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MISSING

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Railway and Engineering Club . . . .
OF CANADA

OFFICIAL PROCEEDINGS

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PROCEEDINGS OF THE CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA MEETING.

ROSSIN HOUSE, TORONTO, April 16th, 1907.

The President, Mr. Kennedy, occupied the chair.

Chairman,—

Gentlemen, before opening our meeting, I would be pleased if any of the members of the Executive that are here would take a seat up in the front.

The first order of business is the reading of minutes of the previous meeting. I understand that a copy of the proceedings of the previous meeting has been forwarded to each member and trust that you have each received one; if not, you had better take up with the Secretary. I would suggest that some member make a motion that the minutes be adopted as read.

Moved by Mr. J. C. Garden, seconded by Mr. J. J. Fletcher, that the minutes as published and forwarded to each member be adopted as read. Carried.

Chairman,—

The next order of business is the remarks of the President. I am sure that all present will regret to hear that one of our Executive Committee, Mr. H. H. Brewer, Terminal Superintendent G. T. Ry., Toronto, has received an appointment with another railway, and while we have lost an able man in regards to the welfare of this Club, I am sure we will all be pleased to hear of him getting advancement with other railroads. Mr. Brewer was one of the first in connection with the railway that took an interest in this Club, and we felt that we had good loyal support on our Executive in the assistance he gave us. This will necessarily leave a vacancy on the Executive which will have to be filled, although I may say that Mr. Brewer has not yet tendered his resignation.

We have to-night a paper to be read by Mr. J. R. Armer, Mechanical Draughtsman of the Grand Trunk Railway, Toronto, and I think that our time will be fully taken up listening to his remarks without anything further from me.

I might say that the membership of the Club has increased considerably since the last meeting, so that you will see that there has been some response to the Secretary's request that each member bring in another one, but we feel that we have not made as good progress as we should have. I believe the Secretary sent out a letter to each member requesting them to do what they could in regard to increasing the membership, and there are some that have responded to this request and others that have not, and we trust that they will endeavor to do so before the next meeting.

Mr. Vaughan, assistant to Vice-President of the Canadian Pacific Railway, was requested to give us a paper at the May meeting, but has written the Secretary that owing to pressure of business he will not have time to prepare a paper for the May meeting. The Executive Committee will, therefore, have to arrange for some other gentleman to give a paper at that meeting.

We will now call upon the Secretary for the announcement of new members.

NEW MEMBERS.

F. C. Westman, Foreman Machine Shop, London.
Jno. W. Grippin, Electrician, Toronto.
H. M. Paton, Engineer, G.T.R., Stratford.
Henry Hague, Traveller, East Toronto.
A. Sharpe, Foreman Boilermaker, American Abell Co., Toronto.
J. C. Blanchflower, Engineer, Fairbanks-Morse Co., Toronto.
H. H. Beasley, Storekeeper, Toronto Railway Co., Toronto.
Wm. Stinson, Engineer, G.T.R., Sarnia Tunnel.
H. W. Cook, Engineer, Toronto.
J. G. Moorehead, Steam Fitter, Canadian Shipbuilding Co., Toronto.
Jas. McKenzie, Machinist, G.T.R., Toronto.
Robt. A. Miller, Machinist, G.T.R., Toronto.
J. W. McCulloch, Divisional Superintendent, Toronto Railway Co., Toronto.
Christopher Steel, Divisional Superintendent, Toronto Railway Co., Toronto.
Chas. L. Wilson, Assistant General Manager, Toronto & York Radial Railway Co., Toronto.
A. J. Edmonds, Divisional Superintendent, Toronto Railway Co., Toronto.
J. J. McWilliam, Divisional Superintendent, Toronto Railway Co., Toronto.
W. Pringle, Leading Fitter, G.T.R., Sarnia Tunnel.
D. N. Perrin, Assistant Engineer, Temple Building, Toronto.
D. A. McGhee, Fireman, G.T.R., Toronto.
H. D. Langlois, Engineer, G.T.R., Sarnia Tunnel.
W. H. Farrell, Terminal Superintendent, G.T.R., Toronto.
R. W. Grace, Mechanical Superintendent, Canada Foundry Co., Toronto.
F. S. Ferguson, Western Representative Canadian Iron Foundry Co., St. Thomas.
General Chas. Miller, President, Galena Signal Oil Co., Franklin, Pa.
J. W. McLintock, Clerk, Master Mechanic's Offices, G.T.R., Toronto.

Secretary,—

I would just like to say that in sending in applications you will note at the bottom of the form used for that purpose there is a space for the title to be filled in. In a good many cases this information is not given and I shall be glad if the members when making out applications will see that all the information asked for on these forms is given.

MEMBERS PRESENT.

J. C. Blanchflower.	W. Kennedy.	J. Duguid.
J. E. Stephenson.	J. G. Abraham.	J. J. Fletcher.
T. F. Monypenny.	Harry Ellis.	R. Ivers.
R. J. Goudy.	J. R. Armer.	F. R. Wickson.
H. Cowan.	J. A. Mitchell.	J. C. Garden.
J. McWater.	M. W. Barker.	Geo. Black.
Robt. Pearson.	N. MacNicol.	A. G. McLellan.
J. H. Stortz.	E. Logan.	I. O. Frost.
D. A. Dixon.	J. Mooney.	J. C. Brady.
Jno. Dodds.	Wm. Evans.	G. McIntosh.
I. Jeffries.	Geo. Cooper.	W. H. Wensley.
J. B. Wilson.	J. Hay.	Frank Stortz.
R. M. Perrin.	S. Groves.	Geo. Shand.
N. Quisnel.	F. J. Ward.	T. G. Casson.
J. J. Moat.	G. C. Morring.	A. S. Wright.
W. Gell.	F. Burrows.	

Chairman,—

"Reports of standing committee." Nil.

"Unfinished Business." Nil.

"New Business." I expect we will take the same procedure as has been in the past in regard to the appointment of a new member for the Executive, the Executive nominating a member for the vacancy.

"Reports of Special Committee." Nil.

"Unfinished discussions of papers read at previous meetings."

Would be pleased to know if any member present has anything to say in regards to the paper given at the last meeting by Mr. Patterson. Nil.

"Reading of papers and reports and discussions thereof."

As said before, we have with us to-night Mr. J. R. Armer, Mechanical Draughtsman of the Grand Trunk Railway, Toronto, who has prepared a paper on "Producer Gas." I have now much pleasure in introducing Mr. Armer.

PRODUCER GAS—ITS MANUFACTURE AND USE.

BY MR. J. R. ARMER, MECHANICAL DRAUGHTSMAN, GRAND TRUNK RAILWAY, TORONTO.

There is not time to go into any detail on any of these points. In taking up the subject generally we have not time in one evening, but perhaps at a later meeting, if it is of sufficient interest to the members, it might be gone over more in detail.

The use of producer gas is steadily growing in favor in America. Each year sees a marked increase in the installations made throughout the country, although as yet there is not by any means the widespread knowledge of gas power that there is of steam power plants.

In European countries, the necessity of economic use of fuel has lead to the making of numerous experiments and tests, with the producer gas plant. In these countries they have become well known and for many years have been in successful operation. They are used extensively in supplying gas for the generation of power both in manufacturies and in central power, and lighting stations.

GASES USED FOR HEATING AND POWER PURPOSES.

Producer gas is only one of a number of gases used for power and heating purposes. Among these are illuminating gas, ordinarily used for lighting, natural gas, and blast furnace gas.

Illuminating gas is manufactured in such a way as to make it a good clean gas, high in heat units and in illuminating power, for domestic use. It consists usually of a mixture of coal gas and carbureted water gas.

The coal gas is made from bituminous coal which is distilled in externally heated air-tight retorts or ovens, an exhauster taking the gas thus formed and after passing it through the tar extractor, scrubbers, etc., stores it in the gas holder.

The carbureted water gas is formed by passing steam through an incandescent bed of carbon, and then further treating it by passing it through hot checker brick sprayed with oil. Before being treated with oil the product was plain water gas, which, although a good gas for heating, has no illuminating properties; these properties are given to it by the oil. The carbureted water gas is used to increase the illuminating quality of the coal gas as required.

This illuminating gas, on account of its high price, is altogether out of the question as a fuel for large engines in comparison with other sources of power.

Natural gas is extensively used in districts where it is available, and gives very satisfactory results for power, heating, and lighting purposes; its use is limited, however, on account of being found only in certain localities, and even then the chance of failure in supply makes its use uncertain.

Blast furnace gas is the product of the blast furnace, being formed during the process of smelting the ores. The blast furnace, although an ore smelter, is incidentally a huge gas producer and the resulting gas is similar to producer gas, only of lower quality, averaging about 110 B.T.U. It is used for heating purposes, and when cleaned is suitable for gas engines, being used in this way for driving blowers, etc., about the smelting plant.

Producer-gas, with which this paper has to deal, is the product of incomplete combustion in the gas producer. It has a low calorific value, ranging from 125 to 150 B.T.U.; being made partially through the decomposition of steam, it contains a certain amount of hydrogen but not enough to make it as inflammable as water gas. On this account it is well suited for gas engine purposes. It is made by passing air and steam through a deep incandescent bed of fuel. The temperature of the fire is regulated by the steam supply, and is kept at a point which will insure the proper chemical action between the carbon in the fuel and the air and steam, without allowing any of the resulting gases to be burned.

The method of manufacture differs from that of ordinary coal gas, in that all the combustible part of the fuel is gasified; the heat required to make the gas being supplied in the generator by the incomplete combustion of the fuel which is being gasified, while with coal gas external heat is applied, and we have part of the coal left in the retorts in the form of coke.

Producer gas was used for heating purposes as early as 1840. About twenty-eight or twenty-nine years ago it was first used for power purposes; it is only within recent years, however, through the improvement and simplification of the apparatus for generating it, that producer-gas has received the impetus which has brought it into such general use to-day. One of the earliest uses to which it was put was the firing of furnaces for the manufacture of iron, and along this line it has filled an important position, assisting in no small measure in the bringing of the steel and iron industry to its present state of development.

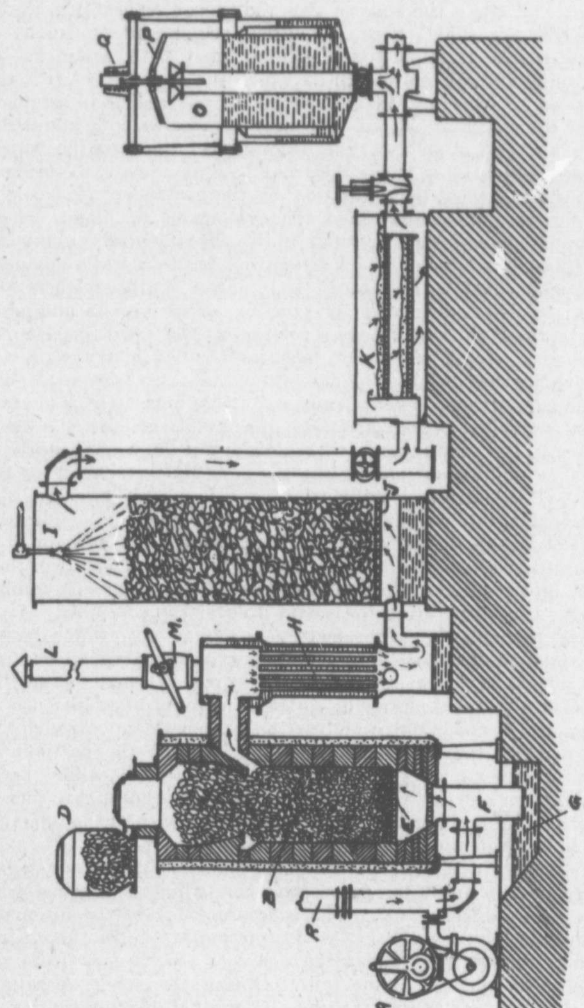
METHOD OF MANUFACTURING PRODUCER GAS.

The methods of manufacturing producer gas may be conveniently classified under two headings, according to the way the draught is created in the producer, namely: induced draught and forced draught. In the former case the plant is under a slight vacuum, and in the latter it is under pressure.

Inducing the draught is accomplished in two distinct methods, either by the exhausting action of the gas engine piston, as in the suction producer type, or by a separate exhauster or fan as in the Loomis-Pettibone System. The former is well illustrated in slide No. 1, which is a cross-section view of the Pintsch suction gas producer plant.

(NO. 1 SLIDE) INDUCED DRAUGHT PRODUCERS.

Although the styles of plants on the market vary considerably in detail, slide No. 1 gives a very good idea of the



SLIDE No. 1.

principle and general arrangement of the Suction Producer plant. (A) is the hand-blower for blowing up fires when starting them, (B) is the body of the producer or generator in which the coal is gasified; it is a cylindrical vessel built up usually of steel plates rivetted together and lined with firebrick. It contains a set of grates (E) on which the fuel rests, (D) is the hopper for charging the generator with fuel and is so arranged that the coal may be put into the generator without admitting any air, (E) is an ash tube, leading the ashes to the water-sealed ashpan, (G), where they may be removed at will, without interfering with the operation of the producer, (H) is the vaporizer, sometimes called the evaporator or boiler, which supplies steam for gas making; in this case it contains a number of tubes, like a boiler, which are surrounded by a water chamber partially filled with water. (I) is a wet scrubber where the gas is cooled and cleaned; it is built up of steel plates and has a grate at (J) on which rests a column of coke used for cleaning the gas. (K) is a purifier sometimes called a dry scrubber, which further purifies the gas; it contains two trays as shewn, each supporting a layer of sawdust or shavings. (L) is a waste pipe controlled by the valve (M); it is used to conduct the waste gases to the atmosphere, when blowing up the fires in starting.

The method of making the gas is as follows: air from the pipe (R), and steam supplied by the vaporizer are admitted under the grate (E) and are drawn up through the incandescent bed of fuel in the producer. The resulting gases pass out into the vaporizer where, in going through the tubes as shown, they give up a portion of their sensible heat to the water surrounding them, thus generating the steam used in the producer. After going through the water seal and cleaning pot, which beside cleaning the gas considerably, also serves as a trap, preventing its return to the generator, or waste pipe, the gas enters the wet scrubber. A spray of water is introduced at the top of the scrubber as shown, and as the gas passes up through the coke it intermingles with the water, leaving the particles of dust or other matter in the gas, deposited on the coke. Tarry vapors are also arrested here; and the gas is thoroughly cooled. In the dry scrubber the gas is further purified, and the moisture in it is given up to the shavings, or excelsior.

In the Pintsch Suction Producer plant more than one engine may be run from the same producer, which is unusual with suction producer plants. This is accomplished by the automatic regulator shown at (0). On the suction stroke of the engine, gas is drawn from under the dome (P) as well as from the generator and the dome falls. During the other operations of the engines the dome resumes its original position by the aid of a spring (Q) and in so doing is filled with gas again, ready for the next suction stroke. This keeps a constant and even flow of air through the generator.

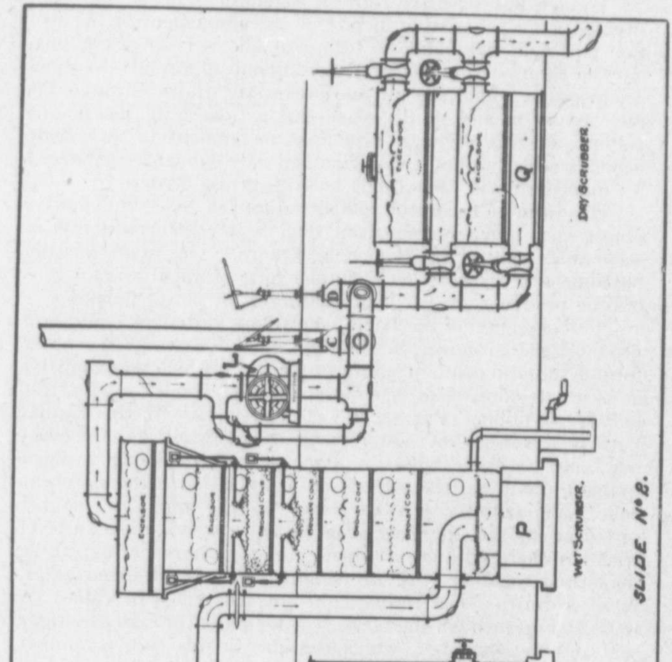
A much less sensitive form of regulator is in use on other suction plants, consisting merely in an enlargement of the suction pipe near the engine to form a small reservoir or gas box.

The term suction-gas producer should apply only to those producers in which the air and steam are drawn through the fuel bed by means of the exhausting action of the gas engine piston. In this style of producer the amount of gas made depends directly upon the engine and only enough is generated for immediate use, thus doing away with gas holders.

This form of generator was introduced in 1884, but did not obtain very much success until 1895, with the introduction of a suction producer by Benier, in France. This style was the outcome of a desire to get a simpler form of apparatus for generating producer gas in small quantities for power purposes.

A cross section of the Loomis-Pettibone system of generating producer gas is shown on slide No. 2, it illustrates the other form of induced draught producer plants, in which an exhauster is used. It consists of generators (M & O), boiler at (N), wet and dry scrubbers (P & Q) and exhauster (L). In this system both producer-gas for power purposes and water gas for heating, may be made with the same generator; being a down draught producer, the generators are filled with incandescent coke, and combustion takes place on the top. In making producer gas, the charging doors (H & I), which are on a level with the charging floor are open; the air enters through these doors and together with the steam, which is admitted at (E & F) is drawn down through the fire past the two valves (A & B) and up through the boiler. After going through the water seal and wet scrubber, which contains in this case a number of trays covered with coke, it passes on to the exhauster and is either forced through the dry scrubber and on to the producer gas holder, or by closing valve (D) and opening (C) it may be discharged into the atmosphere according to whether gas is being made or whether fires are simply being blown up.

In making a run of water gas the fires are blown up with air by the exhauster, then the valve (B) and the charging doors (H & I) are closed; steam is then admitted under the grate at (J) and forced up through this generator, across, and down through the other, thus thoroughly fixing the gas in passing through the hot fuel of the second generator. After passing valve (A) and going up through the boiler it is conducted by a separate pipe to the water gas scrubbers and holder. The steam required in making the gas soon deadens the fires so that it is not generated for more than five minutes at a time. Producer and water gas are made alternately. In the next run of water gas the steam is admitted at (K) and passes through the generator in the opposite direction, thus keeping the fires uniform. The valves controlling these operations are all within easy reach of the operator.


DRY SCRUBBER
Q
WET SCRUBBER
P
GENERATOR
O
BOILER
N
GENERATOR
M
SLIDE No 2.

PRESSURE PRODUCER PLANTS.

The pressure style is the original form of producer. They are extensively used with low grade fuels and generate gas for various purposes. The principle in generating the gas in these producers is very similar to that in a suction plant, the essential difference being in the fact that the air and steam are forced through the producer instead of being sucked through. This is accomplished either by the pressure of the steam itself, which requires a separate power boiler or by a motor driven blower, the resulting gases being stored in a holder. The details vary considerably from those of a suction plant, however, according to the purpose for which the plant is built. In large pressure plants where an inferior grade of fuel is used and at the same time a clean gas is required for engine use, the cleaning apparatus has to be much more extensive than in the suction plant.

Some of these pressure plants through certain modifications take the form of by-product plants, such as the Mond system, in which the tar and ammonia are recovered. By-product plants are usually not installed except in large units of from 5.000 h.p. upwards, where a large quantity of gas is required.

The merits of these different systems depend largely upon the requirements of the particular case. The use to which the gas is to be put, size of plant required, the kind of fuel which is most convenient or profitable to use, have all a very important bearing on the question.

Suction producer plants although installed in large units, are specially adapted to small power plants where the installation of a gas holder and extensive cleaning apparatus would not be warranted.

Where a number of engines, perhaps at some distance apart, are to be supplied with gas, and where the gas is to be used for other purposes as well, the pressure producer is very suitable on account of having the gas holder, which takes care of any variation in the quantity of the gas being used and also keeps a uniform pressure in the supply pipes. As these plants are usually installed in large sizes, it is found most economical to use a low grade of fuel such as bituminous coal, and install extra apparatus for cleaning the gas.

Mechanical contrivances are also used on many of these large plants for giving such vertical, lateral, or other motions to the grates as will break up the clinkers and keep the fire in a compact and uniform condition. In all large producers using a low grade of coal these mechanical devices for loosening the clinkers are desirable, as hand barring, on account of the deep bed of fuel, is laborious and sometimes ineffective.

FUELS.

A great variety of fuels are used for generating producer-gas, in fact almost any carbonaceous fuel may be used, including charcoal, coke, hard coal, lignite, peat, wood, sawdust, etc., and even city refuse. If coal is used, to get the best results it should be of good quality. It should have a low percentage of ash, and should not clinker. In case the gas is to be used in gas engines or in the manufacture of iron, it should contain a low percentage of sulphur. The coal should be as nearly as possible uniform in size and not too large, as this would make the fuel bed too porous. The fuels usually used for suction producers are coke and hard coal. These fuels do not clinker; they also produce a gas containing a low percentage of tar, which is important in a plant having limited facilities for cleaning the gas, as the presence of tar is the cause of valves sticking and other troubles in the gas engine. Lignite and peat have been used in Europe in pressure producers, and the gas used as a fuel for gas engines in many instances.

USES TO WHICH PRODUCER GAS IS PUT.

Besides being used in gas engines, producer gas has several other uses, including the firing of brick, lime, and all classes of pottery kilns and the firing of steam boilers; it is also used in the manufacture of iron, steel and glass.

Some of the advantages of gas firing are as follows:—Increased economy, the obtaining of higher temperatures and the more complete control over combustion and temperatures.

Producer gas as a means of firing brick kilns, etc., has been used considerably in Europe, it has many advantages in this line including some of the foregoing.

Its use for firing steam boilers, except in special instances, is not recommended in view of the high efficiency of the gas engine; it is a well recognized fact that to use the gas in the gas engine would be more economical. However, in plants where steam or hot water is required in the process of manufacture and the elimination of smoke nuisance is desirable, the use of producer-gas will be found advantageous and will give better results than direct firing, but with no perceptible saving in fuel.

The gas in this case is manufactured very cheaply, not requiring any cleaning. In some cases the producer is separate from the boiler entirely, and in other cases is placed under it, forming a part of the boiler setting.

GAS CLEANING.

The object of cleaning the gas is to remove just such constituents as would have a harmful effect in the use to which it is to be put. The amount of cleaning will thus depend upon the work the gas has to do.

Some of the devices used for this purpose are as follows:— Liquid scrubbers, rotary scrubbers, deflectors and absorbers. A combination of some of these is usually used, as shown in slide No. 1.

The extraction of tar is one of the greatest difficulties met with in cleaning producer gas, and as its elimination is absolutely necessary for the best results in gas engine practice, the means adopted in the design of a plant for its removal are very important considerations.

Wet scrubbers are used, except where gas contains an excessive amount of tar. Where there is an excessive amount of tar some builders use rotary scrubbers or tar extractors in addition to the wet scrubbers, and they claim very satisfactory results. Other makers have a different opinion and advocate having the fires so arranged that the tendency is for the tar to be converted into a permanent gas in the producer, thus enabling them to do away with tar extractors. To accomplish this the products of distillation are passed through a hot bed of fuel. The fuel bed in the producer is sometimes utilized- or a separate bed of incandescent carbon used. One method of doing this is illustrated in the Loomis-Pettibone System where the products of distillation formed in the upper part of the producer are drawn down through the hot fuel bed and leave the producer below the grate.

OPERATION OF PRODUCER GAS PLANTS.

Producer gas, on account of the carbon-monoxide it contains, is very poisonous. The presence of any considerable amount of it in the air may be very injurious if not fatal to the operator of a producer plant. It is only in pressure plants that the gas is liable to escape while in operation, however, and with ordinary care, the room containing the plant being well ventilated, and the plant in good condition, there is no danger.

For the best results, the plant should be kept clean; pipes kept gas tight and arranged so that they may be cleansed of dust and tar. Scrubbers should be inspected periodically to see if the coke or other material is clean enough to insure efficient working. They should usually be cleaned once in six or eight months, according to conditions.

The fire should be drawn from the producer about once a week and clinkers removed; if the fires are rekindled immediately without allowing the firebrick lining to be chilled, it will prolong its life considerably.

When cleaning scrubbers, etc., open flame lamps should not be used, on account of danger from explosion.

The method of starting producers varies considerably according to the type, but the following description of the starting of a suction producer plant will give an idea of the method of procedure. The cock in the waste pipe should be opened and the passage to the scrubbers closed; the ashpit door should also be open. The fire is then kindled on the grates with oily waste and built up gradually with wood and coal. When the fire is nicely started all doors are closed and the blower used. After blowing the fire for several minutes, more coal is added through the feed hopper on top of the generator, filling it quite full. The blowing is then continued until the gas is fit for use, which usually takes from fifteen to twenty minutes. The gas should be tested about ten minutes after starting, a test cock being provided for that purpose between the producer and the waste pipe. At first the gas may burn with a blue flame, but as the blowing continues, it will gradually turn to an orange color which indicates that the gas is fit for use in the engine. The water is then turned on in the scrubber and the waste pipe closed, the gas passing into the scrubbers. After the air in these vessels has been driven out and good gas appears at the engine test cock, the engine should be started and hand blowing discontinued.

The steam supply is a very important point in the operation of a gas producer. Besides enriching the gas it serves to regulate the temperature of the fire and retards clinkering, thus enabling the fire to be kept in good condition.

In pressure producers the regulation of the steam supply is not very difficult, but in suction producers where the air supplied to the producer depends upon the load on the engine, it requires special attention. The amount of steam going into the suction producer must always be proportional to the amount of gas being used by the engine. If the supply of steam is too great, the fires will be deadened and there will not be enough heat to cause the chemical union of the oxygen and carbon, on the other hand too little steam will allow the fires to get too hot.

In some suction producers the steam supply is regulated by the amount of air allowed to pass over the water in the vaporizer on its way to the producer. In this case there are two air supplies, one passing through the vaporizer as mentioned, the other supplying the dry air only; these two may be adjusted so as to give the proper proportion of each. This is the method used in the Crossley Suction plant, and others.

Another device in use is to have part of the air supply pipe coiled in an iron box through which is passed the engine exhaust. A valve controlled by the engine admits to this hot-air pipe a certain amount of water at each power stroke of the engine, varying with its requirements. The water, on entering the hot coils of the pipe, is turned into steam and, mingling with the air supply which is pre-heated, is drawn into the producer.

PRODUCER GAS POWER PLANTS.

In Europe, gas producer power plants are regarded with much the same confidence as is universally placed in steam plants. In America, however, for various reasons, its use has not become general, although its progress is being watched with great interest.

Some of the reasons attributed to its slow introduction into America are as follows:—Lack of knowledge as to its use and advantages, the presence of abundance of fuel, the usual hesitancy with regard to change, and the absence of laws against smoke nuisance.

One of the important points about a producer power plant is the short time required to start and stop the plant and the little attention required when it is standing idle; even after several hours idleness the plant may be started and be working at its full capacity in a few minutes.

The labor required to operate a pressure producer plant is about the same as that required for a steam plant of a similar size. With a suction producer plant the labor required is much less.

In a locality where good fuels are scarce or where the water supply is scarce or unfit for boilers on account of its mineral nature, the gas producer power plant has special advantages. These mineral waters which ordinarily give so much trouble in steam boilers are quite suitable for cooling and washing the gas in the scrubbers. The amount of water used in a producer plant is not more than half that required in a steam plant of a similar size. If the cooling water is used over and over this figure may be greatly reduced.

Danger from explosion with gas producers is less than with steam boilers, and should an explosion occur it would be much less violent and destructive than in a steam plant.

No more skill is required to handle a producer gas power plant than is needed for a steam plant of similar size, but it may require some time for men trained to handle steam plants to become accustomed to gas engines and gas producers.

In closing, a few comparisons between producer gas power plants and steam power plants will bring out many points of interest.

The essential difference between these plants is in the direct method of converting the heat units in the coal into power on one hand, and the indirect method, through the medium of steam, on the other.

In the case of the gas producer, after the gas is generated and cooled it may be transmitted without loss to the engine cylinder where almost perfect combustion is obtained. The losses in this case are taken up mainly in the heat radiated from the producer and connecting pipes, in the heat lost in cooling the gas, and the engine cylinder, and in that lost in the exhaust. The amount of energy lost in this way compared to the amount originally in the coal is very large, the proportion lost, however, is much smaller than in a steam plant.

In a steam plant all the combustion takes place in the fire-box under poorly regulated conditions, an excess of air being required which carries a large portion of the heat up the stack, together with unburnt gases and particles of carbon in the form of smoke. The remaining heat is absorbed by the boiler in generating steam or is radiated from the fire-box; further losses occur through the radiation from steam pipes and engine, and finally, in the exhaust there is another large loss.

The following figures taken from a diagram which was published in *Power* shows the proportion of these heat losses in a modern steam plant, and when compared with the losses in a gas plant will give an idea of where the greater efficiency of a gas power plant, over a steam plant, comes in. Out of 13.500 B.T.U. the value per pound of the coal used in the fire-box, 135 were lost in ashes, 675 in radiation from the boiler, 2,970 were carried off into the stack, 190 in auxiliary exhaust, 520 radiating from steam pipes and engine, 7,737 rejected to the condenser and 1,273 were converted into power. Considering the mechanical efficiency of the engine as 93%, would give 1,176 B.T.U. as delivered from the engine in B.H.P. By comparing 1,176 B.T.U. with 13,500 B.T.U., the original number in the coal, the efficiency of the whole plant comes to 8.7 per cent.

As a comparison with this, the following figures have been taken from a report on tests made with the Crossley suction gas plants and gas engines by consulting engineers and others, and read before the Manchester Association of Engineers in connection with a paper on this subject.

In the tests reported, the thermal efficiency of the plants ran as high as 24.95%. One of these tests was made with a plant at Milford-on-Sea Electric works, which at the time of making the test had been in operation for some months. The efficiency of this plant was low in comparison with some of the results obtained, as will be seen, so that the comparison is conservative. The fuel used was anthracite coal having a heating value of 14,895 B.T.U. per pound. The indicated horse power of the engine was 46.25 I.H.P. The test lasted 3 hrs. 49 mins. The total amount of coal used was 133.5 pounds; the coal used per I.H.P. hour was .785. Assuming that the mechanical efficiency of the engine was 85% the amount of coal per B.H.P. would be .89 pounds. The value in B.T.U. of .89 pounds of coal would be 13,256 B.T.U., which when compared with 2,545, the B.T.U. value equivalent to 1-H.P., gives the efficiency of the whole plant including the mechanical efficiency of the engine as 19.35%. If the losses in this case be divided up according to the usual proportion of loss in the different parts of the suction producer power plant they will be as follows, out of 13,256, the B.T.U. value of the fuel used, 2,651 are lost in ashes, radiation, cooling of gas, etc., 4,445 in exhaust and 3,166 in cooling the cylinder; the remaining 2,994 are converted into power; the efficiency of the engine being 85%, 2,545 of these are converted into B.H.P.

In comparing these two plants, the efficiency of the steam plant being 8.7%, and that of the gas plant being 19.35%, we find a saving of 55% in favor of the suction producer power plant. In neither of these cases has allowance been made for standby losses, which favor the steam plant.

Regarding fuel required per H.P., manufacturers make numerous claims, many of which have been substantiated. The claims average about one pound of anthracite per H.P. per hour, and vary from 0.6 to 1⅓ pounds per B.H.P. per hour. The 0.6 figure is pretty low, but numerous tests have shown a consumption as low as .8 pounds anthracite per B.H.P. per hour.

Considering the high thermal efficiency and the many other points of advantage about a producer gas power plant, its outlook for the future is very bright. It has passed the experimental stage and has become a formidable competitor of all classes of power. Its field of usefulness will doubtless be widened greatly and already it is being considered as a means of propelling vessels, driving traction engines and for developing power under many other conditions.

The following slides were exhibited showing a few of the suction producer gas plants.

SLIDES.

No. 3. American-Crossley Suction Gas Plant.
No. 4. Cross Section of The Weber Suction Gas Plant.
No. 5. Outside view of The Weber Suction Gas Plant.
No. 6. Suction Gas Power Plant.
No. 7. Fairbanks-Morse Suction Producer Power Plant.
No. 8. Weber, 450 h.p. Suction Gas Engine.
No. 9. Diagram showing heat losses in a modern steam power plant.

Chairman,—

I am sure we have all been very much interested in this paper. I certainly have been myself. When you take into consideration that Mr. Armer is not out selling gas producers, and I hope he is not looking to these people for a position, I think that a good deal of credit is due him for this paper. He has made a good study of this work for the Grand Trunk, they having in view the making use of this power, and from the interest taken in preparing his paper he has made a success of it. From the number of faces I see here to-night that I have not seen before, we have quite a few here that are interested in this work, and I would prefer that members volunteer to come forward in regard to the discussion of this paper and not wait to be called upon. We would be pleased to hear from any member present.

Mr. R. L. Frost,—

I note in the illustration regarding suction producers that steam and air are admitted from the bottom, whereas in the Loomis-Pettibone system it is admitted from the top. Can you explain us why?

Mr. J. R. Armer,—

The idea in the Loomis-Pettibone system is to draw the products of dissolution through the fuel bed and thus convert any tarry vapors into a fixed gas, so that the tar will not condense in the pipes and carry tar to the engine, which is very undesirable. In other systems they have tar extractors, such as in the Crosby gas producers.

Chairman,—

I understand we have with us to-night Mr. Groves, who is an authority on gas producer plants. We would be pleased to hear from that gentleman on the subject.

Mr. S. Groves, late Editor of *The Canadian Engineer*,—

Mr. Chairman and gentlemen:—I have listened to the lecturer to-night with a great deal of pleasure. It is a subject I have given some thought to, and have had some experience in the actual working of gas producers. There is one thing I regret, that the lecturer did not show us what is being done in Canada in this line. The pioneers in this country have been the French-Canadians. In the Province of Quebec yonder, DeClercy has installed—to my knowledge—over 10 suction gas producer plants; but with this exception, progress has been slow. In England they are ahead of both Canada and the United States in the utilization of the gas engine. The United States, however, have beaten the world in the use of the gas producer. There are hundreds of gas producers in the rolling mills and steel works of the United States; of the "Duff" type. Perhaps the best gas producer on the market is the Duff-Whitfield; in which the products of distillation are removed in the middle of the producer, and re-introduced near the bottom; rising up through the zone of incandescent fuel, where they are burnt and converted into fixed gases, thus eliminating the sulphurous coal, tar, etc., which clog the mains and interfere with the operations of the gas engine.

One of the advantages of the gas producer system is, that you can use as fuel, almost anything which contains carbon—wood, peat, sawdust, even cabbage stalks and potato peelings, etc. The only trouble when using these low grade fuels is, that larger and more expensive auxiliary plants for scrubbing and washing have to be provided to take care of the waste by-products. It is analogous to the stomach of a man on the one hand, and that of a cow on the other. Human beings have comparatively small stomachs; because they use concentrated foods; beef steaks, mutton chops, etc.; whereas the cow has a large stomach, because she feeds on grass, and has to take in immense quantities of it in order to get a small amount of nutriment therefrom. (Laughter.)

The figures quoted by the lecturer showing the economy of small suction-gas producer power plants when compared with large, modern steam plants, were remarkable. This agrees with DeClercy's experience in Eastern Canada. I will read from my note-book figures based upon his experiments:—After indicating that the average coal consumption of steam engines of 10 to 30 horsepower is 4 to 8 lbs.,—including starting; and 100 to 500 h.p.—2 lb. per brake h.p., he shows that in small suction gas producer plants the consumption of anthracite coal is 1 lb. per h.p.; while in plants of over 60 h.p. it is 0.8 lb. per h.p. With low grade fuels the data is as follows:—

1 E.H.P. - 3 lb. wood.
1 E.H.P. - 2½ lb. raw peat.
1 E.H.P. - 3½ lb. sawdust.

developing an efficiency at the engine of 80%.

But the best practical results in Canada—as far as I have been able to glean—have been achieved at the little town of Wellington, with its 800 inhabitants, situated on the banks of the St. Lawrence in Prince Edward County, Ontario. The plant consists of a 65 h.p. "Fairbanks-Morse," suction gas producer installation, and gas engine, combined with 3 wire Westinghouse generator; and they are at the present time supplying electrical energy to the factories at $20 per 10 hour h.p. per year; 18 arc lamps for street lighting at $530 per annum. Stores and residents pay ½ cent, per night for continuous incandescent lights; while for such lights intermittent, the rate is only ⅙ cent per night. There is not a steam or hydro-electric plant in the Dominion of Canada supplying power as cheaply as this! The fact is, that for smaller plants, the suction gas producer system, in the matter of economy, has the best hydro-electric system "skinned"—as the Americans say.

The lecturer mentioned the use of waste gases from the blast furnace. It is true that these gases are rich in potential energy, in the shape of unburnt hydro carbons; and the firm I learnt my business with as a mechanical engineer, used the waste gases from their five blast furnaces, under their batteries of egg-ended and Roots boilers for generating steam, to drive their blowing engines. But these crude gases are densely permeated with dust from the gangne in the ore, limestone and fuel; hence, require a very elaborate system of washing; consequently, are uneconomical except when used on a very large scale.

Our hope in Canada, however, is not in the blast furnace, but in the *electric* furnace. The immense iron ore deposits in this country are mostly *magnetites;* requiring for their effective smelting, 1000° of heat more than is developed in the ordinary blast furnace. That is why the pig iron business in this country is so backward. But thanks to our enterprizing Dominion Government, by the elaborate experiments made at Sault Ste. Marie last year with the electric furnace, it has been demonstrated that our rich magnetic ores can be smelted with perfect success, and economically too, in the electric furnace. And it is to be hoped that the enactment of the law offering substantial bounties on pig iron and steel ingots, produced from ores smelted in the electric furnace, will result in the development of a widespread electric smelting industry. When this glad time arrives, the suction gas producer business will have a great impetus; for the waste gases produced in the electric furnace are comparatively pure, and free from dust, and almost ideal for use in the gas engine.

I believe, Mr. President, that there is a great future for the suction gas producer and gas engine; especially in the wide regions of Canada, where neither anthracite or bituminous coal, nor water power is to be found; but where there are immense deposits of the *lignites*—low grade soft coal and peat. These unused sources of energy are practically useless to-day; but I venture to predict that the suction gas producer system will play an important part in opening out and developing industry in the great northwest lands where the *lignites* abound.

Chairman,—

We would like to hear from Mr. Duguid, another one of the Motive Power men, possibly he can tell us something about this.

Mr. Duguid,—

Mr. Chairman and gentlemen:—I am not at all posted on this producer gas question and was not aware that this was the paper that was going to be read to-night until a little while before leaving Stratford. Neither was I aware that I was going to be called on for any remarks.

From what I know of producer gas plants I think they have yet to be experimented on and improved before they will beat a steam plant.

In the first place in installing a gas plant you have no means of arranging for heating, and that is very necessary in any large plant.

Then again if you install one large unit and only use a small amount of your machinery at any time, you cannot (as I understand) control the production of gas.

It takes, in a modern plant with one large unit as a power, about 45 per cent. of power to run shafting and 55 per cent. for machinery, I do not know but in the majority of shops it takes about 60 per cent. to run shafting, so that I think that the proper power is small electric units, and while electricity for these may be generated cheaper by producer gas engines than steam engines, there are other kinds of power required that I do not see you can get from producer gas.

A man representing these gas plants of course will figure out how much it will cost in an old plant where steam is used, and will show you that they will run their plants at ¼ of what they can a steam plant. Perhaps they might, but I think if you take a modern 1,000 h.p. steam plant and figure out the cost of the two plants you will find steam the cheapest. If not the cheapest it is the best suited for all purposes. In the steam plant you can use the exhaust steam for heating purposes or condense it and use it as power, but you have none of this in the gas producer.

I have not gone into this matter very thoroughly and any person here who is familiar with producer gas may show me where I am wrong.

While it is the contention that a gas plant needs little attention, yet I would think it would take twice as much attention as a steam plant.

I am very much in favor of electric power, which I think should be adopted, as shops run by one large unit are undesirable. Take for instance at Stratford, if we want to turn a few bolts after 6 p.m. we have to run the whole plant to do so.

While steam generated electricity may cost you more on paper I think it is the cheaper of the two plants.

The question of power to drive machinery by the producer, gas engine, either directly or by the electric generator, is not all that has to be considered in a locomotive shop. You require steam for testing boilers, W.A.B. pumps, lubricators, injectors, and so on, and what about the heating of the plant? No means of doing this has been shown with the producer gas plant. Would it not be necessary with a power plant of this kind to also have a steam plant for the purpose that I have mentioned?

This is the reason why I think steam even with its low efficiency, would be the cheapest.

Chairman,—

I am sure, gentlemen, we are pleased to hear Mr. Duguid take the opposite side of the question. I think most of the large manufacturers of the present time are taking a great deal of interest as regards cost of power. The Grand Trunk Railway are making a study of this power question at the present time. While some favor steam, electricity, and others gas producers, yet it is a live question, and the discussions I have heard to-night have given me what I have sought for a long time.

Mr. R. J. Goudy is here to-night, and we shall be glad to hear from him.

Mr. R. J. Goudy,—

Mr. Chairman and Gentlemen:—While I expected to be present with you to-night, I did not expect to be called upon to make a speech, or address such an intelligent-looking audience as you have here to-night.

I don't know of any other pastime that could be better spent than to be present at just such meetings or organizations of this kind where there is some instructive topic arranged for discussion. I have listened with much interest to the paper just read by Mr. Armer on Producer-Gas, and I must say that Mr. Armer should be congratulated upon the able manner in which he has outlined to us the use of producer gas, which is growing so rapidly in favor in our country.

The economy of the gas engine operated by producer gas lies in the almost direct conversion of the energy in the coal into work, eliminating the several losses that arise when such energy must be carried through the various stages of the production of steam in converting coal into work, by means of the steam boiler and steam engine, the losses are both direct and indirect. The direct losses include unconsumed coal falling through the grates, chimney gases, unconsumed carbon in the the form of smoke, loss of heat in radiation from the boiler and steam lines, loss in radiation from the engine cylinder and the final waste from the exhaust.

The indirect losses include steam consumed in injectors or boiler feed pumps, and in leakage.

It is true that a certain percentage of these losses are saved when the exhaust steam is used for heating feed water, or buildings, or to operate condensers, but as each cubic foot of steam generated in a boiler represents a definite number of thermal units, the fact remains that the percentage of loss to the work performed is excessive, even in the very lightest types of steam installations.

A gas engine receives its energy in the form of an explosive mixture of air and carbon monoxide at normal atmospheric pressure. This mixture is then compressed in the engine cylinder by the piston to one hundred pounds pressure per square inch and ignited by an electric spark. The explosion resulting raises the pressure to 400 lbs. per square inch, the working pressure of a gas engine at the commencement of the stroke. This is then reduced by the movement forward of the piston to 40 lbs. per square inch, the working pressure at the end of the stroke, and at which pressure it is exhausted into suitable mufflers which brings it down to atmospheric pressure where the operation started. It will be at once observed that heat, the first essential in this steam engine, is in the gas engine only a by-product. It is in this feature chiefly that the gas engine is economical. The work is done simultaneously with the raise in temperature, and before any loss in such heat can occur the work is done, and the only waste product is a small percentage of non-inflammable gases and the heat left in the cylinder walls, which is absorbed by the water in the jackets for that purpose.

Experiments are now being conducted by Mr. Nixon, the chief designer for the United States Navy with the idea of adapting that gas producer and gas engine to naval work. A torpedo boat destroyer was equipped with specially designed producers and engines and was found in every way suitable for driving that type of craft.

He also installed a gas engine in a submarine torpedo boat, and in both cases the radius of activity was increased over 200 per cent. He has asserted that all trans-Atlantic liners of the future will be driven by gas engines and producers, effecting an immense saving in fuel cost, and making available for freight over 60 per cent. of the space now given up to coal storage. As a basis of comparison he took a battleship of the Massachusetts type, which he designed with a present effective radius of 3,000 miles and with the present coal capacity, by using gas engines and producers asserted that the ship could very nearly encircle the earth.

As nearly one-third of the power of a battleship is used for other purposes than driving it, the cost of operating on a peace basis would be immensely reduced.

Thanking you, Mr. President, for calling on me, and with these remarks I will take my seat.

Mr. J. C. Garden,—

Mr. Chairman and gentlemen:—It is with a great deal of hesitation that I rise to make any remarks on gas or gas producers as it is only within the past eighteen months that I have become at all familiar with the subject and consequently approach it very wearily. The first literature that came into my hands on this subject read to me like a chapter from the Arabian Nights or Guillver's Travels. The enormous economy of the gas producer and gas engine over the steam engine, as guaranteed by the leading manufacturers, seemed almost incredible.

I was very much pleased to hear Mr. Duguid speak as he did to-night, as it is as well that the opposite side should be well represented, although I think Mr. Duguid is laboring under a delusion. He states, however, he is open to conviction, and if I had time I think I could convince him that gas-producers are as far ahead of steam plants as electric light is ahead of a tallow candle. He states that he is open to conviction, like the Scotchman he is "Ay, open to conviction but would like to see the live man or dead ghost that would convince him." Mr. Duguid states that in the gas plant the power cannot be conveyed from one point in the plant to another, as is done with electricity. In all the gas plants I have visited, the gas producers were run with direct connected dynamos and electrical power used for all purposes, this, I believe, is one of the strong features of these plants.

With a steam plant up-to-date and of first-class efficiency, two pounds of coal per horse power is about the best results yet obtained, while with the gas we can deliver power to the switchboard with seven-eighths pound of coal per kilo watt which is considerably in excess of horse power. Mr. Duguid states that about 60% of the power is lost in the shafting. If that is the case in any plant in which any of those present are connected, I would strongly advise them to get the kinks out of the shaft.

In his paper Mr. Armer showed a comparison of 55% in favor of the gas plant; this, it seems to me, is a very small saving in comparison to what these plants are capable of making, and I would like to ask Mr. Armer how he arrived at these figures as all the tests I have heard of show a very much greater saving in favor of the gas plant.

Mr. R. Ivers,—

Mr. Chairman and gentlemen:—Why is it that the makers of gas producers do not use gas producer for the manufacture of same? The Fairbanks people do not use them although they make them. If it is such an economical user of fuel you would think the manufacturers would be the first to use them. It seems as though they are trying to give us a gold brick.

Mr. Groves,—

I believe they are installing a gas producer plant in the city.

Mr. R. Ivers,—

They may be doing that for advertisement, which are like the advertisements about Cobalt stocks.

Chairman,—

Perhaps they may be like other concerns, they wish to see other people experiment on it first.

Mr. J. C. Blanchflower,—

Mr. Chairman and gentlemen:—I wish to say I have visited several shops in our own plant, and we are using gas producers for running machinery for the last 16 years. I have been in the gas producer business for thirty years. We use a lot of natural gas, and we have a lot of motors in different parts of the factory. I would like to say that the Fairbanks-Morse people in Toronto have installed a 250 h.p. gas producer, and have been running their factory with it for the past year. On the other side they have a large factory where they have about 6 or 8 gas producers in operation. I have thoroughly investigated the gas producer question, and think there are great advantages in the use of the same. They are not limited to large or small powers, and there is a saving of 50% with their use.

Mr. G. Black,—

Mr. Chairman and gentlemen:—I would like to ask a question. Mr. Armer speaks of hand blowers that were applied on these gas producers in starting the fires, but he did not explain how the fires were kept up.

Mr. J. R. Armer,—

The combustion is kept up by a continual supply of air which is drawn into the producer by the action of the piston on its reducing stroke.

Mr. George Morang,—

Mr. Chairman and gentlemen:—It may not be generally known that at the exhibition last year we had two gas producer plants in the process building. We will very likely have more such plants there next year. I may say that within a stone's throw from this building now, there is a gas producer plant which is costing less than 1-5 of what the Toronto Electric Light Co. can give power for.

Mr. J. J. Fletcher,—

Mr. Chairman and gentlemen:—I am opposed to gas producer power plants simply because it is against my profession; I am a steam man. If the gas producer power plants are to be our source of power, I will have to learn the profession over again in the direction of gas producer power plants.

A carload of gas producer machinery came into the city not long ago, and I was requested to come and see it. After inspecting same I came to the conclusion that there was a little work in it for my profession after all. I stated to the gentleman, that it would not take up much space for a 70 h.p. machine, and what amount of ash do you take away, or does it burn up all the ash? He stated it burns everything. I then stated, I suppose you can burn rocks in this machine and make gas. He answered, "Oh, yes, burn anything."

I have much pleasure in moving a very hearty vote of thanks for the paper Mr. Armer has read before the club to-night.

Seconded by Mr. W. Kennedy. Carried.

Chairman,—

Gentlemen:—The next will be the adjournment, but before we do so I would be pleased if each and every one of you would fill in the attendance cards on your seats.

Moved by Mr. Kennedy, seconded by Mr. J. C. Garden, that meeting be adjourned.—10.30 p.m.