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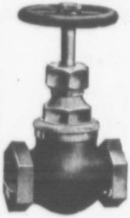
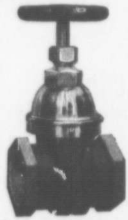
THE CENTRAL RAILWAY AND ENGINEERING CLUB

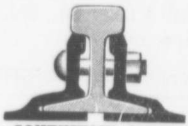
OF CANADA

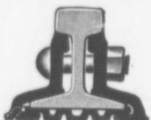
OFFICIAL PROCEEDINGS FOR NOVEMBER, 1909

C. A. JEFFERIS, *President* C. L. WORTH *Sec-Treas.*









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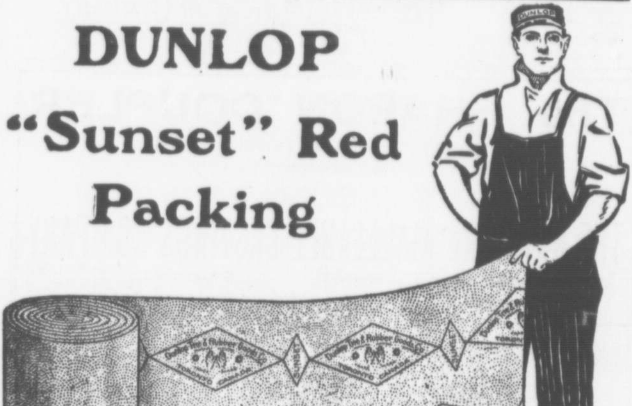

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OF CANADA

OFFICIAL PROCEEDINGS

Vol. 3. No. 8. TORONTO, CAN., November 16, 1909. $1.00 per year 15c. per copy

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C. L. WORTH, Sec.-Treas., Room 409 Union Station, Toronto.

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

Prince George Hotel, TORONTO, November 16, 1909.

The President, Mr. Jefferis, occupied the chair.

Chairman,—

The first order of business is the reading of the minutes of the previous meeting. You have all had a copy of these in the journal, therefore it is in order for someone to move that the minutes be adopted as read.

Moved by Mr. Fletcher, seconded by Mr. Baldwin, that the minutes of the previous meeting be adopted as read. Carried.

Chairman,—

The second order of business is the remarks of the President. I suppose you all know that you are not in the usual room to-night. There is a convention going on here and they are occupying our usual room so that we will have to put up with this room to-night.

I hope you have all recovered from the effects of the Social Evening. I was very much impressed by the sociability of the members and their friends. No doubt everybody enjoyed himself very much. The Glee Club selections were a very great success, and they came as a great surprise especially to the singers. Our Reception Committee is the finest in Canada and deserves a great deal of praise and on behalf of the Club I have very great pleasure in tendering them a very hearty vote of thanks.

I am sorry our secretary Mr. Worth, is not with us tonight. He is away taking a few days holiday, but his assistant, Mr. Hyde, who is a hard working and valuable member of the Club will now read the list of new members. We have between twenty-five and thirty new members to-night.

NEW MEMBERS.

Mr. G. S. Browne, Fitter, Canadian Pacific Railway, Toronto.

Mr. F. McDonald, Foreman Boilermaker, Canadian Pacific Railway, West Toronto.

Mr. A. Laird, Machinist, Canada Foundry Co., Limited, Toronto.

Mr. F. Hardisty, Engineer, Grand Trunk Railway, Sarnia Tunnel.

Mr. G. T. Allen, Manager, Hoyt Metal Co., Toronto.

Mr. F. A. Corns, Principal, Dominion Engineering Academy, Toronto.

Mr. Chas. Daniel, Foreman, Moulding Shop, Canada Foundry Co., Limited, Toronto.

Mr. A. L. Reading, Manager, Standard Inspection Bureau, Toronto.

Mr. C. D. Scott, Gutta Percha & Rubber Manufacturing Co., Toronto.

Mr. J. C. Donald, Foreman Carpenter, Canada Foundry Co., Limited, Toronto.

Mr. G. A. Young, Machinist, Grand Trunk Railway, Toronto.

Mr. C. A. Tobin, Draughtsman, Economical Gas Apparatus Construction Co., Limited, Toronto.

Mr. J. S. Crassick, Salesman, Consumers' Gas Co., Toronto.

Mr. H. V. Armitage, Foreman, Chapman Double Ball Bearing Co., Toronto.

Mr. A. H. Kirby, Chief Engineer, Methodist Book Room, Toronto.

Mr. S. Tomlinson, Jr., Master Moulder, Toronto.

Mr. F. H. Dence, Traveller, Canadian Fairbanks Co., Toronto.

Mr. A. T. Cowpersmith, Engineer, Consumers' Gas Co., Toronto.

Mr. L. W. Swift, Engineer, Grand Trunk Railway, Stratford.

Mr. A. E. Baines, Machinist, Grand Trunk Railway, Stratford.

Mr. J. F. Alexander, Local Manager Babcock & Wilcox, Limited, Toronto.

Mr. F. W. Barron, Chief Engineer, Copeland Brewing Co., Toronto. (This name should have been read at the September meeting.)

Mr. G. Blyth, Engineer, Chapman Double Ball Bearing Co., Toronto.

Mr. W. Dony, Machinist, Grand Trunk Railway, Toronto.

Mr. Jos. J. Moat, Engineer, T. Eaton Co., Limited, Toronto.

Mr. W. Malott, Machinist, International Weather Strip Co., Toronto.

Mr. H. W. Robinson, Toolmaker, Chapman Double Ball Bearing Co., Toronto.

Mr. R. Titlaw, Machinist, Grand Trunk Railway, Toronto.

Mr. John Adam, Clerk, Stores Department, Polson Iron Works Limited, Toronto.

Mr. J. W. Hetherington, Machinist, Canada Foundry Co., Limited, Toronto.

Mr. H. A. Mosher, Manager, Sundries Department, The Canadian H. W. Johns-Manville Co., Toronto.

Mr. Baldwin,—

I think if this is the result of the Social Evening; we had better have another one next month.

MEMBERS PRESENT.

R. Pearson.	A. W. Shallcross.	G. D. Bly.
T. B. Cole.	W. J. Woolidge.	E. Blackstone.
G. H. Boyd.	W. J. Bird.	G. Baldwin.
W. E. Cane.	A. Chalmers.	E. Seeds.
W. F. Commins.	E. R. Maltby.	B. Clarke.
G. Clarke.	W. E. David.	H. G. Fletcher.
J. Herriot.	A. H. Kirby.	J. W. McLintock.
W. Philpotts.	E. A. Wilkinson.	A. M. Wickens.
C. A. Tobin.	H. E. Rowell.	J. Hunter.
H. P. Ellis.	J. McWater.	J. F. Alexander.
R. Stockhill.	J. Dewsbury.	W. Doney.
A. W. Carmichael.	J. E. Stephenson.	J. M. Griffin.
W. Marchington.	H. A. Mosher.	H. O. R. Horwood.
G. McDonald.	W. Malott.	J. Barker.
G. Bernard.	J. Adam.	G. Kyle.
G. S. Browne.	R. H. Brown.	W. E. Archer.
J. Archer.	S. Turner, Jr.	J. Kyle.
F. K. Evans.	G. Blyth.	H. Cowan.
H. Armitage.	H. Robinson.	O. A. Cole.
J. F. Campbell.	E. Logan.	C. A. Jefferis.
H. Eddrup.	L. S. Hyde.	

Chairman,—

I think we shall require a place of meeting something larger than Massey Hall if we go on increasing our membership like this.

If you will turn to page 6, section 10, of the By-laws you will read the following:

"At the meeting preceding the Annual Meeting a nominating committee of five shall be elected, who shall present at the Annual Meeting nominees for each office to be filled; it shall be the privilege of any member of the Club to nominate other candidates, the nominee receiving the highest number of votes for each office, to be declared elected."

It is to the best interests of the Club that the various industries who have the largest number of members should be represented on this Committee.

Before you proceed I would like to say that I think this Nominating Committee should come from the rank and file, and that none of the officers of the Club should be on this Committee. Select five men representing the different interests, of which we have members.

After the list of names has been presented by the Nominating Committee it is the privilege of any member of the Club to add any other names to this list. The object of the Nominating Committee is to assist you in the selection of the officers for the coming year.

I will now declare the meeting open for the nomination of five members for the Nominating Committee.

The following members were nominated:

Mr. O. A. Cole, Manager, Philip Carey Manufacturing Co., Toronto.

Mr. J. Herriot, Storeman, Canada Foundry Co., Toronto.

Mr. E. Logan, Machinist, Grand Trunk Railway, Toronto.

Mr. H. Cowan, Foreman, Motor Shops, Toronto Railway Co., Toronto.

Mr. D. Campbell, Store-keeper, Consumers' Gas Co., Toronto.

Moved by Mr. Bird, seconded by Mr. Wilkinson, that the nominations be accepted. Carried.

Chairman,—

I would like to charge the Nominating Committee with just this one thought that in selecting the officers for next year they will not lose sight of the workers, at the same time they must not lose sight of the different interests in the Club and that the larger institutions will each have, as far as possible, a representative because we all know that the success of this Club depends upon its Committees, but there is no doubt about it that the Nominating Committee will use its best judgment in selecting officers for the ensuing year.

The next order of business is the reading of papers and discussion thereof.

We have with us to-night Mr. G. M. Henderson, Mechanical Engineer, Toronto, who has very kindly consented to read us a paper on "Gas engines, their origin and commercial use."

Mr. Henderson,—

Mr. Chairman and gentlemen, it gives me very great pleasure to come before you to-night with this humble effort of mine.

I do not propose dealing with this subject from a technical point and if you think I am going into the details of clearances, valve areas, and questions of that kind I am afraid you will be disappointed. I have tried to bring into this paper what I have learned during twenty-five years travelling around the world.

At the present time I am more particularly interested in small power gasoline plants. The largest power my people manufacture is 30 horse power. We are now contemplating the manufacture of a 45 horse power engine, but we do not purpose at present going any higher than that. We confine ourselves exclusively to marine engines.

GAS ENGINES: THEIR ORIGIN AND COMMERCIAL USE.

BY MR. GEO. M. HENDERSON, MECHANICAL ENGINEER, TORONTO.

Gas engines may be divided into three types:—

1st. Those igniting at constant volume but without previous compression.

2nd. Those igniting at constant pressure with previous compression.

3rd. Those igniting at constant volume with previous compression.

The principle of these engines is almost the same as an ordinary steam engine but the pressure is applied only during a short portion of the stroke and in some of the earlier types it was, outside the noise made in running, difficult to distinguish from a steam engine.

The history of the internal combustion motor begins with the invention of cannon. The gun is a motor in which the working substance is the gas resulting from the combustion of the powder and in which the work is done on the projectile. Giving it effective energy such a motor is not continuous in its action, but it offers possibilities of a practicable engine if the powder charge is small and the projectile or piston on which the gases act is restricted in movement. The earliest internal combustion motors devised for doing useful work were intended to use gunpowder. The earliest was built by Abbé Hautefuille in 1687 and was shortly followed by many others none of which were of any commercial use or value. It was not till the end of the eighteenth century on the discovery by Murdock that a combustible gas could be produced from coal by a process of distillation that a practical internal combustion engine or motor was possible.

As soon as the useful properties of coal gas and the method of producing same became known, numerous attempts were made to use it for motive power. Previous to 1860 many engines were devised, patented, sold and operated, none of which were at all satisfactory. They were irregular in action, noisy, wasteful of fuel and full of mechanical defects. The Lenoir engine was really the first practical gas engine.

This engine must be classed under our first type. Igniting at constant pressure without previous compression.

In this engine the piston moves forward drawing in gas and air of a combustible mixture at about half stroke: this was exploded by an electric spark. The work done being represented by the pressure upon the piston caused by explosion on the return stroke. The burned gases were expelled at this end and a new charge and explosion respectively taking place on the other side of the piston. The cylinder of this engine represented in a marked degree a horizontal steam engine with a slide valve on either side. The valves were driven by simple eccentrics and so designed that the inner edge alone uncovered the edge of the port.

The next engine of note was the Otto & Langden free piston engine. This was of a vertical type. The cylinder was open to the atmosphere at the upper end. The piston was impelled upwards by the explosion of the air and gas below it. The force of explosion was intense, but momentary, hence great expansion to piston speed, consequently the explosive force was used in the most efficient manner and power was derived from the pressure of the atmosphere by which the piston was driven downwards against a partial vacuum due to a collapse of the gaseous products. To cool and contract the gases the lower half of cylinder was jacketed with cold water. The cycle of operation was the piston was lifted through one-eleventh part of the stroke to receive the gas and air—next mixture was fired by gaslight. Then the piston makes its up stroke the plenum becomes a vacuum at the beginning of the down stroke of the piston. The down stroke was made under an effective pressure of eleven pounds per square inch, and the force transmitted to the shaft. When the piston arrives near the bottom the vacuum becomes a plenum by compression of the gases and by the weight of the piston the gases are expelled from the cylinder.

The next engine of note was the Griffin & Baker resembling very much the engine previously mentioned except that it only received an impulse every third revolution. The taking in of charge occupied one stroke, one working stroke, and one stroke to expel the burned gases.

Then followed the Clerk. This engine obtained an impulse at each revolution when at full power. It had two cylinders, one being used for compressing and charging the working cylinder. This system was the origin of the two cycle engine.

In 1862 it was shown by Beau de Nochas, an eminent French engineer, that to get high economy certain conditions were necessary. The most important of these conditions is that the explosive mixture should be compressed to a high degree before ignition, but it was for Dr. Otto in 1876 to place upon the market the first commercially successful engine, the four operation cycle still known as the Otto cycle. Otto appears to have sold or disposed of his patent rights and several high class factories manufacturing Otto Cycle Gas Engines came into prominence, notably and more prominently the Otto Gas Engine Works, Philadelphia, controlling and operating the Otto patents in America and several European countries with allied manufacturing plants in Cologne and Berlin, Germany; Vienna, Austria; Milan, Italy; Paris, France; and Copenhagen, Denmark. Messrs. Crossley Bros., Limited, Manchester, England, controlling the British patents, particular mention may be made by these two firms because they quickly realized the possibilities of the gas engine in its infancy and each to-day stand unrivalled in their respective sphere, either in business method or the excellence of their production. During the last twenty years and particularly since the expiration of Otto's patents, a great many factories sprang into existence manufacturing this type of engine with more or less success, and to-day it is almost impossible to go into a town where motive power is not derived from the gas or more particularly speaking internal combustion engine, the overwhelming number using the Otto Cycle.

The construction of modern stationary gas engine tends to the horizontal type for large powers and vertical for small powers and marine purposes. The engine is single acting and has a long trunk piston which acts as a crosshead and permits the use of several rings by which leakage past the piston is prevented even with the highest pressure obtained by the explosion.

The engine is made single acting because the cylinder would get too hot for continuous running if it were double acting and also a piston rod would give continual trouble if exposed to the high temperature of the burned gasses.

As the cycle of operation occupies two revolutions, the valves and ignition have to operate only once in that period. The cams operating these parts are mounted on shafts running only half as fast as the main shaft. The cycle of operation is

1st—Induction;
2nd—Compression;
3rd—Explosion;
4th—Exhaustion.

Two methods of ignition are in common use, electric ignition and the hot tube. In European countries the hot tube is the more popular. In this country electric ignition, which has the advantage of altering the point of ignition whilst the engine is running, thereby securing the most advantageous results. Current for ignition purposes may be easily and cheaply generated from dry or wet cells. The most satisfactory being the wet cell of the Gordon or Edison.

The practice of using a small D. C. dynamo is also a very popular means to the same end, but my experience is that a high tension magneto of the Bosch type is the most satisfactory of all. It is not liable to readily get out of order and is practically fool proof.

The proper point of ignition when engine has attained its ordinary running speed is about 15° before the dead centre when engine is turned over slowly but for starting very little advance can be had. The angle of advance is necessary because the actual duration of explosion depends largely upon the strength of the explosive mixture and the amount of compression. It must also be recognized that the explosion is not instantaneous but requires a lapse of considerable time before the maximum pressure is reached.

The controlling mechanism or governor does not differ materially from that of the steam engine, and in some instances the ordinary Pickering steam engine governor is used with good effect. The more popular method being the hit and miss which, on the idle stroke, cuts out the gas supply entirely, and in the better class of engine also the current.

In the internal combustion engine the charge consists of air mixed with a comparatively small supply of gas or gaseous fuel. In city gas of 650 B.T.U., the proportions are about 9 to 1.

The most economical method of obtaining gas for motive power is by a suction producer. The suction producer gas plant consists of a producer, a scrubber, a gas receiver, and the engine together with the necessary piping. The producer is generally a heavy iron or steel jacket lined with fire brick provided with a grate, and has an evaporator on top. The producer is by far the most important part of the apparatus; here the gas is made, *i.e.*, the air is carbonized, the carbon gasified, and the volatile matter vaporized and the water decomposed.

The whole object of the producer is to bring vapor and the highly heated carbon or combustible part of the fuel into contact with oxygen, the combustible part of air, and to continuously remove the gas which is made when these unite.

In the successful working of a gas plant much depends upon the location. Room must be provided to easily reach all parts of the producer and engine. Next to ample room, light and ventilation must have first consideration. Nothing will be kept clean in a dark place and the clinkers, ashes and dirt from several hundred pounds of coal every day will soon clog the apparatus if not regularly cleaned out. Have a free air opening near the top of the room and not far from the producer. When the fire is cleaned the hot clinkers create a strong upward draft of hot dusty air and this must have free vent. Good drainage is also important. The scrubber water contains sulphur and will corrode valves and fittings slowly, but surely. It is best to let it drain directly into the sewer.

Before beginning to erect or install the plant it would be wise to decide on the man who is to run it, also the foreman or superintendent, who will have general charge of the power plant and who will be responsible for ordering necessary supplies of coal, coke, oil, etc. The engineer, who will run the oufit should be present and assist in the erection. This will permit him to become familiar with every detail. The superintendent should watch this closely and learn how to operate the plant himself, while the apparatus is extremely simple it takes study to know how to operate it and no business concern should have to be dependent on the presence of any one man to keep the shop running. If an operator from the makers erects and starts the plant he should not be allowed to run it, but this should be done by the purchaser's own man. He may make mistakes and errors at first and this will give the expert a chance to give him advice at a time when he is glad to get it and the instruction gained will not be forgotten. It is of the utmost importance that sufficient oil be supplied to the working parts of all machinery, most particularly so to a gas engine cylinder.

To maintain a film of oil between the rubbing surfaces grooves or channels should be carefully lead in such directions as will give uniform lubrication to all areas subject to friction.

Only oil of good quality such as will not carbonize under high temperature should be used for the cylinder and valve stems, while any good machinery oil, animal, mineral, or vegetable is immaterial for the crank and shaft journals. The oil should be supplied in just the right quantity to insure efficiency without waste.

Smoke coming from the exhaust of a gas engine is an almost sure sign of over lubrication. Either to this or a too rich mixture. The first may be detected by the smell of burned oil and a slightly yellow colored smoke, while a rich mixture may be denoted by a dense white smoke and a very pungent smell.

If the engine is working properly the exhaust gases should be of a slight blue haze. While the attendant should make sure that a sufficient quantity of oil is supplied he should be just as careful that no excess is fed to the cylinder most particularly.

Too much oil will favor a gummy deposit, which will increase the frictional strain, foul the igniter points, block the valves and interfere materially with the explosive mixture for this reason the lubricators should be always closed after a run just before the engine is stopped.

As the cylinder of a gas engine operates under a far higher temperature than a steam engine it will be readily seen that oil for this purpose must necessarily be of a correspondingly high flash point, not only so, but it should contain no acid or other substance having any harmful effect on the surface it is intended to lubricate.

One plant I would point out is the plant driving the engines for the power plant of the city of Chatham, which as far as I am able to learn has given every satisfaction from its inauguration. Another plant in this country is the Winnipeg plant of 4,500 horse power. These are looked upon as being very large plants while really they are only an average plant and there is nothing abnormal about them.

There is a plant in Westphalia, Germany, which ran for sixteen months continually and was never stopped. I tried to get some details of this plant, but failed, the details given me being of 1,200 horse power plant instead of 12,000 horse power, and the material placed before me was such that I could not use it here to-night.

If there are any points anyone would like to question me upon I will go into details.

Chairman,—

If there is anyone who would like to ask Mr. Henderson any question, now is the time.

Mr. Corns,—

I have listened to Mr. Henderson's paper with considerable interest, but at the present moment cannot think of any important points on which to open a discussion.

On the early part of the paper I would like to make a remark or two, mainly to bring forward the man who first used a cylinder and piston in his experiments. Mr. Henderson mentions the Abbé Hautefuille as being the inventor of the first gas engine. To him certainly belongs the honor of designing the first machine, using heat as a motive power, his proposal in 1678 being to produce power from the explosion of gunpowder, indirectly, by using the atmospheric pressure. He does not seem however to have actually constructed the machines he designed nor to have put his proposals into practice, so that at the most it was likely no more than a laboratory experiment.

Two years later, 1680, another Frenchman named Huyghens constructed a working engine which is of interest as being the first record of a cylinder and piston being employed.

In 1688, Denis Papin, the inventor of the safety valve, continued Huyghens' experiment and read a paper before the Liepsic Academy in which he stated that until now all experiments have been unsuccessful.

Coming to the practical part of the paper Mr. Henderson mentions the Suction Gas plant as the producer of the cheapest power. This is correct for small or medium sized plants, but for large units the Pressure plant shows the greatest economy. In the case of Gas Producers of the Mond type of 2,000 horse power or over, the by-products obtained are of sufficient value to cover the actual cost of the coal. The principal by-product is sulphate of ammonia, which is a most valuable fertilizer, being nearly 30 per cent. richer in nitrogen than nitrate of soda.

Nearly one ton of this fertilizer is obtained from 25 tons of bituminous slack coal.

The first cost of this type of producer is undoubtedly high, but notwithstanding this and the consequent increased expenses for upkeep and interest on first cost, the actual cost of the power produced at the switchboard is considerably less than by any other system.

There is a very interesting gas producer at the Gendron Manufacturing Co.'s Works. It is a Riché plant and shavings, sawdust and other refuse is the fuel used. It has apparently been a success as I understand the firm are duplicating the plant. If any gentleman present knows anything about this plant, I think it would be of interest to the members to hear more about it.

Mr. Wickens,—

I have only just got in and did not have the pleasure of hearing Mr. Henderson's paper throughout, although I had a glance at it before it was printed. There is no doubt that Mr. Henderson has gone into this matter very thoroughly.

In this country we are all after cheap power; we have got electric power from Niagara Falls brought into the city and everybody is looking for cheaper power.

We have got steam engines which are being run remarkably cheap. I had the pleasure of conducting a test on a 250 horse power steam engine a short time ago. The engine was running a large flour mill, and we found that the cost per horse power was $22.50 per year. This is getting down where no gas producer would go.

In another place where they use natural gas to make the steam under ordinary steam boilers we had a test and got a horse power for $24.30 per year, and we made a further test using coal at $3.10 per ton. In the first case they used natural gas for which they paid 12 cents per 1,000 feet, the coal at $3.10 per ton beat it. The gas company then immediately cut the gas down to 10 cents per 1,000 feet and beat the coal.

While the gas engine is here, and likely to stay, it has got to be under exceptionally good conditions before it can beat out the steam plant, especially where they are using producer gas plants. There must naturally be a considerable amount of repairs to gas furnaces, more repairs are necessary to a gas furnace than you would have to make to ordinary steam power furnaces.

One other thing that has struck me very forcibly during the last few years is the increasing number of gas plants running in Canada.

There is a municipal plant in Berlin that is doing remarkably well, but it did very poorly for over a year and a half.

The gas and electric plant at Chatham is being run practically by gas engines, and while they have had that plant about four years, they always keep a steam engine and boiler ready to get into the game when they have trouble. They have three engines there, and I have never been to that plant yet when one of those gas engines is not on the floor in trouble.

Gas engines have got a little way to travel before they become as popular as steam engines, and I feel that the time is coming when gas engines will do better.

I have in mind one engine which was purchased in the Old Country. The gas producer was purchased there, because the party who bought it fully expected that the builders would have had greater experience and no one would be able to tell them anything that they did not know about gas producer plants. They have now had three gas producers, and the mills have been standing idle for more than a third of the time, and they have been a poor success so far. The makers of the engine and gas producer plant do not seem to know why they are having this trouble. The first reason given was, their producer was designed for Welsh coal, and as you know we have no coal in this country like Welsh coal, they changed the producer to make up for this difference in the coal. The second producer did not do well enough, although it did better than the first, to keep the mill running ten hours at a time, with a full load. The third producer ran the mill fairly well, but they do not get the gas as fast as they require it.

I have in mind also a crude oil engine which does away with the producer. You pump the oil into the cylinder just the same as gasoline, or producer gas, and this engine follows the line of internal combustion engines, using crude oil instead of gasoline. This engine proved to be remarkably successful in some cases, but the builders have yet to put them on the market, they have some of them from 15 to 65 horse power, and will guarantee a horse power for $18.00 per year using a cheap crude oil at about 5 cents per gallon.

There is one thing sure to my mind, and that is, that our electrical friends have got to come down considerably more than they are doing in this part of Canada before they get all the power plants.

Mr. Clark,—

There are just a few words I would like to say about a gas engine in Derbyshire, England. It was the first gas engine in England to be run by the waste gases from blast furnaces, the old style steel open top furnaces. The gas was taken from the furnace somewhere below the charge hole and from there was passed through a washer or coke scrubber, and from there was carried into a gas bag and then into the engine. For the first two years there was a terrible amount of trouble in getting the engine started and sometimes in stopping it too, one time it bent the piston rod into the letter "s," once the gas bag burst, and the gas fired back and it broke a cast iron casing around the gas bag blowing it all to pieces. For about two years they had a good deal of trouble to put up with, but since then the plant has run very successful. They bought another one of the same size, 150 horse power. The cost of obtaining this gas was of course much cheaper than if they had used a producer as they were using gas which they had previously allowed to escape into the air.

Mr. Henderson,—

Our friend Mr. Corns suggests that Hautefuille did not make the first gunpowder engine. Ancient history, on this point, is somewhat vague and I am glad to learn anything authentic in regard to this. Huyghens followed on his identical lines and does not appear to have experimented until two years later.

Now as far as gas is concerned, gas was made a matter of two centuries before the Christian era. Murdock is credited with having discovered it on his way home by throwing a lighted match on the ground. He noticed the flame continued to burn, and set to work to discover how that gas was generated. He generated from the products of the earth a gas that would burn, and put it before the public, and from the time of Murdock until the present time the use to which gas can be put has gone on increasing year after year. Archimedes used gas extensively. You will remember he is credited with the invention of screws, and to make his screws he used a piece of square iron, which he heated and twisted. He found in heating his iron in the fire that his screws did not turn out regularly, but he found that by placing the metal, which he used to heat, on the top of the fire, that although he got a slower heat. he got it more uniform and it spread over the length of the iron,

To help him in his work, he made a generator, and generated gas, which he used for heating up his material for making his screws, but this was never handed down to us in anything like a commercial form.

Hero found that when he threw water on his fire that he got a gas which at the present time we would describe as water gas, and he tried to gather up the gas, but in this he did not succeed. He used it to some extent in many of his experiments, but never handed down to us anything that we could use. It is to Hero that we must give the credit of being the originator of our present turbine engine.

Hautefuille and Huyghens went through the roof when their engine exploded. Hautefuille was seriously injured and Huyghens was killed, but they had succeeded in making an engine that would work satisfactorily, and it was to Haute fuille that we owe the first commercial engine. He used a piston, and his engine was of the vertical type, it had no crank, but a ratchet arrangement allowed for reciprocating movement.

Our friend also spoke of Mond gas. Mond gas is produced in a somewhat different manner. Steam is blown instead of being drawn through the incandescent fuel.

Sawdust has been mentioned as a fuel for a producer. In New Zealand and Australia you almost invariably find gas engines are using sawdust or peat for fuel. In England it seems that the most common fuel is either gas coke or bituminous coal, but from bituminous coal considerable trouble is experienced on account of the tar deposits which it is found very difficult to get rid of.

The leading English makers have been experimenting for three or four years on the best method of utilizing the by-products, and they have succeeded in taking almost every by-product out that can possibly be had from bituminous coal. They do not appear to have experimented with anthracite coal. Mr. Wickens spoke about Welsh coal, and to those of you who are not familiar with Welsh coal, I would say it is very similar to anthracite, and they do not appear to have met with any great success with this coal.

The English people are very conservative, they work along a certain line until someone comes along and tells them that they might do better by trying something else. We owe a great deal to the English people.

We have perfected a great many English ideas that have been brought out, but we do not appear to have originated any data or any original ideas; we have no doubt improved upon ideas that have been placed before us, but as to their origin we cannot honestly lay claim.

Right here in Toronto I met a man who claims he made the first gas engine on the American continent, but, as far as I can learn, gas engines were made pretty nearly as early as he was.

In regard to the cost of operating producer plants, I may say that they compare very favorably with steam. I placed in the hands of the Secretary the results of a series of tests that were carried out in Chicago on gas engines, which, as far as I know, have never before been published, and when they come into your hands will show you that the gas engine and producer plant compare very favorably with the steam plant, in spite of the expense of putting in the producer. A new producer should not be required for at least ten years. They are lined with fire brick, and for that reason I do not see why they should come to grief so quickly.

The large power engine that I spoke of in Westphalia is run exclusively with blast furnace gas.

The most common practice in Germany is to use gas or waste fuel, and they do not take their gases through their engines without utilizing every scrap of power and a great deal of by-product is taken. Ammonia, sulphur, and aniline dyes are also collected from the furnace gases, and it is a fact that the coal, in any large plant using bituminous coal for gas production, when the bill is worked out, costs nothing, as the by-products more than pay for the cost of the coal.

Mr. Woolidge,—

I do not know that I have any more to add to what has been said. I have listened with a great deal of pleasure to Mr. Henderson's paper. We have a producer, National gas engine and Pintsch lighting plant, and we have practically had little or no trouble since we started. With regard to the repairs to the producer, we have relined it with fire brick once in the two years we have had it, so that taking it right through we have had little or no trouble with our system.

Mr. Cole,—

I do not know that I can add any more to what my superintendent, Mr. Woolidge, has said. I have had charge of the gas engine that he spoke about, for two years and six months, and during that time we have had practically no trouble with the engine. We take the piston out once in a while to clean it. The tool marks are still in the rings and there is very little sign of wear, and the producer has been re-lined once. A short time ago we had a little trouble with tar clogging our valves in spite of the fact that we have a coke scrubber, and a dry scrubber. In the dry scrubber the gas is forced through a bed of shavings or excelsior after it comes through the coke scrubber, but we found that that did not take out all the tar, and we tried Anthracite coal, and we found that we got a much richer gas.

We found that slightly over one ton of coal would go as far as 100 bushels of coke, so that the coal is the cheaper of the two. We ignite the gas with a magneto.

Mr. Wickens,—

What about clinkers?

Mr. Cole,—

At times I do not get enough clinkers. I find that the clinkers hold up the body of the fuel in the producer.

The producer is practically a round cylinder, and there is only a very small place to clean it out, and that only on one side, and if you have a lot of soft ashes, and sometimes we get as much as 10 per cent. of ashes, when you commence to clean it out the live coal falls down, and you get a poorer quality of gas.

Mr. Phillpots,—

In regard to the oil that is used in the cylinders, in what manner do they test it to find the flash point?

Does the flash point indicate in any way the value of an oil for use in lubricating the cylinder of a gas engine?

Mr. Henderson,—

It is very difficult for any ordinary person to test the flash-point. I am not an expert chemist, but where you get tar or shellac deposits carbon will form, and your rings will stick in the grooves, and you will get a leaky piston.

Mr. David,—

What sort of scrubbers are used in producer gas plants?

Mr. Henderson,—

At the present time I have no interest in producer gas plants. It is seven years since I had any close connection with these plants or high power gas engines. There are a good many producers made, and before deciding on buying a producer I would decide on the fuel I was going to use. If I was going to use bituminous fuel or soft coal, I would certainly follow the lines of the English people. For anthracite coal I think our own people should stay at home and buy their plants instead of going out of the country for them. They are not manufactured in this country to any extent, there being only one or two firms making gas producers in Canada, but on the American side there are a good many firms making them, and as far as I can tell you, they are working satisfactorily.

Mr. Phillpots,—

It depends a great deal on the kind of fuel used. One gentleman made a remark just previous, that 10 per cent. of ash was a usual figure found in fuels used in gas producers.

I have analyzed various kinds of coal and never found 10 per cent. of ash. The coke now sold by the Consumers' Gas Co., of Toronto, only contains about 4 to 5 per cent. of ash, and this I would think would be first-class fuel for suction producers, etc.

Mr. Stephenson,—

Mention was made regarding the Chatham plant. This appears to be a very satisfactory plant. I was speaking to the engineer the other day, and he told me that they burn manure, etc., in this plant.

Mr. Henderson,—

I may say that this is quite possible. In some plants where they have plenty of sawdust, the sawdust has to be got rid of, and instead of throwing it out, it is taken right to the producer from the saws, and used as fuel.

Our friend said that they use manure as a fuel. I may say that manure is a good thing to get gas from, and there is a grea: deal of gas produced from manure.

Mr. Clark,—

I would like to say that I have had a good deal of experience with producers for drying moulds, principally those with water bottoms. They can be cleaned out any time while they are running. The clinkers just hold up the fire, and we use steam in the producer and the gas is not purified at all.

Chairman,—

I have been sitting here listening to this discussion with a great deal of interest, and I was just thinking about the small manufacturer. The gas-man comes along and says, I will put in a plant that will cost so much, the steam-man comes along and say, that he will put in a plant for so much, and along comes the electrical man, and says he will put in a motor that will run the plant for so much. The manufacturer does not know what to do, he goes and asks his friend across the way whether he shall put in a gas plant, a steam plant, or an electrical plant, as he cannot try them all. The first question he asks is this—can I get something that is going to run 365 days without stopping? I do not want particularly to boost the gas engines, but it seems to me that the time is coming when you will be able to get a gas engine, I speak more particularly of the smaller engines, that will be absolutely reliable, and I believe a market will come for them, if we can get them as reliable as steam engines. Gas engines are noted for their unreliability. I am not talking of the latest gas engines, but of those built about ten years ago, when it was difficult to get a gas engine that was reliable, and that could be depended upon. The next question is, how about the cost of installation and maintenance, when they are run on the most economical basis, and given the best possible attention, how do they compare, can you give us any data on that?

Mr. Henderson,—

The cost of installing an electric motor cannot be outdone by any other motive power, I believe, but the repair bill is somewhat enormous. The fuel bill and the current bill is also very high. Figuring on a 2,600 horse power plant, and taking Mr. Wickens' figure of $22.50 for the steam plant, the cost of the electric motor against the steam engine will come somewhere about two-thirds, as near as I can remember, and the gas engine will come about one-half the cost of a good steam plant. This is for small power.

In the firm I am connected with, we run our shop with a small gas engine, and our repair bill for twelve months running will not exceed $2.00, and that engine is started in the morning and plugs away till night, and a stoppage or shut down with us is almost unknown. We do not have a man to tinker round the engine even when it is shut down, and the engine is left alone, except that the lubricators are filled.

I am not interested in the manufacturing of these engines, but I think, on account of the small repairs, that a gas engine is an ideal power.

Away from cities, the gasoline engine is a very good thing, easy to operate, and easy to set up, in fact 5 or 6 horse power engines are turned out complete on their own bed, and all you have go to do is to attach the belt to the shafting or machine. An electric motor cannot be carried around like a gasoline engine.

I was in the employ of a firm in Ohio and I travelled around the country boring cylinders, and facing valves, and I had a small 2 horse power engine to operate my machines, and for over three years that engine was running three days a week, and never cost one cent for repairs. I could couple it up to use gas or gasoline. I had a rubber hose for my gas connection, and when I could not get gas, I used gasoline.

Previous to quitting their service, I fitted up a coal oil generator, so that when I could not get gas or gasoline I used coal oil.

Mr. Bird,—

Did you use the same engine, without any change of valves, for gas, gasoline, or coal oil?

Mr. Henderson,—

There was no change whatever in the valves. To get the right mixture of gas there are two valves, and one pipe leading into a smaller pipe, the smaller pipe for the gas, and the larger pipe for the air. These are throttled down until you get your mixture of the right proportion. The most effective gasoline generator I find, is a small spray of gasoline trickling down a pipe, and you require nothing further. The handy man in the shop made the apparatus for me and it ran very successfully.

With coal oil it is necessary to use a generator, and the generator must be heated by artificial heat until by successive explosions the generator becomes heated. The coal oil engine is very popular in Austria, Roumania, and Bulgaria.

Mr. Bly,—

What would you term a small manufacturer, a man who is using a 5 or 10 horse power engine, or a man who is using a 100 to 150 horse power engine? You have got to get something that will strike a comparison. While it does not take much to install and operate a gas engine, you must take into consideration what would be the position of a man if he was to set up a gas engine at a nominal cost, and the thermometer went down to 20 below zero. He would not have a very comfortable place for his gas engine, and how would that affect the man who is employed by the manufacturer, I think he would have to put on a little more gas to operate his gas engine. If he had to put in a heating plant as well, it would run up the cost considerably.

To my mind the steam engine is going to get as near to the cheapest motive power as any engine or motive power that we can get. I believe to-day it will beat out the electric power of the Hydro-Electric. When you remember that the high pressure reciprocating engine only takes about 15 per cent. of the heat of the fuel, the balance can be utilized for heating purposes in the building.

If the manufacturer cannot find sufficient use in his building for 85 per cent. of his steam he can easily get his neighbor next to him to let him furnish him with power and heat, and when we get our power for 15 per cent. of the fuel, we are getting pretty cheap power.

I am operating two reciprocating engines to-day, and I do not think they have cost $35.00 for repairs in three years.

Mr. Henderson,—

From a point of economy, I think it would pay to put in a separate heating plant, if you have steam blowing into the atmosphere you are wasting it. You can use it for power all the year round, whereas using it for heating five months in the year there are seven months when you are wasting it by heating your smokestack or the atmosphere. My experience is that instead of using exhaust steam for heating purposes, it is much cheaper to use live steam.

Mr. Bly,—

I would say that I have failed yet in the city of Toronto to see a building heated for five months in the year. I have somewhere between twenty and twenty-five buildings that require heat for eight months in the year, and for some seasons nine. From this you will see that we have only from three to four months at the outside to throw away the exhaust steam, and when you come to condensing steam the cost of condensing it is a great deal more than using it for heating purposes, and I find that by heating with exhaust steam I can heat the buildings for comparatively nothing when I am generating power.

My men who are firing have asked me to allow them on Sundays when the heating was heavy to run the engines without generating any current or any power because they could heat the buildings easier by putting the steam through the engines than by heating straight from the boilers. That seems strange notwithstanding it is true. I find that we do not have nearly so much water in the steam nor do we use so much of it when heating by exhaust steam as the vibration of the engines seems to take the water out of the steam consequently the men who do the firing invariably ask me to let them run the engines, therefore it seems to me that we ought to be able to heat buildings, and make our power about as cheap as you can do it with a gas engine.

Mr. Henderson,—

Steam per pound contains a certain amount of heat units whether it passes through the engine or through the live steam valve, and I should assume that if they use more water to heat their buildings with live steam than by passing it through the engine that there is some leakage some place that should be stopped so that the energy that is used up by the engine could be turned into heating the building. I would advise Mr. Bly to look to his steam traps or outlets.

Mr. Bly,—

What we get in our return pipe, I presume we lose, but the loss seems to be in the larger steam pipes that we do not get any benefit from in the building. The scheme seems to work out all right as far as I have been able to see, and we can do it as cheaply with the engine running as we can without. I know it takes heat to generate power. We have got to do the heating and can make our power for 15 per cent. of our coal bill. You cannot generate your gas for 15 per cent. of your fuel.

Chairman,—

I wish to say that I would be glad if the Nominating Committee would remain at the close of the meeting.

Mr. Baldwin,—

I beg to move a hearty vote of thanks to Mr. Henderson for the excellent paper he has given us to-night. Seconded by Mr. Clark. Carried.

Chairman,—

On behalf of the Club I tender you a very hearty vote of thanks. We have all enjoyed your paper and we thank you very much for giving us such an interesting paper, and we would like to have you come to every meeting.

Mr. Henderson,—

I thank you very much for your cordial reception. My paper was not very large, but it has taken me a long time to gather up some of the information I have laid before you, and if you have reaped any benefit from anything I have said, I am sure I am very gratified.

Mr. Bird,—

I would move that "A letter of sympathy be written to our esteemed member, Mr. Acton Burrows, expressing the sympathy of this Club with him on account of the death of his daughter."

Seconded by Mr. Baldwin. Carried.

Chairman,—

I am sure we all deeply sympathize with Mr. Burrows in his bereavement, and for the benefit of the new members I will say that Mr. Burrows is one of the Fathers of this Club.

Moved by Mr. Herriott, seconded by Mr. Logan, that the meeting be adjourned. Carried.

Cost of Power Delivered to Shafting Using Various Prime Movers.

March 10, 1905.

Electric Motor—City Current.	20 H.P. Total.	20 H.P. per B.H.P.	50 H.P. Total.	50 H.P. per B.H.P.	100 H.P. Total.	100 H.P. per B.H.P.
1st Cost—						
1—Motor and Main Line Switch.....	$310 00	$15 50	$650 00	$13 00	$1,200 00	$12 00
2—Foundation and Erecting.........	60 00	3 00	80 00	1 60	100 00	1 00
3—Wiring, Insulators, etc.	20 00	1 00	30 00	0 60	40 00	0 40
4—						
5—						
6—						
Total........................	$390 00	$19 50	$760 00	$15 20	$1.340 00	$13 40

	20 One Year 3,000 hrs.	20 per B.H.P. Hour.	50 One Year 3,000 hrs.	50 One B.H.P. Hour.	100 One Year 3,000 hrs.	100 One B.H.P. Hour.
Cost of Operation—		c.		c.		c.
1—Interest, depreciation and repairs 1st cost, 15 per cent.	$58 50	0.10	$114 00	0.08	$201 00	0.067
2—"Fuel"—current at 5c. per h.p.hr.	3,000 00	5.00	7,500 00	5.00	15,000 00	5.00
3—Attendance { 20 h.p.—0. 50 h.p., ½ hr. at 20c. 100 h.p., ¾ hr. at 20c. }			30 00	0.02	45 00	0.015
4—Oil, Waste and Supplies	60 00	0.10	150 00	0.10	300 00	0.10
Total........................	$3,118 50	5.20	$7,794 00	5.20	$15,546 00	5.182

Steam Plant.	20 B.H.P. Total.	20 B.H.P. One B.H.P.	50 B.H.P. Total.	50 B.H.P. One B.H.P.	100 B.H.P. Total.	100 B.H.P. One B.H.P.
1st Cost—						
1—Horizontal Engine { 20—Non-Conders. 50—Condensing. 100—Comp. & Cond. }	$480 00	$24 00	$1,250 00	$25 00	$3,000 00	$30 00
2—Foundation and Erecting..	90 00	4 50	150 00	3 00	150 00	1 50
3—Tubular Boiler....................			800 00	16 00	1,700 00	17 00
4—Piping and Accessories...........	70 00	3 50	200 00	4 00	475 00	4 75
5—Stack { 20 h.p.—Steel. 50 h.p.—Steel. 100 h.p.—Brick. }			75 00	1 50	450 00	4 50
6—Condenser.			350 00	7 00	600 00	6 00
Total........................	$640 00	$32 00	$2,825 00	$56 50	$6,375 00	$63 75

	20 One Year 3,000 hrs.	20 One B.H.P. Hour.	50 One Year 3,000 hrs.	50 One B.H.P. Hour.	100 One Year 3,000 hrs.	100 One B.H.P. Hour.
Cost of Operation—		c.		c.		c.
1—Interest, depreciation and repairs 15 per cent. of 1st cost	$96 00	0.16	$424 00	0.28	$956 00	0.32
2—Fuel { 20 h.p.—12 lbs. B.H.P. hr. 50 h.p.—8 lbs. B.H.P. hr. 100 h.p.—6 lbs. B.H.P. hr. } (Coal at $2.50 per 2,240 lbs.)	804 00	1.34	1,339 00	0.89	2,009 00	0.67
3—Attendance { 20 h.p., 10 hrs. at 15c. 50 h.p., 10 hrs. at 15c. 100 h.p., 10 hrs. at 20c. }	450 00	0.75	450 00	0.30	600 00	0.20
4—Oil, Waste and Supplies	90 00	0.15	180 00	0.12	300 00	0.10
Total........................	$1,440 00	2.40	$2,393 00	1.59	$3,865 00	1.29
Total—Coal at $3.00 per 2,240 lbs.....	1 601 00	2.67	2,661 00	1.77	4,267 00	1.42
Total—Coal at $3.50 per 2,240 lbs.....	1,761 00	2.94	2,928 00	1.95	4,668 00	1.56

Cost of Power Delivered to Shafting Using Various Prime Movers.

March, 1905.

City Gas and Otto Engine.	20 B.H.P.		50 B.H.P.		100 B.H.P.	
	Total.	One B.H.P.	Total.	One B.H.P.	Total.	One B.H.P.
1st Cost—						
1—Engine	$800 00	$40 00	$1,850 00	$37 00	$3,500 00	$35 00
2—Foundation	40 00	2 00	110 00	2 20	175 00	1 75
3—Erection	15 00	0 75	25 00	0 50	40 00	0 40
4—Piping	45 00	2 25	100 00	2 00	175 00	1 75
Total	$900 00	$45 00	$2,085 00	$41 70	$3,890 00	$38 90

	20		50		100	
	One Year 3,000 hrs.	One B.H.P. Hour.	One Year 3,000 hrs.	One B.H.P. Hour.	One Year 3,000 hrs.	One B.H.P. Hour.
Cost of Operation—		c.		c.		c.
1—Interest, depreciation and repairs 15 per cent. of 1st cost.	$135 00	0.23	$313 00	0.21	$584 00	0.19
2—Fuel—18 feet per B.H.P. hr. Gas at $1.00 per 1,000	1,080 00	1.80	2,700 00	1.80	5,400 00	1.80
3—Attendance { 20 h.p., 1 hr. at 15c. 50 h.p., 1 hr. at 20c. 100 h.p., 1½ hrs. at 20c.	45 00	0.07	60 00	0.04	75 00	0.03
4—Oil, Waste and Supplies	60 00	0.10	120 00	0.08	180 00	0.06
Total	$1,320 00	2.20	$3,193 00	2.13	$6,239 00	2.08
Total—Natural Gas { 25c. per 1,000. 15 ft. per B.H.P. hr.	465 00	0.78	1,055 00	0.70	1,963 00	0.65
Total—Natural Gas { 50c. per 1,000. 15 ft. per B.H.P. hr.	690 00	1.15	1,617 00	1.08	3,087 00	1.03

Otto Gasoline Engine.	20 B.H.P.		50 B.H.P.		100 B.H.P.	
	Total.	One B.H.P.	Total.	One B.H.P.	Total.	One B.H.P.
1st Cost—						
1—Engine	$800 00	$40 00	$1,850 00	$37 00	$3,500 00	$35 00
2—Foundation	40 00	2 00	110 00	2 20	175 00	1 75
3—Erection	15 00	0 75	25 00	0 50	40 00	0 40
4—Piping	45 00	2 25	100 00	2 00	175 00	1 75
Total	$900 00	$45 00	$2,085 00	$41 70	$3,890 00	$38 90

	20		50		100	
	One Year 3,000 hrs.	One B.H.P. Hour.	One Year 3,000 hrs.	One B.H.P. Hour.	One Year 3,000 hrs.	One B.H.P. Hour.
Cost of Operation—		c.		c.		c.
1—Interest, depreciation and repairs 15 per cent. of 1st cost.	$135 00	0.23	$313 00	0·21	$584 00	0.19
2—Fuel { 20 h.p.—1 pint B.H.P. hr. 50 h.p.—9-10 pint B.H.P. hr. 100 h.p.—9-10 pint B.H.P. hr. (Gasoline at 9c. per gallon).	675 00	1.12	1,519 00	1·01	3,038 00	1.01
3—Attendance { 20 h.p., 1 hr. at 15c. 50 h.p., 1 hr. at 20c. 100 h.p., 1½ hrs. at 20c	45 00	0.07	60 00	0.04	75 00	0.03
4—Oil, Waste and Supplies	60 00	0.10	120 00	0.08	180 00	0.06
Total	$915 00	1.52	$2,012 00	1.34	$3,877 00	1.29
Total—Gasoline, 12c. gallon	1,140 00	1.90	2,518 00	1.68	4,890 00	1.63
Total—Gasoline, 15c. gallon	1,365 00	2.28	3,024 00	2.02	5,903 00	1.97

Cost of Power Delivered to Shafting Using Various Prime Movers.

March 10, 1905.

Otto Suction Producer Plant.	20 B.H.P.		60 B.H.P.		110 B.H.P.	
	Total.	One B.H.P.	Total.	One R.H.P.	Total.	One R.H.P.
1st Cost—						
1—Engine	$1,100 00	$55 00	$2,750 00	$45 83	$4,750 00	$43 18
2—Foundation	50 00	2 50	150 00	2 50	225 00	2 05
3—Producer and Scrubber	800 00	40 00	1.200 00	20 00	1,400 00	12 73
4—Piping for Engine	55 00	2 75	150 00	2 50	200 00	1 82
5—Piping for Producer	125 00	6 25	160 00	2 67	250 00	2 27
6—Erection, Producer and Engine	40 00	2 00	50 00	0 83	75 00	0 68
Total	$2.170 00	$108 50	$4.460 00	$74 33	$6.900 00	$62 73

	20		60		110	
	One Year 3,000 hrs.	One B.H.P. Hour.	One Year 3,000 hrs.	One B.H.P. Hour.	One Year 3,000 hrs.	One B.H P. Hour.
Cost of Operation—		c.		c.		c.
1—Interest, depreciation and repairs 15 per cent. of 1st cost.	$326 00	0.54	$6 9 00	0.37	$1,035 00	0.31
2—Fuel { 20 h.p.—1½ lbs. B.H.P. hr; 60 h.p.—1½ lbs. B.H.P. hr.; 110 h.p.—1¼ lbs. B.H.P. hr. (Coal at $4.25 per 2,240 lbs.)	171 00	0.29	512 00	0.28	783 00	0.24
3—Attendance { 20 h.p., 3 hrs. at 15c.; 60 h.p., 4 hrs. per day at 15c.; 110 h.p., 4 hrs. per day at 20c.	135 00	0.23	180 00	0.10	240 00	0.07
4—Oil. Waste and Supplies	90 00	0.15	216 00	0.12	330 00	0.10
Total	$722 00	1.203	$1,577 00	0.876	$2 388 00	0.724
Total—Coal at $3.25 per ton	682 00	1.14	1 457 00	0.81	2,208 00	0.67
Total—Coal at $5.00 per long ton	752 00	1.25	1,667 00	0.93	2.526 00	0.77

Gas Consumption—City Gas of 625 B.T.U. to

ENGINE.				CUBIC FEET OF GAS PER HOUR														
Series	No.	Rated Power.	B.H.P.	Idle	½	1	1½	2	2½	3	3½	4	5	6	7	8	9	10
		1	Total Gas															
			Gas per B.H.P.															
918	20	2	Total Gas	8¼	19	30	41	52										
			Gas per B.H.P.		38	30	27	26										
794	21	3½	Total Gas	16 0	26	35	45	55	65	74	84							
			Gas per B.H.P.		52	35	30	27	26	25	24							
951&959	3	5	Total Gas	21.3		40		59		78		97	116					
			Gas per B.H.P.			40		30		26		24	23					
995&999	4	9½	Total Gas	30.7		46		62		77		93	109	124	140	156	172	
			Gas per B.H.P.			46		31		26		23	22	21	20	19½	19	
932&1012	5	14	Total Gas	47.2		62		76		91		106	120	136	151	166	181	196
			Gas per B.H.P.			62		38		30		27	24	22	21½	21	20	19½
1052 s e	6	20	Total Gas	69				99				129		159		189		219
			Gas per B.H.P.					49				32		26		23½		22
1129-1130	66	25	Total Gas	75						120			150			195		226
			Gas per B.H.P.							40			30			24½		22 6 10
	7	30	Total Gas															
			Gas per B.H.P.															
1014	8	36	Total Gas	149									223					297
			Gas per B.H.P.										45					30
910&965	9	50	Total Gas	214														370
			Gas per B.H.P.															37
893	10	60	Total Gas	252														
			Gas per B.H.P.															
772	11	80	Total Gas	370														
			Gas per B.H.P.															
755	12	100	Total Gas	4[illegible]0														
			Gas per B.H.P.															
	13		Total Gas															
			Gas per B.H.P.															

650 B.T.U.—Oct., 1907.

This table is compiled from Test Records.
An allowance should be made for safety in Guarantee.

USED AT VARIOUS LOADS.

	12	14	18	20	25	30	35	38	40	45	50	60	70	80	90	100	110	120	130	140	150
	225 18½	255 18																			
	249 21	279 20	338 19	368 18																	
	255 7-10 21 3-10	286 20 4-10	346 19 2-10	376 18 8-10	451 18																
		357 25		446 23	520 21	594 20	668 19	713 19													
				526 26		682 23			838 21		994 20										
	436 36			559 28		712 24			867 22		1020 20 4-10	1174 19½									
				631 32		761 25			892 22		1022 20	1152 19	1283 18	1414 18	1544 17						
				677 34		810 27			944 23½		1077 22	1211 20	1344 19	1478 18½	1612 18	1745 17½	1879 17				

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