs.	Net, Lbs.	Total charged, Lbs.	Time of poking.
10.45 a.m.	148	3	145	145	
11.45 "	102	2	100	245	11.30 a.m.
12.45 p.m.	138	3	135	380	
1.45 "	143	3	140	520	2.00 p.m.
2.50 "	143	3	140	660	
3.50 "	141	3	138	798	
4.50 "	116	2	114	912	
5.45 "	120	2	118	1030	

TABLE XXXIV.

OBSERVATIONS OF POWER OF ENGINE.

NO. OF TRIAL, 29. DATE, Nov. 9, 1911

Time.	Volts.	Amps.	Brake horse-power of engine.
9.50 a.m.	106·5	247	40·1
10.20 "	109	272	45·2
10.50 "	106·5	292	47·4
11.20 "	104·5	284	45·3
11.50 "	104·5	297	47·3
12.20 p.m.	105·5	302	48·6
12.50 "	108·5	292	48·3
1.20 "	110·5	287	48·4
1.50 "	110·5	282	47·5
2.20 "	101·5	283	43·8
2.50 "	101·5	288	44·6
3.20 "	102·5	292	45·2
3.50 "	102·5	277	43·3
4.20 "	101·5	273	42·3
4.50 "	101·5	277	47·1
5.20 "	110·5	277	46·7

TABLE XXXV.

OBSERVATIONS OF TEMPERATURES AND PRESSURES.

NO. OF TRIAL, 29. DATE, Nov. 9, 1911.

Time.	Temperatures of gas, °F.			Suction in gas mains. Millimetres of water			
	Final gas leaving No. 1 exit.	Leaving upper zone of producer.	Final gas leaving No.2 exit.	Leaving producer.	Leaving coke scrubber.	Leaving tar filter.	Leaving dry scrubber.
10.00 a.m.	390	305	300	12	78	215	260
10.30 "	440	290	430	13	88	194	205
11.00 "	490	270	510	12	110	205	235
11.30	570	260	640	23	128	240	272
12.00 Noon	580	260	710	24	133	248	270
12.30 p.m.	600	260	700	22	132	240	260
1.00 "	660	250	720	22	136	238	250
1.30	660	250	720	22	120	230	250
2.00 "	680	240	730	23	145	270	310
2.30 "	680	230	655	21	155	275	315
3.00 "	690	225	700	21	150	270	290
3.30 "	680	210	710	20	148	275	295
4.00 "	680	240	720	20	139	225	290
4.30 "	690	370	750	23	180	300	320
5.00 "	680	240	790	23	170	283	310
5.30 "	680	250	790	23	165	280	297

TABLE XXXVI.

REPORT OF GAS ANALYSIS.

TRIAL No. 29. Nov. 9, 1911.

Source of Sample.	No. of Sample.	Time of Sampling.	PER CENT BY VOLUME.								CALORIFIC VALUE B. T. U. PER CUB. FT.		Remarks.
			Carbon dioxide.	Oxygen.	Ethylene.	Carbon monoxide.	Methane.	Hydrogen.	Nitrogen.	Inflammable gas.	Gross.	Net.	
After tar washer.	1	11.55 a.m.	4·9	0·4	0·2	26·7	1·1	4·1	62·6	32·1	113	109	
"	2	4.25 p.m.	5·2	0·5	0·5	27·0	2·4	5·3	59·1	35·2	135	130	
Stand pipe	3	5.35 "	3·0	17·6	0·1	0·1	....	....	......	......	......	......	Gas quite clear.

TABLE XXXVII.

OBSERVATIONS OF FUEL CHARGED TO PRODUCER DURING TRIAL.

No. OF TRIAL, 30. DATE, Nov. 10, 1911.

Time of charging.	Gross, Lbs.	Tare, Lbs.	Net, Lbs.	Total charged, Lbs.	Time of Poking.
11.40 a.m.............	117	2	115	115	
12.45 p.m.............	117	2	115	230	
1.45 "	168	3	165	395	1.30 p.m.
2.50 "	173	3	170	565	2.00 "
3.50 "	92	2	90	655	
4.50 "	163	3	160	815	4.45 "
5.50 "	82	2	80	895	
6.40 "	148	3	145	1040	6.40 "

Fuel used for starting and banking overnight=150 lbs.

TABLE XXXVIII.

OBSERVATIONS OF POWER OF ENGINE.

No. OF TRIAL, 30. DATE, Nov. 10, 1911.

Time.	Volts.	Amps.	Brake horse-power of engine.
10.45 a.m.	115·5	132	23·2
11.15 “	108·5	274	45·4
11.45 “	105·5	302	48·6
12.15 p.m.	107·5	302	49·5
12.45 “	106·5	302	49·0
1.15 “	110·5	294	49·5
1.45 “	109·5	302	50·4
2.15 “	108·5	292	48·3
2.45 “	112·5	292	50·1
3.15 “	112·5	282	48·3
3.45 “	115·5	267	47·0
4.15 “	109·5	318	53·0
4.45 “	109·5	322	53·8
5.15 “	114·5	260	45·4
5.45 “	114·5	277	48·4
6.15 “	115·5	277	48·8

TABLE XXXIX.

OBSERVATIONS OF TEMPERATURES AND PRESSURES.

No. OF TRIAL, 30. DATE, Nov. 10, 1911.

Time.	Temperatures of gas, °F.			Suction in gas mains. Millimetres of water.				
	Final gas leaving No. 1 exit.	Leaving upper zone of producer.	Final gas leaving No. 2 exit.	Base of stand-pipe.	At producer.	Leaving coke scrubber.	Leaving tar filter.	Leaving dry scrubber.
11.00	340	280	690	3	10	210	320	400
12.00	490	300	770	3	17	160	300	325
12.30	500	320	760	3	18	160	280	310
1.00	520	280	760	3	18	140	270	300
1.30	530	260	760	3	20	150	280	310
2.00	560	250	730	3	17	310	380	410
2.30	600	235	780	3	20	155	300	310
3.00	640	235	810	3	20	160	290	310
3.30	640	240	830	3	20	120	220	250
4.00	630	240	820	3	21	130	245	255
4.30	630	250	820	3	22	125	230	260
5.00	620	250	790	3	22	135	245	280
5.30	570	240	800	3	23	130	260	270
6.00	610	240	860	3	18	140	250	265
6.30	600	240	730	3	20	150	260	270

TABLE XL.

REPORT OF GAS ANALYSIS.

TRIAL No. 30. Nov. 10, 1911.

Source of sample.	No. of sample.	Time of sampling.	PER CENT BY VOLUME.								CALORIFIC VALUE. B.T.U. PER CUB. FT.	
			Carbon dioxide.	Oxygen.	Ethylene.	Carbon monoxide.	Methane.	Hydrogen	Nitrogen.	Inflammable. gas.	Gross.	Net.
After tar washer	1	2.50 p.m.	11·5	0·3	0·1	17·0	2·2	11·5	57·4	30·8	115	107
" "	2	4.15 "	8·0	....	....	....	....	....	....	....	....	....
" "	4	4.50 "	6·5	0·1	0·1	24·4	1·6	9·8	57·5	35·9	127	121
Stand-pipe	3	4.25 "	10·3	1·8	0·9	20·3	3·5	8·4	54·8	33·1	141	133
"	5	6.00 "	12·0	1·0	0·9	19·2	3·5	8·4	55·0	32·0	138	129

TABLE XLI.

OBSERVATIONS OF FUEL CHARGED TO PRODUCER DURING TRIAL.

NO. OF TRIAL, 31. DATE, Nov. 13, 1911.

Time of Charging.	Gross, Lbs.	Tare, Lbs.	Net, Lbs.	Total charged, Lbs.	Time of poking.
10.45 a.m.	132	2	130	130	
11.45 "	140	3	137	267	
12.45 p.m.	145	2	143	410	
1.45 "	143	3	140	550	
2.45 "	102	2	100	650	
3.45 "	148	3	145	795	4.20 p.m.
4.45 "	128	3	125	920	
5.45 "	138	3	138	1055	

Fuel used for starting and banking overnight=200 lbs.

TABLE XLII.

OBSERVATIONS OF POWER OF ENGINE.

NO. OF TRIAL, 31. DATE, Nov. 13, 1911.

Time.	Volts.	Amps.	Brake horse-power of engine.
9.50 a.m.	108·5	262	43·4
10.20 "	107·5	277	45·4
10.50 "	107·5	277	45·4
11.20 "	110	280	47·0
11.50 "	109	278	46·2
12.20 p.m.	110	272	45·6
12.50 "	106	292	47·2
1.20 "	106·5	292	47·5
1.50 "	107·5	292	47·9
2.20 "	106·5	297	48·2
2.50 "	110·5	287	48·4
3.20 "	108·5	302	50·0
3.50 "	105·5	324	52·1
4.20 "	109·5	278	46·4
4.50 "	111	257	43·4
5.20	108·5	282	46·7

TABLE XLIII.

OBSERVATIONS OF TEMPERATURES AND PRESSURES.

No. of Trial, 31. Date, Nov. 13, 1911.

Time.	Temperatures of gas. °F.			Suction in gas mains. Millimetres of water.			
	Final gas leaving No. 1 exit.	Leaving upper zone of producer.	Final gas leaving No. 2 exit.	Leaving producer.	Leaving coke scrubber.	Leaving tar filter.	Leaving dry scrubber.
9.55 a.m......	260	340	460	14	105	255	260
10.25 "	410	280	600	8	170	305	310
10.55 "	500	280	640	15	150	260	280
11.25 "	540	300	700	16	145	270	290
11.55 "	570	300	740	15	145	260	290
12.25 p.m......	570	300	730	20	130	282	315
12.55 "	590	300	730	20	150	285	315
1.25 "	570	290	950	20	145	280	310
1.55 "	580	270	800	22	155	285	320
2.25 "	610	270	710	25	140	275	290
2.55 "	670	280	770	25	145	260	285
3.25 "	670	270	810	25	150	270	300
3.55 "	680	270	850	24	150	270	290
4.25 "	650	270	810	17	230	320	340
4.55 "	710	260	750	17	155	240	270
5.25 "	720	250	790	17	155	250	260

TABLE XLIV.

REPORT OF GAS ANALYSIS.

TRIAL No. 31. Nov. 13, 1911.

Source of sample.	No. of sample.	Time of sampling.	PER CENT BY VOLUME.								CALORIFIC VALUE. B.T.U. PER CUB. FT.	
			Carbon dioxide.	Oxygen.	Ethylene.	Carbon monoxide.	Methane.	Hydrogen	Nitrogen.	Inflammable gas.	Gross.	Net.
After tar washer........	2	2.10 p.m.	9·8	0·4	0·3	19·8	2·5	10·4	56·8	33·0	127	119
"	4	4.15 "	10·1	0·3	0·5	18·8	2·4	11·4	56·5	33·1	129	120
Stand-pipe.............	1	11.00 a.m.	12·0	1·5	1·1	19·5	3·5	8·8	53·6	32·9	143	134
"	3	2.20 p.m.	9·4	2·4	1·2	21·1	3·1	8·5	54·3	33·9	145	136
"	5	4.30 "	11·1	5·8	0·9	11·6	2·6	5·0	63·0	20·1	94	88

Table XLV.

OBSERVATIONS OF FUEL CHARGED TO PRODUCER DURING TRIAL.

No. of Trial, 32. Date, Nov. 14, 1911.

Time of charging.	Gross, Lbs.	Tare, Lbs.	Net, Lbs.	Total charged, Lbs.	Time. of poking.
9.00 a. m	112	2	110	110	
10.00 “	102	2	100	210	
11.00 “	122	2	120	330	
12.00 noon	110	2	108	438	12.00 noon
1.00 p. m.	122	2	120	558	
2.00 “	102	2	100	658	
3.00 “	117	2	115	773	
4.00 “	164	4	160	933	

Fuel used for starting and banking overnight=100 lbs.

Table XLVI.

OBSERVATIONS OF POWER OF ENGINE.

No. of Trial, 32. Date, Nov. 14, 1911.

Time.	Volts.	Amps.	Brake horse-power of engine.
8.00 a. m	106·5	222	36·1
8.30 “	106·5	272	44·1
9.00 “	112·5	282	48·3
9.30 “	110·5	272	45·8
10.00 “	112·5	277	47·5
10.30 “	112·5	272	46·6
11.00 “	111.5	272	46·2
11.30 “	111·5	267	45·4
12.00 noon	107·5	292	47·9
12.30 p. m.	105·5	292	47·0
1.00 “	104·5	292	46·5
1.30 “	108·5	282	46·5
2.00 “	110·5	292	49·2
2.30 “	110·5	282	47·5
3.00 “	108·5	287	47·4
3.30	110·5	275	46·3
4.00 “	111	277	46·9

TABLE XLVII.

OBSERVATIONS OF TEMPERATURES AND PRESSURES.

NO. OF TRIAL, 32. DATE, Nov. 14, 1911.

Time.	Temperatures of gas. °F.			Suction in gas mains. Millimetres of water.			
	Final gas leaving No. 1 exit.	Leaving upper zone of producer.	Final gas leaving No.2 exit.	Leaving producer.	Leaving coke scrubber.	Leaving tar filter.	Leaving dry scrubber.
8.00. a. m.	410	320	690	10	80	200	210
8.30. "	490	320	680	12	90	220	230
9.00. "	580	260	700	15	105	230	240
9.30. "	640	270	680	15	115	205	215
10.00. "	600	220	680	14	270	470	500
10.30. "	640	220	730	12	125	215	245
11.00. noon.	640	220	740	15	130	215	235
11.30. p. m.	650	220	700	15	130	225	255
12.00. "	660	255	700	12	145	270	282
12.30. "	700	255	780	15	145	265	290
1.00. "	720	255	750	15	150	290	300
1.30. "	715	270	755	15	145	255	285
2.00. "	700	280	820	15	145	245	260
2.30. "	720	270	780	15	135	260	265
3.00. "	710	270	860	15	125	240	245
3.30. "	720	280	890	15	125	240	245
4.00. "	740	280	900	14	140	225	255

TABLE XLVIII.

REPORT OF GAS ANALYSIS

TRIAL No. 32. Nov. 14, 1911.

Source of sample.	No. of sample.	Time of sampling.	PER CENT BY VOLUME.								CALORIFIC VALUE. B.T.U. PER CUB. FT.	
			Carbon dioxide.	Oxygen.	Ethylene.	Carbon monoxide.	Methane.	Hydrogen	Nitrogen.	Inflammable gas.	Gross.	Net.
Tar washer	1	9.40 a.m.	6·8	0·3	0·2	24·6	1·3	9·8	57·0	35·9	127	120
“	3	11.45 “	6·3	0·2	0·1	24·7	2·8	7·9	58·0	35·5	134	127
Stand-pipe	2	10.00 “	9·0	7·9	0·6	10·5	2·0	4·4	65·6	17·5	77	73
“	4	Noon	11·7	3·7	0·9	12·3	3·4	5·1	62·9	21·7	104	97
“	5	3.35 p.m.	11·6	3·2	0·8	16·5	3·5	7·6	56·8	28·4	125	117

TABLE XLIX.

OBSERVATIONS OF FUEL CHARGED TO PRODUCER DURING TRIAL.

No. OF TRIAL, 33. DATE, Nov. 16, 1911.

Time of charging.	Gross, Lbs.	Tare, Lbs.	Net, Lbs.	Total charged, Lbs.	Time of poking.
10.00 a.m.	92	2	90	90	
11.00 "	102	2	100	190	
12.00 noon	100	2	98	288	
1.00 p.m	102	2	100	388	1.00 p.m.
2.00 "	112	2	110	498	
3.00 "	122	2	120	618	3.30 p.m.
4.00 "	122	2	120	738	4.50 "
5.00 "	102	2	100	838	

Fuel used for starting and banking. 200 lbs..

TABLE L.

OBSERVATIONS OF POWER OF ENGINE.

No. OF TRIAL, 33. DATE, Nov. 16, 1911.

Time.	Volts.	Amperes.	Brake horse-power. of engine.
9.00 a.m.	119·5	232	42·3
9.35 "	106	283	45·7
10.05 "	111	272	46·0
10.35 "	111	262	44·3
11.05 "	110	281	47·1
11.35 "	108·5	267	44·1
12.05 p.m.	106·5	284	46·1
12.35 "	108	280	46·1
1.05 "	107·5	282	46·2
1.35 "	106·5	287	46·6
2.05 "	107·5	292	47·9
2.35 "	107·5	297	48·6
3.05 "	102·5	284	44·4
3.35 "	111·5	289	49·2
4.05 "	101·0	281	43·3
4.35 "	107·5	277	45·4

TABLE LI.

OBSERVATIONS OF TEMPERATURES AND PRESSURES.

NO. OF TRIAL, 33. DATE, NOV. 16, 1911.

Time.	Temperatures of gas. °F.			Suction in gas mains. Millimetres of water.			
	Final gas leaving No. 1 exit.	Leaving upper zone of producer.	Final gas leaving No. 3 exit.	Leaving producer.	Leaving. coke scrubber.	Leaving tar filter.	Leaving. dry scrubber.
9.10 a.m.	220	300	400	10	200	280	300
9.40 "	460	290	690	10	200	270	280
10.10 "	520	270	710	12	140	215	240
10.40 "	550	260	680	10	140	210	220
11.10 "	590	250	770	11	154	229	245
11.40 "	640	240	780	10	185	245	265
12.10 p.m.	660	240	790	12	185	235	260
12.40 "	660	240	820	13	170	235	270
1.10 "	680	250	800	14	165	230	260
1.40 "	660	240	750	14	170	260	275
2.10 "	650	250	780	13	175	265	275
2.40 "	640	250	720	14	180	260	270
3.10 "	620	240	790	11	305	320	405
3.40 "	610	240	840	15	295	320	420
4.10 "	610	240	850	10	185	290	300
4.40 "	640	240	840	15	195	275	300

TABLE LII.

REPORT OF GAS ANALYSIS.

TRIAL No. 33. Nov. 13, 1911.

Source of sample.	No. of sample.	Time of sampling.	PER CENT BY VOLUME.								CALORIFIC VALUE. B. T. U. PER CUB. FT.	
			Carbon dioxide.	Oxygen.	Ethylene.	Carbon monoxide.	Methane.	Hydrogen	Nitrogen.	Inflammable gas.	Gross.	Net.
Tar washer.............	1	10.15 a.m..	5·6	0·3	0·5	25·8	1·6	9·5	56·7	37·4	137	130
"	3	11.55 a.m..	6·4	0·1	0·4	26·1	2·2	9·0	55·8	37·7	141	134
"	5	3.15 p.m..	5·7	0·2	0·4	26·9	2·0	8·8	56·0	38·1	141	134
Stand-pipe.............	2	10.20 p.m..	9·8	6·3	0·6	12·1	2·4	5·2	63·6	20·3	89	83
"	4	Noon.......	12·9	0·6	0·9	18·0	4·1	7·3	56·2	30·3	137	128
"	6	3.20 p.m..	14·2	0·3	0·9	16·8	3·9	6·6	57·3	28·2	128	120
"	7	4.30 "	15·6	....	....	....	....	....	....	....	....	....

TABLE LIII.

OBSERVATIONS OF FUEL CHARGED TO PRODUCER DURING TRIAL.

NO. OF TRIAL, 34. DATE, Nov. 17, 1911.

Time of charging.	Gross, Lbs.	Tare, Lbs.	Net, Lbs.	Total charged, lbs.	Time of poking.
10.15 a.m.	102	2	100	100	
11.15 "	132	2	130	230	
12.40 "	120	2	118	348	12.30 p.m.
1.35 "	102	2	100	448	
2.30 "	102	2	100	548	
3.25 "	102	2	100	648	4.00 p.m.
4.20 "	112	2	110	750	5.05 "
5.15 "	112	2	110	686	

TABLE LIV.

OBSERVATIONS OF POWER OF ENGINE.

NO. OF TRIAL, 34. DATE, Nov. 17, 1911.

Time.	Volts.	Amps.	Brake horse-power of engine.
9.20 a.m.	115·5	182	32·1
9.50 "	109·5	256	42·7
10.20 "	111·5	277	47·1
10.50 "	111·5	265	45·1
11.20 "	106·5	267	43·3
11.50 "	107·5	293	48·0
12.20 p.m.	105·5	290	46·6
12.50 "	105	297	47·5
1.20 "	106·5	297	48·2
1.50 "	106·5	272	44·1
2.20 "	112·5	272	46·6
2.50 "	112·5	262	44·9
3.20 "	110·5	257	43·3
3.50 "	108·5	272	45·0
4.20 "	102·5	312	48·7
4.50 "	106·5	297	48·2

TABLE LV.

OBSERVATIONS OF TEMPERATURES AND PRESSURES.

NO. OF TRIAL, 34. DATE, NOV. 17, 1911.

Time.	Temperatures of gas. °F.			Suction in gas mains. Millimetres of water.			
	Final gas leaving No. 1 exit.	Leaving upper zone of producer	Final gas leaving No. 2 exit.	Leaving producer.	Leaving coke scrubber	Leaving tar filter	Leaving dry scrubber.
9.25 a.m.......	405	300	700	12	368	497	507
9.55 "	540	280	750	10	287	320	330
10.25 "	570	260	780	11	230	320	340
10.55 "	580	240	830	11	245	340	350
11.25 "	635	230	880	13	305	400	410
11.25 "	640	230	840	12	305	400	405
12.25 p.m.......	650	230	870	12	305	415	425
12.55 "	655	240	855	12	305	400	410
1.25 "	610	240	820	12	260	340	345
1.55 "	660	240	840	12	260	330	340
2.25 "	660	240	830	15	240	310	320
2.55 "	610	240	830	12	240	310	320
3.25 "	620	270	820	14	252	310	350
3.55 "	630	270	850	13	255	330	350
4.25 "	570	270	800	17	290	405	430
4.55 "	580	260	780	15	320	419	445

TABLE LVI.

REPORT OF GAS ANALYSIS

TRIAL No. 34. Nov. 17, 1911.

Source of sample.	No. of sample.	Time of sampling.	PER CENT BY VOLUME.								CALORIFIC VALUE. B.T.U. PER CUB. FT.	
			Carbon dioxide.	Oxygen.	Ethylene.	Carbon monoxide.	Methane.	Hydrogen	Nitrogen.	Inflammable gas.	Gross.	Net.
From tar washer.	2	11.20 a.m.	4·6	0·6	0·1	26·9	1·9	7·6	58·3	36·5	131	125
"	4	2.20 p.m.	5·1	0·3	0·3	26·9	2·2	7·1	58·1	36·5	136	130
Stand-pipe............	1	9.55 a.m.	10·9	3·7	0·9	16·7	3·3	6·6	57·9	27·5	122	114
"	3	11.25 "	9·2	9·3	0·5	7·2	2·6	3·2	68·0	13·5	67	63
"	5	2.40 p.m.	13·2	1·3	0·9	17·0	4·1	6·8	56·7	28·8	132	123
"	6	4.20 "	17·0	2·8	0·7	5·4	2·5	2·0	69·6	10·6	60	56

Table LVII.

OBSERVATIONS OF FUEL CHARGED TO PRODUCER DURING TRIAL.

No. of Trial, 35. Date, Nov. 23, 1911.

Time of charging.	Gross, Lbs.	Tare, Lbs.	Net, Lbs.	Total charged, Lbs.	Time of poking.
10.00 a.m.	102	2	100	100	
11.00 "	105	2	103	203	11.00 a.m.
12.00 noon	107	2	105	308	
1.00 p.m.	112	2	110	418	3.00 p.m.
2.00 "	100	2	98	516	
3.00 "	110	2	108	624	
4.00 "	110	2	108	732	
5.00 "	127	2	125	857	

Fuel used for starting and banking overnight=130 lbs.

Table LVIII.

No. of Trial, 35. Date, Nov. 23, 1911.

Time.	Volts.	Amps.	Brake horse-power of engine.
9.00 a.m	120·5	172	31·6
9.30 "	110	280	47·0
10.00 "	106·5	278	45·2
10·30 "	110·5	277	46·7
11.00 "	110·5	280	47·2
11.30 "	109·5	272	45·4
12.00 noon	115·5	274	48·2
12.30 p.m	114	280	48·7
1.00 "	112·5	272	46·7
1·30 "	114·5	272	47·5
2.00 "	110·5	272	45·8
2.30 "	113·5	272	47·1
3.00 "	114·5	264	46·1
3.30 "	107·5	291	47·7
4.00 "	109·5	278	46·5
4.30 "	109·5	281	46·9
5.00 "	108·5	284	47·0

TABLE LIX.

OBSERVATIONS OF TEMPERATURES AND PRESSURES.

NO. OF TRIAL, 35. DATE, NOV. 23, 1911.

Time.	Temperatures of gas. °F.			Suction in gas mains. Millimetres of water.			
	Final gas leaving No. 1 exit.	Leaving upper zone of producer.	Final gas leaving No. 2 exit.	Leaving producer.	Leaving coke scrubber.	Leaving tar filter.	Leaving dry scrubber.
9.20 a.m	300	330	555	14	255	420	430
9.50 "	370	300	590	15	265	450	460
10.20 "	440	310	670	18	295	510	520
10.50 "	460	310	700	22	295	415	425
11.20 "	490	310	720	21	265	370	380
11.50 "	520	300	700	22	290	430	440
12.20 p.m	540	255	730	22	285	420	430
12.50 "	540	230	740	18	260	320	325
1.20 "	590	250	750	18	260	320	330
1.50 "	620	270	780	17	250	325	330
2.20 "	610	270	800	17	245	320	365
2.50 "	580	245	800	18	175	250	270
3.20 "	580	230	820	18	170	245	265
3.50 "	590	220	840	20	109	185	220
4.20 "	590	210	840	16	105	200	215
4.50 "	590	210	840	18	70	165	190

TABLE LX.

REPORT OF GAS ANALYSIS.

TRIAL No. 35. DATE, Nov. 23, 1911.

Source of sample.	No. of sample.	Time of sampling.	PER CENT BY VOLUME.								CALORIFIC VALUE. B.T.U. PER CUB. FT.		Remarks.
			Carbon dioxide.	Oxygen.	Ethylene.	Carbon monoxide.	Methane.	Hydrogen	Nitrogen.	Inflammable gas.	Gross.	Net.	
After tar washer.	1	10.35 a.m.	9·8	0·5	0·4	20·3	2·0	9·9	57·1	32·6	123	116	½ gauge openings.
"	3	3.45 p.m.	6·8	0·3	0·2	24·5	1·9	7·8	58·5	34·4	126	120	Full gauge openings.
Stand-pipe	2	10.40 a.m.	11·6	0·7	0·9	20·4	3·2	9·7	53·5	34·2	143	134	½ gauge openings.
"	4	3.45 p.m.	15·0	0·3	0·9	16·3	3·9	7·4	56·2	28·5	129	121	Full gauge openings.

TABLE LXI

OBSERVATIONS OF FUEL CHARGED TO PRODUCER DURING TRIAL.

NO. OF TRIAL, 36. DATE, NOV. 24, 1911.

Time of charging.	Gross, Lbs.	Tare, Lbs.	Net, Lbs.	Total charged, Lbs.	Time of poking.
10.00 a.m.	102	2	100	100	10.30 a.m.
11.00 "	117	2	115	215	11.00 "
12.00 noon	120	2	118	333	
1.00 p.m	112	2	110	443	1.10 p.m.
2.00 "	163	3	160	603	2.00 "
3.00 "	102	2	100	703	
4.00 "	133	3	130	833	
5.00 "	128	3	125	958	

TABLE LXII.

OBSERVATIONS OF POWER OF ENGINE.

TRIAL No. 36. DATE, NOV. 6, 1911.

Time.	Volts.	Amps.	Brake horse-power of engine.
9.15 a.m.	106·5	261	42·4
9.45 "	100·5	272	41·7
10·15 "	106·5	267	43·4
10.45 "	107·5	287	47·1
11.15 "	107·5	288	47·2
11.45 "	107·5	287	47·1
12.15 p.m.	107·5	282	46·3
12.45 "	106·5	281	45·6
1.15 "	112·5	272	46·7
1.45 "	112·5	267	45·8
2.15 "	106·5	282	45·8
2.45 "	112·5	267	45·8
3.15 "	111·5	264	44·9
3.45 "	111·5	270	45·9
4.15 "	111·5	287	48·8
4.45 "	111·5	286	48·6

Table LXIII.

OBSERVATIONS OF TEMPERATURES AND PRESSURES.

No. of Trial, 36. Date, Nov. 24, 1911.

Time.	Temperatures of gas, °F.			Suction in gas mains. Millimetres of water.			
	Final gas leaving No. 1 exit.	Leaving upper zone of producer.	Final gas leaving No. 2 exit.	Leaving producer.	Leaving coke scrubber.	Leaving tar filter.	Leaving dry scrubber.
9.20 a.m.	400	240	630	12	220	460	500
9.50 "	480	230	720	15	255	420	450
10.20 "	495	240	770	18	265	392	410
10.50 "	490	240	760	18	240	390	420
11.20 "	500	240	790	19	225	425	445
11.50 "	520	230	830	18	265	432	475
12.20 p.m.	540	230	860	18	245	430	450
12.50 "	570	230	880	19	255	483	500
1.20 "	530	230	840	19	280	490	500
1.50 "	510	230	870	17	255	430	440
2.20 "	480	230	860	19	255	440	450
2.50 "	480	230	910	19	265	460	470
3.20 "	530	230	930	19	250	420	435
3.50 "	490	220	820	19	265	460	470
4.20 "	490	220	840	19	285	456	490
4.50 "	500	230	850	19	270	450	500

TABLE LXIV.

REPORT OF GAS ANALYSIS.

TRIAL No. 36. Nov. 24, 1911.

Source of sample.	No. of sample.	Time of sampling.	PER CENT BY VOLUME.								CALORIFIC VALUE. B.T.U. PER CUB. FT.	
			Carbon dioxide.	Oxygen.	Ethylene.	Carbon monoxide.	Methane.	Hydrogen	Nitrogen.	Inflammable gas.	Gross.	Net.
After tar washer......	1	10.25 a.m.	7·1	0·5	0·2	24·0	2·7	7·9	57·6	34·8	132	125
"	3	11.50 "	5·8	0·9	0·5	24·1	2·7	8·2	57·8	35·5	139	131
"	5	3.10 p.m.	6·6	0·7	0·6	25·2	3·3	6·4	57·2	35·5	144	137
From stand-pipe........	2	10.30 a.m.	14·6	1·1	1·1	15·6	3·8	6·7	57·1	27·2	127	119
"	4	2.00 p.m.	15·7	0·1	1·0	16·5	4·2	7·1	55·4	28·8	134	125
"	6	3.15 "	15·5	0·1	0·8	15·9	3·8	6·7	57·2	27·2	123	115

CANADA

DEPARTMENT OF MINES

MINES BRANCH

Hon. Robert Rogers, Minister; A. P. Low, LL.D., Deputy Minister;
Eugene Haanel, Ph.D., Director.

REPORTS AND MAPS OF ECONOMIC INTEREST

PUBLISHED BY THE

MINES BRANCH

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2. Great Landslide at Frank, Alta. Report on—by R. G. McConnell and R. W. Brock, M.A., 1903.
3. Investigation of the different electro-thermic processes for the smelting of iron ores, and the making of steel, in operation in Europe. Report of Special Commission—by Eugene Haanel, Ph.D., 1904. (Out of print.)
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11. Asbestos: Its Occurrence, Exploitation, and Uses—by Fritz Cirkel, M.E., 1905. (Out of print: see No. 69).
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24. General Report on the Mining and Metallurgical Industries of Canada, 1907-8.
25. The Tungsten Ores of Canada. Report on—by Dr. T. L. Walker.
26. The Mineral Production of Canada, 1906. Annual Report on—by John McLeish, B.A.
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*A few copies of the Preliminary Report 1906, are still available.

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32. Investigation of Electric Shaft Furnace, Sweden. Report on—by Eugene Haanel, Ph.D.
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44. Production of Asbestos in Canada during the calendar years 1907 and 1908. Bulletin on—by John McLeish, B.A.
45. Production of Coal, Coke, and Peat in Canada during the calendar years 1907 and 1908. Bulletin on—by John McLeish, B.A.
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47. Iron Ore Deposits of Vancouver and Texada islands. Report on—by Einar Lindeman, M.E.
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Schedule of Charges for Chemical Analysis and Assays.
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71. Investigation of the Peat Bogs, and Peat Industry of Canada, 1909-10; to which is appended Mr. Alf. Larson's Paper on Dr. M. Ekenberg's Wet-Carbonizing Process: from Teknisk Tidskrift, No. 12, December 26, 1908—translation by Mr. A. Anrep, Jr.; also a translation of Lieut. Ekelund's Pamphlet entitled 'A Solution of the Peat Problem,' 1909, describing the Ekelund Process for the Manufacture of Peat Powder, by Harold. A. Leverin, Ch.E. Bulletin No. 4—by A. Anrep, Peat Expert. (Second Edition, enlarged). (Out of print.)
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    Vol. II—Boiler and Gas Producer Tests.
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    - Vol. III—
        - Appendix I
            - Coal Washing Tests and Diagrams, by J. B. Porter.
    - Vol. IV—
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            - Boiler Tests and Diagrams, by R. J. Durley.
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        - Appendix III
            - Producer Tests and Diagrams, by R. J. Durley.
    - Vol. VI—
        - Appendix IV
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            - Chemical Tests, by Edgar Stansfield.
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6. Magnetometric Survey, Vertical Intensity: Calabogie mine, Bagot township, Renfrew county, Ontario—by E. Nystrom, M.E., 1904.
13. Magnetometric Survey of the Belmont Iron Mines, Belmont township, Peterborough county, Ontario—by B. F. Haanel, B.Sc., 1905.
14. Magnetometric Survey of the Wilbur mine, Lavant township, Lanark county, Ontario —by B. F. Haanel, B.Sc., 1905.
15. Magnetometric Survey, Vertical Intensity: Iron Ore Deposits at Austin brook, Bathurst township, Gloucester county, N.B.—by E. Lindeman, M.E., 1906.
33. Magnetometric Survey, Vertical Intensity: Lot 1, Concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, M.Sc., 1909.
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36. Survey of Mer Bleue Peat Bog, Gloucester township, Carleton county, and Cumberland township, Russell county, Ontario—by Erik Nystrom, M.E., and A. Anrep, Peat Expert.
37. Survey of Alfred Peat Bog, Alfred and Caledonia townships, Prescott county, Ontario —by Erik Nystrom, and A. Anrep, Peat Expert.
38. Survey of Welland Peat Bog, Wainfleet and Humberstone townships, Welland county, Ontario—by Erik Nystrom, M.E., and A. Anrep, Peat Expert.
39. Survey of Newington Peat Bog, Osnabrook, Roxborough and Cornwall townships, Stormont county, Ontario—by Erik Nystrom, M.E., and A. Anrep, Peat Expert.
40. Survey of Perth Peat Bog, Drummond township, Lanark county, Ontario—by Erik Nystrom, M.E., and A. Anrep, Peat Expert.
41. Survey of Victoria Road Peat Bog, Bexley and Carden townships, Victoria county, Ontario—by Erik Nystrom, M.E., and A. Anrep, Peat Expert.
48. Magnetometric Map of Iron Crown claim at Klaanch river, Vancouver island, B.C. —by Einar Lindeman, M.E.
49. Magnetometric Map of Western Steel Iron claim, at Sechart, Vancouver island, B.C. —by Einar Lindeman, M.E.
50. Vancouver island, B.C.—by Einar Lindeman, M.E.
51. Iron Mines, Texada island, B.C.—by E. H. Shepherd, C.E.
52. Sketch Map of Bog Iron Ore Deposits, West Arm, Quatsino sound, Vancouver island, B.C.—by L. Frank.
53. Iron Ore Occurrences, Ottawa and Pontiac counties, Quebec, 1908—by J. White, and Fritz Cirkel, M.E.
54. Iron Ore Occurrences, Argenteuil county, Quebec, 1908—by Fritz Cirkel, M.E.
57. The Productive Chrome Iron Ore District of Quebec—by Fritz Cirkel, M.E.
60. Magnetometric Survey of the Bristol mine, Pontiac county, Quebec—by Einar Lindeman, M.E.
61. Topographical Map of Bristol mine, Pontiac county, Quebec—by Einar Lindeman, M.E.
64. Index Map of Nova Scotia: Gypsum—by W. F. Jennison, M.E.
65. Index Map of New Brunswick: Gypsum—by W. F. Jennison, M.E.
66. Map of Magdalen islands: Gypsum—by W. F. Jennison, M.E.
70. Magnetometric Survey of Northwest Arm Iron Range, Lake Temagami, Nipissing district, Ontario—by Einar Lindeman, M.E.
72. Brunner Peat Bog, Ontario—by A. Anrep, Peat Expert.
73. Komoka Peat Bog, Ontario—by A. Anrep, Peat Expert.
74. Brockville Peat Bog, Ontario—by A. Anrep, Peat Expert.
75. Rondeau Peat Bog, Ontario—by A. Anrep, Peat Expert.
76. Alfred Peat Bog, Ontario—by A. Anrep, Peat Expert.
77. Alfred Peat Bog, Ontario: Main Ditch profile—by A. Anrep, Peat Expert.
78. Map of Asbestos Region, Province of Quebec, 1910—by Fritz Cirkel, M.E.
86. Map showing general distribution of Serpentine in the Eastern Townships—by Fritz Cirkel, M.E.
94. Map showing Cobalt, Gowganda, Shiningtree, and Porcupine districts—by L. H. Cole, B.Sc.
95. General Map of Canada showing Coal Fields. (Accompanying report No. 83—by Dr. J. B. Porter).

96. General Map of Coal Fields of Nova Scotia and New Brunswick. (Accompanying Report No. 83—by Dr. J. B. Porter).
97. General Map showing Coal Fields in Alberta, Saskatchewan, and Manitoba. (Accompanying Report No. 83—by Dr. J. B. Porter).
98. General Map of Coal Fields in British Columbia. (Accompanying Report No. 83—by Dr. J. B. Porter).
99. General Map of Coal Field in Yukon Territory, (Accompanying Report No. 83—by Dr. J. B. Porter).
106. Austin Brook Iron Bearing district, Bathurst township, Gloucester county, N.B.—by E. Lindeman, M.E.
107. Magnetometric Survey, Vertical Intensity: Austin Brook Iron Bearing district—by E. Lindeman, M.E.
108. Index Map showing Iron Bearing Area at Austin Brook—by E. Lindeman, M.E.
109. Sections of Diamond Drill Holes in Iron Ore Deposits at Austin Brook—by E. Lindeman, M.E.
112. Sketch plan showing Geology of Point Mamainse, Ont.—by Professor A. C. Lane.
119-137. Mica: Townships Maps, Ontario and Quebec—by Hugh S. de Schmid, M.E.
138. Mica: Showing location of Principal Mines and Occurrences in the Quebec Mica Area —by Hugh S. de Schmid.
139. Mica: Showing location of Principal Mines and Occurrences in the Ontario Mica Area —by Hugh S. de Schmid.
140. Mica: Showing Distribution of the Principal Mica Occurrences in the Dominion of Canada—by Hugh S. de Schmid.
141. Torbrook Iron Bearing District, Annapolis county, N.S.—by Howells Fréchette, M.Sc.

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113. Holland Peat Bog, Ontario—by A. Anrep, Peat Expert.
146. Distribution of Iron Ore Sands of the Iron Ore Deposits on the North Shore of the River and Gulf of St. Lawrence, Canada—by Geo. C. Mackenzie, B.Sc.
152. Map showing the location of peat bogs investigated in Ontario—by A. Anrep, Jr.
153. Map showing the location of peat bogs investigated in Manitoba—by A. Anrep, Jr.
157. Lac du Bonnet Peat Bog, Ontario—by A. Anrep.
158. Transmission Peat Bog, Manitoba "
159. Corduroy Peat Bog, Manitoba "
160. Boggy Creek Peat Bog, Manitoba "
161. Rice Lake Peat Bog, Manitoba "
162. Mud Lake Peat Bog, Manitoba "
163. Litter Peat Bog, Manitoba "
164. Julius Peat Litter Bog, Manitoba "
165. Fort Francis Peat Bog, Ontario "
166. Magnetometric Map: part of McKim township, Sudbury Nickel district, Ont.—By E. Lindeman. (Accompanying Summary Report, 1911.)
168. Map showing Pyrites mines and prospects in Eastern Canada—by Dr. A. W. G. Wilson.
171. Geological Map of Sudbury Nickel Region, Ont.—by Prof. A. P. Coleman, Ph.D.
172. Geological Map: Victoria Mine—by Prof. A. P. Coleman.
173. " " Crean Hill Mine—by Prof. A. P. Coleman.
174. " " Creighton Mine—by Prof. A. P. Coleman.
175. " " showing contact of Norite and Laurentian in vicinity of Creighton mine—by Prof. A. P. Coleman.
176. " " Copper Cliff Offset—by Prof. A. P. Coleman.
177. " " No. 3 Mine—by Prof. A. P. Coleman.
178. " " showing vicinity of Stobie and No. 3 Mines—by Prof. A. P. Coleman.