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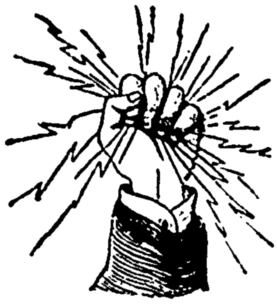

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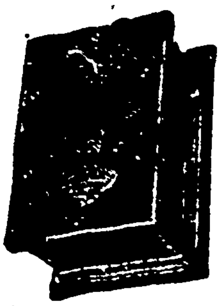

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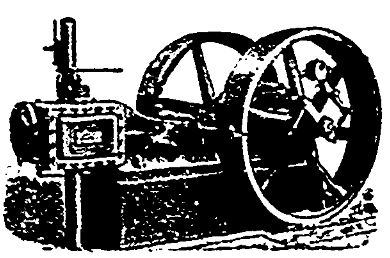

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CHATHAM MUNICIPAL LIGHTING PLANT.

THE year 1897 marked the inauguration of the electric light plant installed, under civic control, for lighting the streets of the city of Chatham, Ont. In February of that year a by-law was carried by the ratepayers authorizing the City Council to expend $15,000 in the purchase of an arc plant. Tenders were subsequently invited and awards made for the same. The contract for the complete electrical equipment, including dynamos, lamps, wiring, etc., was placed in the hands of the Thompson Electric Company, then of Hamilton, but now amalgamated with the Toronto Electric Motor Co., and doing business in Toronto. Messrs. E. Leonard & Sons, of London, were the successful tenderers for the engine, and Park Bros., of Chatham, for boilers. The accompanying view shows one of the arc machines and the engine.

VIEW OF ELECTRIC LIGHT PLANT, CHATHAM, ONT., SHOWING ONE ARC MACHINE AND ENGINE.

The electrical equipment consists of two automatic arc dynamos of nominally 50 lamps capacity each. These are supplying current to 104 arc lamps and 10 series incandescents through circuits which aggregate some 24 miles in length. The 10 incandescent lamps and 2 arc lamps are used for illuminating the power house and adjoining waterworks plant, while 102 lamps are for street illumination exclusively. These latter are provided with substantial telescoping storm protectors, and are suspended from a suitable steel mast arm. Sleet proof lamp-supporting pulleys and thoroughly insulated lamp hangers are used throughout.

The outside circuit throughout is of No. 6 B. & S. hard drawn copper wire, triple braided, strung over double petticoat insulators, and at intervals of two miles is protected by an effective magnetic blow-out lightning arrester. Wherever possible the circuit is divided into loops, comprising some 5 to ten lamps, each loop being controlled from a substantial absolute cut-off switch. The interior wiring is of No. 6 B. & S. rubber covered wire.

A plug switchboard, arranged so that machines and circuits may be interconnected, is provided. This is furnished with ammeters and magnetic blow-out lightning arresters of a new pattern, the whole being neatly arranged on a white marble base.

The plant is said to have been subjected to the most vigorous tests, and to have proved very satisfactory. The machines were short circuited at full load for one minute, and also while at full load the circuits were suddenly opened. These tests thoroughly demonstrated their ability to withstand any exigencies of service.

The engine is a Leonard-Ball automatic compound, of 100 h.p., and is designed with a heavy shrouded frame and box base. The bearings are large and well-proportioned. The engine is well finished and is equipped with a very complete oiling device, making a power plant neat in appearance, silent running and economical.

The Windsor Hotel Company, Montreal, Que., are making extensive alterations in their electric installation, and have ordered from the Canadian General Electric Company two 1,000 light slow speed multipolar generators, with marble switch-board panels.

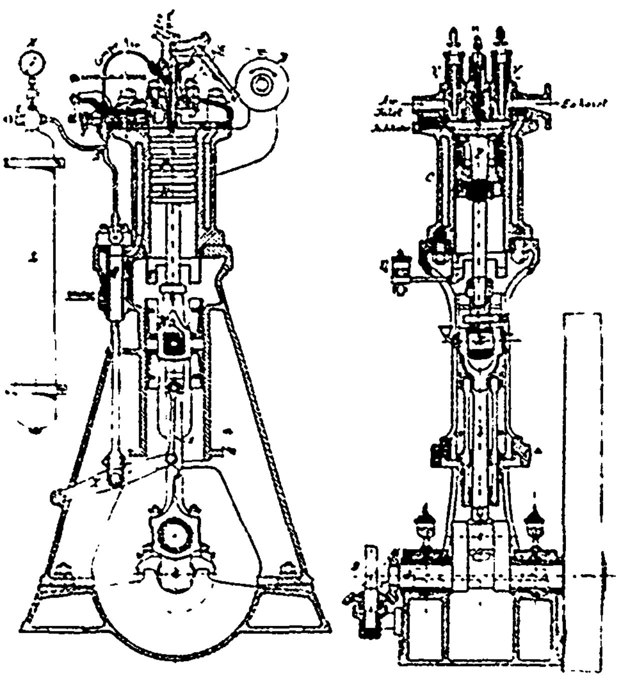
Mr. Wm. Fowden, of Camden, N. J., gives the following plan for preventing arc lamps from freezing: Take a number of thin sheets of cardboard and punch a hole in them the same size as the carbon, and if the trimmer thinks that things are going to freeze, slip one of these small pieces of cardboard on the upper carbon of the early side of the lamp. This will act as a shed for the water, and prevent the lamp from freezing.

THE DIESEL HEAT MOTOR.

An invention which is attracting considerable attention throughout the United States and Europe is the Diesel heat motor, the tests of which have shown remarkable results in the way of converting the whole heat contained in the fuel into actual work. In a paper read at a meeting of the Deutscher Ingenieure Verien, the inventor, R. Diesel, of Munich, describes the principles of the apparatus, from which we obtain the following particulars:

Mr. Diesel states that in every process of combustion two kinds of temperatures are to be distinguished: 1. The temperature of ignition; 2. The temperature of combustion. The temperature of ignition is that temperature to which a fuel must be heated to ignite it in presence of air. The temperature of combustion is that temperature subsequently generated by the chemical process of combustion after ignition has taken place. The combustion temperature must be generated not by the combustion and during the same, but before and independent of it after ignition has taken place, by mechanical compression of pure air. To deviate from the perfect process, directly compress the air adiabatically instead of first isothermally from 2 to 4 atmospheres and then adiabatically to the 30 or 40 fold. By so doing one realizes the first of the required conditions, i.e., the generation of the combustion temperature by mere compression with pressures which are two and four times lower than those used in performing the perfect cycle.

The fuel must be introduced gradually into the air, which is compressed adiabatically to the combustion temperature in such a manner that the heat generated by gradual combustion is absorbed in the so-called nascent state, in consequence of a corresponding expansion, i.e., by mechanically cooling off the gases so that the

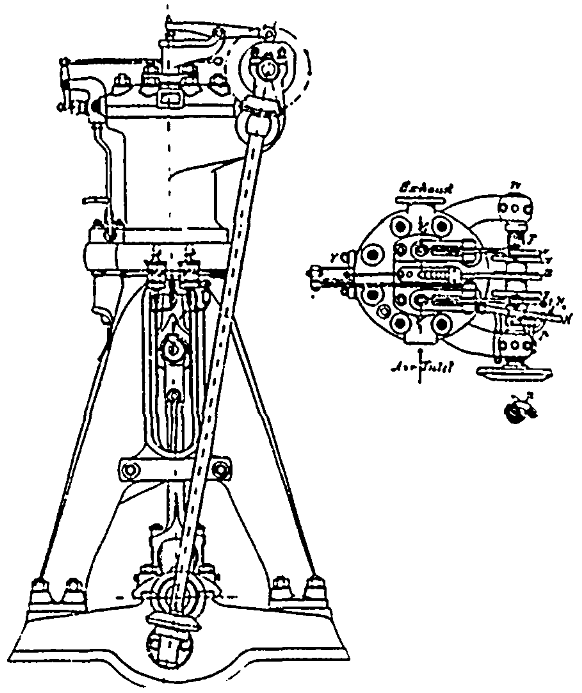


FIGS. 1 AND 2. CROSS SECTIONS OF DIESEL RATIONAL HEAT MOTOR.

period of combustion is going on constantly isothermally. It is evident that the fuel, in order to fulfil that condition, must be charged in its physical composition to a gaseous, liquid or powdery form. That is to say, that through the combustion and during the same, no, or a relatively small, increase of temperature is caused, an idea which seems to be absurd after having heretofore always effected the increase in temperature by the combustion and during the same.

The fourth condition also presents a revolution of ideas hitherto considered correct, according to which the combustion had to be carried on with as little surplus of air as possible, while he contends that a considerable surplus of air, whose amount can be determined theoretically in each special case, is necessary.

The operation of the motor may be briefly described



FIGS. 3 AND 4. SIDE VIEW AND PLAN OF VALVES, DIESEL RATIONAL HEAT MOTOR.

as follows: An auxiliary air pump compresses the air to about 500 pounds per square inch, storing it in a separate reservoir, from which it is led into the cylinder along with the oil or gas or coal-dust, and compressed still further, the temperature due to compression rising to the ignition temperature of the combustible. The fuel begins to burn and generates still higher temperature and pressure by doing so; at the end of the stroke the consumed gases, still at a high temperature, are led into a larger low pressure cylinder, which brings the pressure down so low that the succeeding exhaust is comparatively quiet.

In such an engine there are great possible advantages of superiority over the steam engine. No steam boiler is used; there is, therefore, no loss of heat in the flue gases or by boiler radiation, nor steam pipe condensation. The maximum available theoretical efficiency for such a motor is greater than that of the steam engine, owing to the possibility of using higher pressures, and consequently a higher range of temperature. This theoretical efficiency varies from 50 to 70 per cent. There is no cylinder condensation, and several other sources of loss are abolished. The mechanical efficiency is, however, likely to be a little lower than that of the steam engine, owing to the high compression necessary and consequent transmission and retransmission of energy between the piston and the fly-wheel.

The experimental engines so far constructed have been of the single-cylinder four-cycle single-acting vertical type, one of which of 20 horse power was tested with petroleum in the early part of 1897. This engine is provided with a ring piston and separate cross head, water jacketed and provided with poppet valves operated by cams for admission and exhaust. A small pump is attached which keeps an auxiliary vessel filled with air compressed to a higher pressure than that obtained in the cylinder. This serves to inject the fuel, and also to start the engine.

With this engine of 20 horse power working with refined liquid petroleum. the maximum available theoretical efficiency was about 50 per cent., and the actual ratio of indicated energy to the total energy of the fuel was about 35 to 40 per cent., showing an indicated efficiency of the engine as such of 70 to 80 per cent. The mechanical losses of this engine varied between 25 and 30 per cent. on high loads, giving over 26 per cent. of the total heat of the fuel as available energy at the shaft. With reduced loads the mechanical efficiency, of course, falls off, but the thermal efficiency, owing to the greater expansion, increases, thereby counterbalancing to a large extent the other and rendering the consumption of fuel per horse power low at all but the lightest loads. Owing to the high pressure employed in this engine also, the cylinder dimensions are from 30 to 50 per cent. less than those of gas engines of the explosion type.

The governing of the speed is also as simple and easy as that of the steam engine. The exhaust gases are noticeably invisible and nearly odorless during ordinary running, owing to the perfect combustion, which also prevents fouling of the interior of the engine.

In a paper read before the same meeting by Professor Schroter, describing the tests made with the engine, the following facts were shown :

There was a noticeably exact regulation of the combustion process. One hundred and more diagrams were found to coincide exactly as with steam engines on constant load. The ratio of indicated work on compression to that of indicated work on expansion, average values for full and half load being taken, showed a value of about 50 per cent. The mean effective pressure in the working cylinder was about 7½ kilograms per square centimetre on full load and 5¼ on half load, corresponding to 100 and 70 pounds per square inch. The effective work was measured by a modified prony break. The mechanical efficiency, that is, the ratio of effective work to indicated work, varied from 75 per cent. to about 58 per cent., as the work was varied from full to half load. The consumption of petroleum per break horse power was about 0.24 kilogram on full load and 0.28 on half load. Careful tests were made of the calorific value of this fuel, showing that there was converted into brake horse power over 25 per cent. of the available energy of the fuel at full load and over 22 per cent. at half load.

The Diesel motor has been patented in all countries where patents are granted for inventions, and the rights for the United States and Canada have been acquired by a company since incorporated under the laws of New York State as the "Diesel Motor Company of America," with offices at No. 11 Broadway, New York.

AMALGAMATION OF ELECTRICAL INTERESTS.

WITHIN the past month the amalgamation of the Thompson Electric Co., of Hamilton, and the Toronto Electric Motor Co., of Toronto, has taken place. The new concern will be known as the Toronto Electric Motor Co., Limited, with headquarters in Toronto, and a capital of $50,000. A new factory building, 95 by 50 feet, is now being erected on Pearl street, which will be equipped with modern tools for manufacturing and appliances for fully testing the finished product. A travelling crane will extend the whole length of the shop, and each machine will be connected with a separate motor, making a thoroughly complete establishment. The manufacture of arc and incandescent lighting and power plants will be continued.

CANADIAN ELECTRICAL ASSOCIATION.

A WELL attended meeting of the Executive Committee of the above association was held at the office of the secretary, Mr. C. H. Mortimer, Confederation Life Building, Toronto, on the 5th inst., to further arrangements for the annual convention which is to be held in Montreal.

The dates chosen for the convention are Tuesday, Wednesday and Thursday, the 28th, 29th and 30th of June. The headquarters of the association during the convention will be at the Windsor Hotel, where the business sessions and the annual banquet will also be held.

The draft programme recommended by the local committee of arrangements, with some slight amendments, was adopted, and is as follows :

FIRST DAY.—Executive meeting 9.30 to 10 a.m.; session, 10 a.m. to 1 p.m.; session, 2 to 5 p.m.; 7.30 p.m., trip around Mount Royal by special Park and Island cars, afterwards ascending Incline railway to lookout on mountain to view the city under illumination.

SECOND DAY.—Session, 9 to 12, noon; cabs and busses from Windsor Hotel at 1 p.m. to visit : (1) Bell Telephone Company's new building; (2) Street Railway Company's power house; (3) power house and works of the Lachine Rapids Hydraulic & Land Co., returning to city at 7.30 p.m.; 9 p.m., annual banquet of Association at Windsor Hotel.

THIRD DAY.—Session, 9 to 12 a.m., election of officers and visit to McGill University; 1.30 p.m., visit to Royal Electric Company's lighting station and factory, then by special G. T. train to visit the works of the Chambly Manufacturing Company at Chambly.

A number of very interesting and instructive papers relating to various phases of electrical work have been promised, and are in course of preparation.

Negotiations are in progress with the object of securing special transportation rates to enable a large number of the western members to participate in the proceedings of what will undoubtedly be a very pleasurable and instructive occasion. We hope to be in a position to announce further particulars in our May number.

PROPOSED MARITIME ELECTRICAL ASSOCIATION.

A MEETING has been called at the Halifax Hotel, Halifax, Nova Scotia, for Tuesday, the 12th inst., for the purpose of organizing a Maritime Electrical Association. The preliminary circular states that "while it is felt that all those engaged in the electrical business in Canada should, if possible, belong to the Canadian Electrical Association, there still remains a great need for an association of a more local character, whose place of meeting would be accessible to all its members, and which could discuss not only papers of a technical character, but also the questions arising from purely local circumstances." Among the principal promoters of the new organization are : Mr. E. T. Freeman, of the General Electric Co., Halifax; Mr. Jas. Waddell, P. E. I. Electric Co., Charlottetown, P.E.I.; Mr. F. A. Bowman, New Glasgow Electric Co., and Mr. J. H. Winfield, Nova Scotia Telephone Co., New Glasgow, N. S.

ROYAL ELECTRIC ENGINEERING SOCIETY.

AT a meeting of the Royal Electric Engineering Society held on March 17th, Mr. K. B. Thornton, of the Royal Electric Co., read a paper on "Alternating Current Arc Lamps," and at a meeting held on March 31st Mr. W. F. McLaren and Mr. R. F. Morkill read a paper on "Alternating Current Motors." Mr. Dix will read a paper at the next meeting on April 14th. The society are holding their meetings in the Board room at the Royal Electric Company's general offices, Queen street.

Messrs. Ness, McLaren & Bate, telephone manufacturers of Montreal, who were recently burnt out at No. 749 Craig street, have taken new premises at No. 419 St. James street (corner of Craig), and have put in a complete new plant of special tools and machinery for the rapid turning out of telephones, telegraph instruments and electrcial supplies of all kinds, and they now have one of the best equipped and up-to-date factories in Canada.

MATTERS AFFECTING THE COST OF ELECTRIC POWER.

By H. P. Elliott, B.A.Sc., Lecturer Toronto Technical School.

The paper, of which the following is a short digest, was written with the intention of pointing out the nature of and relation between the various items that enter into the cost of production of electric power for incandescent lighting, and the effect upon the cost per unit output, of different styles of engines, differences in the cost of coal, and different methods of supply. It may also serve to show why the efficiency of production is lower and the cost higher than for most other forms of power. The chief thing, however, to which attention is called is the great influence of the variable load upon the cost, being much greater than poor engines or high-priced coal.

A problem of this nature cannot be attacked in a general manner, but a particular case must be taken, and results will be obtained which indicate to a greater or less extent what to expect in general practice.

A 350 K.W. dynamo used to supply power for incandescent lights in a city from 30,000 to 60,000 inhabitants will be used as the basis of calculation. This dynamo is assumed (upon information furnished by the Canadian General Electric Co.) to have at an output of 336 K.W., a commercial efficiency of 93.8%. Its efficiency curve is given, No. 17, Plate II.

In order to get the total capital invested we have to figure on boilers erected and connected, engines ready for work, dynamo, including switchboard and all necessary instruments, etc., building chimney and ground, and then allow an additional amount for inspection and loss of interest during construction. Figures are given by Dr. Chas. Emery, of New York, which represent good modern practice for engines and boilers, both in regard to cost and efficiency. These figures, which are given in the report of the proceedings of the A.I.E.E., are used in the present paper to arrive at the capital invested in engines and boilers. Good modern water-tube boilers are used, at a cost of from $22 to $25 per H.P., set up and connected. The horse power required in each case is calculated from the assumed steam consumption of the engine. Four styles of these are used:

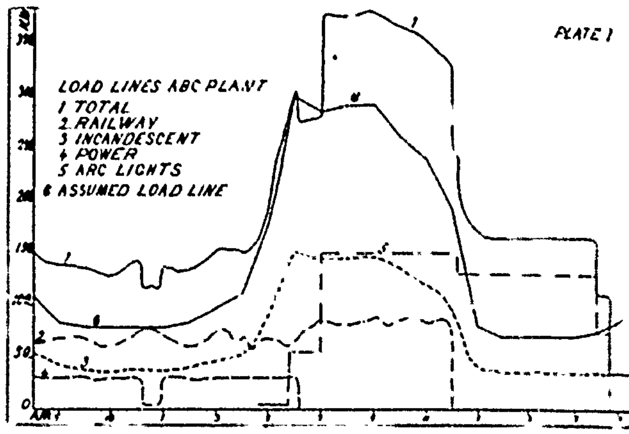
1. Simple high-speed non-condensing.
2. Simple low-speed non-condensing.
3. Compound high-speed condensing.
4. Compound low-speed condensing.

The coal is to have an evaporative power of 8.5 pounds of water, and assuming a four per cent. loss in the belts and a dynamo efficiency of 93.8 per cent., the output in watt hours per pound of coal at full load given in column 39 is obtained.

The interest or dividend to be paid, which comes into the cost account, is placed at 10% on the capital invested. The remaining expenses may be included under: Depreciation on boilers, engines, dynamo and buildings; supplies and probable repairs; wages, insurance, taxes, renewals and cost of coal. Calculation is made with each of the above styles of engine for coal at $2.67 and $4.46 per ton of 2,000 lbs., and for the three cases: first, where the plant runs fully loaded for 308 days of 10 hours each; second, for 365 days of 20 hours each; and third, where the power has to be supplied according to the load line, No. 6, on plate I. It will be noticed that in this case there is the same total output per day as when the plant was fully loaded for 10 hours, that is, 3,360 K.W. hours.

There is not space in the present condensed article to describe and justify the methods used in arriving at the cost in this third case, more than to say that such expenses as wages, renewals, repairs, interest and taxes, will be as high for a year as if the plant ran fully loaded. The cost per unit output is therefore increased. The cost of coal per unit output is obtained by plotting an efficiency curve for the plant, showing the output per pound of coal at various loads. This is done in the case of engine No. 4 only, but in order to compare the total costs in each case, the same efficiency curve is used with the others.

The curve of engine efficiency, No. 16, is plotted in the following way: The decrease in efficiency due to increased cylinder condensation is calculated, using a method given by Professor Carpenter for this style of engine. It is a modified form of Thurston's proposition that the wastes vary as the square root of the



number of expansions, and seems to give results comparable with those obtained by actual experiment. For the friction there is 56 H.P. lost at full load. This includes both engine and jack-shaft friction. Of this, 40 H.P. is assumed to be a constant for all loads, and the remaining 16 H.P. is a function of the 1 H.P. Having by this means obtained curve No. 16, it is easy to obtain No. 18, which gives the engine efficiency in terms of the dynamo output. Combining 18 and 19, we get No. 20, which gives the efficiency of the plant in per cent. of that at full load. Taking this curve in conjunction with the assumed load line, No. 6 on Plate I, the average cost of coal per K.W. hour is found, and then the total costs as given in columns Nos. 33 and 34.

To give an idea of the nature of the costs of distribution to consumers columns 35, 36, 37 and 38 are calculated. Suppose the generator is wound for 111.3 volts, and there is an average drop of 5% on the lines, the average voltage supplied will be 106. The 336 K.W., at a pressure of 111.3 volts, will mean 3018 amperes. A loss of 18 amperes is assumed through the shunts of the Thompson meters and other leakages. This leaves 3000 am-

TABLE OF COSTS.

No. of Engine.	1 Horse Power. i.h.p. of Eng.	2 Horse Power. Commercial of Boilers.	3 Cost of Coal per h.p. per Yr. On basis of 308 days of 10 hrs. each.—Cost of Coal per ton. $2.67	4 (308 days) $4.46	5 On basis of 365 days of 20 hrs. each.—Cost of Coal per ton. $2.67	6 (365 days) $4.46	7 Capital invested per h.p. Boilers er'c'd & c'n't'd, $22 to $25 per h.p.	8 Eng's er'c'd and ready for work.	9 Dynamo, incl'd'g Sw'ch-board, &c.	10 Buildings and Chimneys.	11 Total.	12 Total + 2½% for insp't'n and 6% for loss of int'r't dur'g const'n
			$	$	$	$	$	$	$	$	$	$
1	542	506	19.09	31.82	43.20	72.00	26.22	17.50	17.50	19.18	80.40	87.23
2	556	537	17.22	28.69	38.95	64.92	23.63	25.00	17.50	18.72	84.85	92.00
3	542	361	11.57	19.79	26.18	43.64	15.88	24.50	17.50	14.86	72.74	78.92
4	556	334	10.69	19.29	24.18	40.30	14.70	30.00	17.50	14.92	77.12	83.67

No. of Engine.	13 Interest on Capital, 10% on Col. No. 12.	14 Depreciation on Boilers at 7%.	15 Engines at 4%.	16 Dynamo at 3%.	17 Buildings at 2%.	18 Cost per net h.p. per year of Supplies and Pro'ble R'p'rs on basis of 308 dys. of 10 hrs.	19 Supplies and Pro'ble R'p'rs 365 dys of 20 hrs.	20 Wages on basis of 308 dys. of 10 hrs.	21 Wages 365 dys. of 20 hrs	22 Insur., 0.5%, Taxes, 1.2%, Renewals, 3.3%.
	$	$	$	$	$	$	$	$	$	$
1	8.72	1.83	0.70	0.52	0.38	2.98	7.05	6.01	14.26	4.02
2	9.21	1.65	1.00	0.52	0.37	2.55	6.03	5.72	13.57	4.24
3	7.89	1.11	0.98	0.52	0.30	2.98	7.05	4.86	11.51	3.64
4	8.37	1.03	1.20	0.52	0.30	2.55	6.03	4.72	11.20	3.86

No. of Engine.	23 Total of all Expenses but Coal on basis of 308 days of 10 hours.	24 Total of all Expenses but Coal on basis of 365 days of 20 hours.	25 Total cost per net h.p. per year. On basis of 308 days of 10 hours. Cost of Coal per ton. $2.67	26 (308 days) $4.46	27 On basis of 365 days of 20 hours. Cost of Coal per ton. $2.67	28 (365 days) $4.46
	$	$	$	$	$	$
1	25.16	37.48	44.25	56.98	80.65	109.48
2	25.26	36.59	42.48	53.95	75.54	101.51
3	22.28	33.01	33.85	42.07	59.19	76.65
4	22.55	32.51	33.24	41.84	56.69	72.81

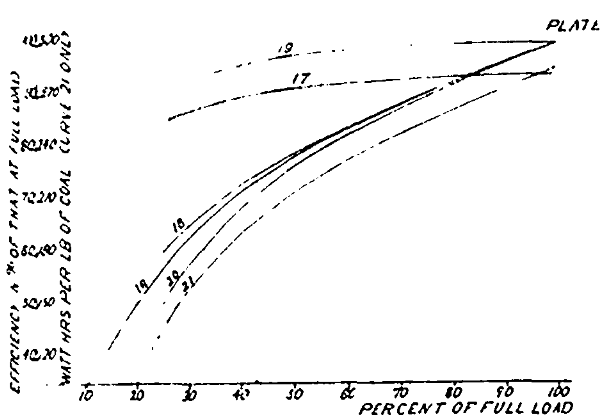
No. of Engine.	29 Total cost per k.w. hour at Switch-board. On basis of 308 days of 10 hours. Cost of Coal per ton. $2.67	30 (308 days) $4.46	31 On basis of 365 days of 20 hours. Cost of Coal per ton. $2.67	32 (365 days) $4.46	33 Assuming a load line. No. 6. Plate 1. $2.67	34 (load line) $4.46	35 Total cost per k.w. hour delivered to Consumers, taking into account the loss in and the cost of distribution. On basis of 308 days of 10 hours. Cost of Coal per ton. $2.67	36 (308 days) $4.46	37 On basis of 365 days of 24 hours. Cost of Coal per ton. $2.67	38 (365 days) $4.46	39 Watt hours per lb. of Coal, not counting coal wasted.
	cents.	cents.	cents.	cents.	cents.	cents.	cents.	cents	cents.	cents.	
1	2.138	2.757	1.645	2.232	3.018	3.676	2.917	3.571	2.016	2.637	159.7
2	2.053	2.607	1.540	2.069	2.768	3.609	2.827	3.412	1.905	2.464	177.1
3	1.636	2.032	1.807	1.560	2.199	2.769	2.386	2.805	1.553	1.908	263.5
4	1.606	2.082	1.156	1.484	2.213	2.639	2.355	2.794	1.498	1.845	285.4

peres at a pressure of 106 volts, or 318 K.W. supplied to customers. For an installation of this size in a city where the consumers do their own inside wiring and the line work is all above ground, the estimated cost of the construction work is placed at $40,000. This provides for 6,000 60 watt lamps, and the estimation is made on figures obtained from one of the agents of the Canadian General Electric Company. The following items will have to added to the cost account :

Interest on $40,000 at 10% . .	$4,000
Depreciation on construction work at 4% . . .	1,600
Salary of clerk to keep books and render accounts, etc., at $12 per week	624
Wages of boy to read meters, etc., at $4 per week. .	208
Total	$6,432

This means that without taking into account the loss in distribution, 0.057 cents will have to be added to the cost per K.W. hour on the basis of 308 days of 10 hours, and 0.277 cents will have to be added in the case where the plant runs 365 days of 20 hours. Taking into account the loss in distribution, the total costs per K.W. hour as given in columns 35, 36, 37 and 38 are obtained.

Upon looking over the official reports of pumping engine tests, it is seen that the work actually done per pound of coal is in many cases equivalent to 400, 500, or even more watt hours, whereas in power houses the output is in many cases less than 100 and seldom over 200 watt hours per pound. This is notwithstanding the fact that an engine and dynamo can be constructed nearly, if not actually, as efficient as a pumping engine. The low efficiency is due directly and indirectly to the variable load, which has a still greater effect on the cost of production. It lowers the efficiency directly, as already pointed out in the preceding calculation. Moreover, if an attempt to keep up the efficiency is made



by dividing the units, it is still much lower than it would be with a constant load. The units must be smaller and, therefore, less efficient, and besides this there are extra belting and friction losses introduced. The total load line in most power houses will be made up of a number of different kinds of load lines. Curves 1, 2, 3, 4 and 5, on Plate I, are taken from a power house in a city having between thirty and forty thousand inhabitants, and illustrate what is meant. Different sizes and styles of units will have to be installed, and this results in a much lower efficiency than could be otherwise obtained. The engines used in the calculations represent good modern practice for this size and style, yet with these even at full load it can be seen that the efficiency is comparatively low, and with the load line assumed, which is equivalent to a load factor of 46, the efficiency has been reduced to 62.5% of that at full load.

The effect of the variable load upon the cost is even greater. The items which enter into the cost account may be classified as follows :

First : Those that vary directly as the output. The cost per unit is the same no matter what the load. This class includes such items as cost of carbons and incandescent lamp renewals.

Second : Those that decrease with the output, but not so rapidly. The cost per unit increases to a great or or less extent. This class includes cost of coal, oil, supplies of certain kinds, and perhaps wages.

Third : Those that remain constant no matter what the output. The cost per unit varies inversely as the output. This includes *insurance, taxes, rent, interest and generally wages.*

It is evident, then, that as the two latter classes include the greater part of the costs, the cost per unit must greatly increase as the load factor becomes smaller.

MUNICIPAL OWNERSHIP VS. PRIVATE CORPORATIONS.

MR. M. J. Francisco, of Rutland, Vermont, has issued the fifth edition of his work entitled "Municipal Ownership vs. Private Corporations," in which he presents many strong arguments against municipal control of electric light plants. Mr. Francisco commenced the investigation of municipal ownership in 1885, and has personally visited nearly all the municipal plants in the United States and Europe. Having had many years' experience in the electric light business he is in a position to analyze statements made in regard to the management of plants, and to judge of their efficiency.

At the outset the author shows how many of the erroneous statements regarding the cost of electric light produced under civic control are arrived at, and refers at some length to municipal ownership in England and Scotland, where the actual facts prove it to be much less successful than is generally supposed.

Some figures submitted by Mr. Francisco are interesting. Statistics from 174 private companies show the cost per lamp per hour to be .0252 cents, while they furnish on an average 654 candle power per hour for one cent. The same analysis of 86 municipal lighting plants, taken from every state in the United States in which municipal plants are operated, shows that the average cost per hour is .0359 cents, while they only furnish on an average 404 candle power per hour for one cent. This shows that the private companies are furnishing the lights on contract on an average of .107 cents per hour less than the municipalities can produce them, and also furnishing 250 candle power per hour more for one cent than the municipal plants. Late reports from municipal plants also show that the expense of maintaining the plant is increasing each year, but notwithstanding this increased cost in municipal plants, the price charged by private companies for lights has decreased every year. A list is published of municipal plants that proved unsatisfactory, and were abandoned or sold.

Massachusetts, it is stated, has a commission which controls the electric companies, and from statistics obtained from the commissioners' report, the following figures as to the average cost are obtained :

Municipal Plants in Massachusetts.	Cost per year.	Cost per hour.	Candle power per hour for 1 cent.	Hours per night	Nights per month	Candle power of lamp.
Braintree. .	$133 34	.0587	204	7	27	1,200
Domers	73 06	.05	240	6	24	1,200
Middleboro	107 34	.049	204	8	25	1,200
Marblehead. .	100 30	.036	333	8	29	1,200
Peabody . . .	90 76	.0266	451	10	30	1,200
Reading . .	138 86	.0951	126	6	23	1,200
Wakefield. . .	124 30	.0851	141	5	23	1,200
Average.	$110 99	.04	248	7	25	1,200
Private Corporations in Massachusetts.						
Hyde Park.	$ 66 66	.042	476	5	26	2,000
Chelsea	109 50	.0286	419	11	29	1,200
Boston	127 75	.0354	536	10	30	2,000
Springfield . .	75 00	.0208	576	10	30	1,200
Westfield . .	82 00	.0379	527	6	30	2,000
Haverhill. .	132 24	.038	526	10	30	2,000
Worcester. .	127 75	.0354	536	10	30	2,000
Average	$102 98	.034	513	8	29	1,771

It will be seen that the average cost per lamp per year in the municipal plants is $110.99, while the same cost with private companies is $102.98. The average cost per hour is .04 and .034 cents respectively, and the average candle power per hour furnished for one cent 248 and 513.

LONG DISTANCE TELEPHONY IN CANADA.

Rapid as has been the development in the application of electricity to the requirements of social and commercial life, in no direction has this development been more surprising than in the science of telephony, and more especially in the extension of its capabilities for long distance communication. It is doubtful if the achievements of the long distance telephone are as yet fully appreciated by many who are well versed in the triumphs of other branches of electricial science; much less to the general public. It is our appreciation of this fact that induces the conclusion that a review of the long distance telephone service of the Bell Telephone Company of Canada would be interesting, as well as instructive, to many of our readers. Comparatively few people in Canada realize that to-day it is perfectly feasible to converse satisfactorily by long distance telephone, say, from Toronto to Portland; Montreal to Pittsburg or Chicago; Hamilton to Baltimore; or Ottawa to Washington. Yet it can be, and is being done.

Leaving aside altogether the enormous and constant application of inventive skill and capital which have been required to bring the local telephone service to its present efficiency, it is certain that the changes and the development of the long distance branch of the service have been equally radical and proportionately expensive.

The first attempt of the Bell Telephone Company of Canada to establish a long distance service, was made in 1881, by the construction of a single iron wire line between Toronto and Hamilton, then considered quite an achievement, and the line was well patronized. Within three years, 855 miles of poles and 1,500 miles of wire were constructed by the company, but so rapidly did conditions change, that even in this short time this type of line was found inadequate to the requirements of a growing business.

In 1885 copper wire was substituted for iron wire, affording better results. The introduction of the electric light and trolley, however, soon forced upon the company another and a more radical change, and metallic circuits had to be adopted upon all principal lines. This change, begun in 1885, was carried on as fast as circumstances would allow until all the principal lines of the company were made metallic, or, in other words, two wires were necessary to transmit a satisfactory converstation where one would suffice before the introduction of electric cars.

The extension of the system, in the meantime, went on apace, until, at the end of ten years, the company had in operation 4,484 miles of pole line and 13,148 miles of wire in its long distance service, and at the present time they have in the provinces of Ontario and Quebec 6,095 miles of poles, bearing 16,507 miles of wire.

Connections have been established with the extensive long distance system of the American Telegraph and Telephone Company and affiliated companies in the United States, at Newport, Vermont, St. Albans, Ogdensburg, Buffalo and Detroit, affording a system of direct telephonic communication as far south as Virginia and Tennessee, and from the cities and towns of the Atlantic seaboard westward to Nebraska.

The difference in the cost of the first long distance line of 1881 and the long distance line of to-day affords one of the serious problems in finance which the company has to meet. It is not a mere matter of change; it is a revolution requiring absolutely new and far more expensive construction. In 1881 a No. 9 iron wire (288 lbs. to the mile) was the best in use. To-day most of the construction is of two copper wires (which together weigh 532 lbs. to the mile). Formerly 32 poles to the mile were sufficient, but with the introduction of copper, in order to reduce the strain upon the wire, 40 poles to the mile are used; the poles have to be set deeper in the ground and more carefully stayed, all of which greatly increases the cost.

The long distance central office equipment of to-day is much more expensive than it was ten years ago, improvements having been made to facilitate the work of operating and to secure the best results in communications. The astonishing results which the long distance telephone service of to-day affords is due as much to the improvement in instruments, switches and other apparatus, and to the system upon which these are employed, as it is to the improvement in the lines.

Many people suppose that the long distance telephone is a competitor of the telegraph, and they are unable to understand the cause of the difference in rates. The competition is largely, if not entirely, mythical, and the reason for difference in rates is easily explained. The telegraph employs a single iron wire conductor, and, by means of a quadruplex instrument, this single wire is made to serve the purpose of four wires. The long distance telephone service requires two copper wires for each circuit, which together weigh nearly double what the single iron wire does, and costs over five times as much per pound. The general construction and office equipment of the long distance telephone service is also far more expensive than that of the telegraph. Nor does the comparison end here. An ordinary ten-word telegram may be transmitted in one minute, and it is practicable to transmit four messages simultaneously over one wire. Each completed conversation over the long distance telephone occupies two wires for an average of ten minutes; the comparison, therefore, being two copper wires for ten minutes, as against one-quarter of a single iron wire one minute.

Another important difference arises from the essential difference in the two systems of communication. The sender of a telegram writes out his message and goes about his business, and the operator forwards it as other demands on the line will best admit, with slight reference to time, thus keeping the telegraph lines fully employed at all hours.

The correspondent by telephone must have the line when he requires it, or not at all, and practically the entire earnings of the long distance telephone line must be within such hours as business men generally are in their offices, the hours during which these lines are productive being thus limited; and, as has already been pointed out, the capacity of the long distance line being confined to an average of six conversations per hour, it is clear that the rate must be sufficient to yield during that time an adequate return upon the investment and expenses.

Telephone rates are based on mileage and the time the line is occupied. The parties to a conversation absolutely control the line for the whole distance between them, on the average, ten minutes (five minutes for the conversation and five minutes to arrange the connection and to disconnect the line). It follows that in equity they must pay for the investment they control for the time it is at their disposal. Therefore, distance and time must be the ruling factors in fixing the rates.

The telegraph and long distance telephone have distinct functions and serve a different purpose to the commercial world. The telephone has, in reality, created a business for itself. Time is, to-day, the prime consideration in the transaction of much business, and the long distance telephone obliterates both time and space. Retail merchants no longer carry the heavy stock of former years, but promptly supply the requirements of their customers through the connection the long distance telephone affords with the wholesaler. So, through every branch of business the telephone has become a distinct and indispensable factor, the usefulness of which will be extended as its possibilities become more generally known and recognized.

AN HISTORICAL CHAPTER ON THE STEAM ENGINE.

For the following historical chapter, which traces from B.C. down to the present time, in chronological order, the different stages the steam engine has gone through to make it what it is to-day, we are indebted to a treatise entitled "Smokeless Heat," issued by the General Engineering Company, of Toronto:

927 B.C.—Homer spoke of steam as we do.

390 B.C.—Plato described steam as water melted into air by heat, which could be compressed into water again.

222 B.C.—Archimedes is said to have used steam in his defensive engines.

150 B.C.—Hero is associated with the invention of the steam engine, although it appears to have been known 1,000 years before his time. He invented hot air, rotatory and idolatrous engines.

1543.—DeGary, a Spanish captain, proposed to propel ships by steam.

1601.—Porta, the inventor of the magic lantern, showed the relative volume and force of steam in raising water.

1612.—De Caus showed the power of the sun on confined water by lenses; to increase the sun's effect, water was forced up six feet in pipes.

1618—David Ramsay obtained a patent for an engine to plough without horses, to raise water and propel ships and to raise water by fire from deep pits, move ships against wind and tide, and to fertilize the earth.

1629.—Branca describes a rotary steam engine he used for grinding drugs

1648.—The suggestion of flying by high pressure steam and large wings was made.

1651.—Marquis of Worcester pumped water by steam engine.

1702.—Savary states, "My engine raises a full bore of water sixty or seventy feet high, and if strong enough I would raise water 500 to 1,000 feet high." Savary was the first to use guage cocks. It is related that Savary accidentally discovered the force of condensation of steam from a wine flask—not quite empty—being thrown on a fire and producing steam. He took it off the fire and immersed its mouth below cold water, which condensed the steam and filled the flask by atmospheric pressure.

1705.—Newcomen employed the air to perform the work of pumping water and steam only used as an auxiliary. Newcomen, by condensing the steam below the piston, forced it and that end of the beam down, whilst the elevation of the other end raised water from the mine. Steam was therefore used merely to raise the piston, and air to do the work.

1740.—Experiments made at Newcastle are said to have realized an evaporation of eight pounds water for one pound coal.

1757.—Fitzgerald added the fly-wheel to the engine.

1762.—Dr. Black investigated the properties of heat and steam and propounded the doctrines of latent heat.

1766.—Blakely introduced tubular boilers.

1770.—Cugnot, French engineer, made a model of a steam locomotive, and the French government constructed one at the Paris arsenal and tried it in 1771, and then "laid it aside."

1772.—Smeaton determined the relative steaming values of different coals. Smeaton realized a duty of 112,500 foot pounds for one pound coal.

1730-1819.—The great defect of Newcomen's engine as improved by Smeaton was the loss of heat arising from condensing the steam in the working cylinder. James Watt estimated this to be nearly 35%, and in

1769.—Watt patented the addition of a separate condenser.

1782.—Watt invented the double acting cylinder, using steam on both sides of the piston.

1799.—Watt's assistant, Murdock, introduced the eccentric and slide valves. Watt invented the governor and throttle valve. To overcome a patent unfairly obtained through one of his workmen, Watt invented and used the

1780.—Sun and planet wheels in place of the crank. Watt claimed the crank was part of his design, but to avoid litigation used this arrangement.

1776.—Watt introduced the expansion of steam. He calculated when cut off at half stroke the performance would be as 1.7, at ¼ stroke as 2.4, and at 1/7 as 3 in economy as compared wi steaming the whole stroke. Watt was the first to recognize fully the importance of gaining some knowledge of the action of steam in the cylinder, and the first form of an indicator was the result of his efforts.

1776.—Bushnell proposed a screw propeller for ships.

1778.—Watt erected at Shadwick waterworks, an engine, working expansively.

1780.—Watt, by improved flue and other arrangements, obtained 8.6 pounds evaporated water per pound coal, or nearly 10% better than Smeaton.

1781.—Hornblower patented the same principle, expanding the steam into a second cylinder which led

1782.—Watt to patent his single cylinder plan of expansion. It cost Boulton, Watt's partner, $400,000 to defend his patent rights and introduce his engines before any profit was realized.

1784.—James Rumsy exhibited on the Potomac a boat propelled by machinery. He exhibited a boat in which a pump worked by steam power drove a stream of water from the stern and thus furnished the motive power.

1786.—Symington tried to combine Newcomen's atmospheric engine with Watt's separate condenser, yet evade the patent, but failed to do so. Symington constructed the first paddle wheel steamboat of the modern class.

1791.—Street dropped turpentine on hot iron and exploded the vapour formed below a piston to produce motion.

1797.—Cartwright used metallic packing.

1790-1816.—Trevethick erected in connection with Watt's former workman, Bull, several engines with double-acting cylinders. This able engineer introduced high pressure steam and expanding to a low pressure. So marked was the economy that the Court of Spain sent him with regal honors to the silver mines in Peru to drain them.

1800.—Bell fitted a four horse power engine in a small vessel and sailed from the Clyde to the Thames at seven miles an hour.

1802.—Trevethick patented a road locomotive which was successfully tried near London.

1804.—Improving on this he completed a locomotive to draw coal. It worked well, drawing ten tons of iron at five miles an hour. Trevethick was the inventor of the first modern locomotive.

1804.—Oliver Evans showed wonderful grasp of the science, but for want of money he could not carry out his ideas. He used the exhaust steam to heat the feed water; he worked with high pressure steam. In the writer's opinion Evans has not got the credit he deserves.

1804.—Stevens, of Hoboken, with a Watts engine 4½ x 9, supplied with steam from a boiler consisting of eighty-one horizontal copper tubes one inch diameter and two feet long, propelled a steamboat four miles an hour by a screw.

1793-1807.—Fulton successfully introduced steam boilers on the Hudson.

1815.—Ralph Dodd put a fourteen h. p. engine into a seventy-five ton boat and made a trip of 758 miles in 122 hours in very stormy weather.

1807.—M. DeRevax moved a locomotive carriage by exploding a mixture of hydrogen and air in a cylinder by electricity.

1813.—Blackett demonstrated that the enormous weight of the adhesion between the smooth rails and the equally smooth wheels would suffice to prevent the wheels of a locomotive from slipping.

1814.—George Stephenson ran his locomotive "Blucher" on the Killingworth railway.

1818.—Napier successfully prosecuted steam navigation and in

1822.—The "James Watt," of 100 h. p. and 440 tons burden, ran from Leith to London at ten miles per hour.

1824.—Brunel tried a carbonic acid gas engine.

1829.—Stephenson obtained the prize of £500 for constructing and running his locomotive "Rocket" over a distance of thirty miles in two hours and seven minutes. This test was between the "Sanspareil" built by Hackworth, and the "Novelty" built by Ericsson, and was to be a run of thirty miles at not less than ten miles per hour backward and forward along a mile level, with a load three times the weight of the engine. The "Novelty" after running twice along the level was withdrawn, owing to the failure of the boiler plates. The "Sansparril traversed eight times at a speed of nearly fifteen miles an hour and was stopped owing to the machinery being deranged. The "Rocket" was the only one to stand the test. The maximum speed was twenty-nine miles per hour and the minimum twelve. Stephenson made a splendid reputation, and projectors of all kinds, together with young men, asked his advice and counsel. This he gave cheerfully, except when these youths were "affectedly dressed," and put on "airs" contrary to his notions of propriety. To one youth applicant of this stamp he said: "I hope you will excuse me, I am a plain spoken person, and am sorry to see a nice-looking and rather clever young man like you disfigured with that fine patterned waist-coat and all these chains and fang-dangs. If I had bothered my head with such things when at your age I should not be where I am now."

1829.—Ericsson introduced hot air as a competitor with steam.

From 1829 until the present date the history of the locomotive is a vast series of improvements in details, far too various and numerous to mention here, until now it is one of the most perfect and beautiful of all the machines with which the engineer has to deal, and of which he is justly proud.

CORRESPONDENCE

CONVERSION OF WAVE FORCE INTO MECHANICAL FORCE.

CALGARY, N.W.T., March 4th, 1898.

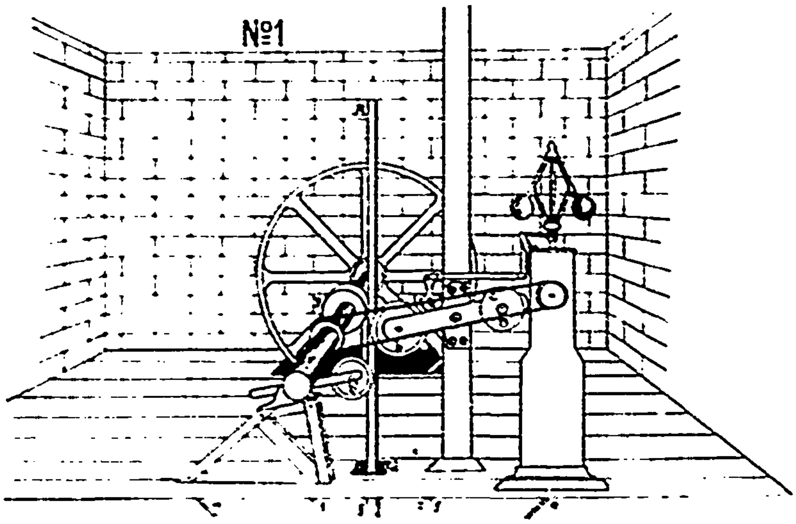
To the Editor of the CANADIAN ELECTRICAL NEWS:

DEAR SIR,—While perusing the contents of the Toronto World of the 15th of January, 1898, I came across an article headed, "Thomas A. Edison, Jr., thinks he has a plan to harness old ocean for man's benefit." Now, sir, Thomas A. Edison, Jr., is not the only individual who has solved this problem, as I believe I have plenty of evidence to prove.

About five years ago I showed this same plan of applying wave force to mechanical appliances to Joseph Powell, an architect and civil engineer, of Hamilton, Ont., and endeavored to persuade him to start a company to finance it and take out patents, but he said that it would require such a large amount of money that he could not get anyone to take hold of it. I showed him how it could be used to generate current for the Pacific cable at the intermediate stations in the Pacific Ocean, and thereby save the shipping of coal to these stations; also that wherever a body of water existed that had any swell or roll whatever on its surface, how it could be used or applied for lighting, heating, cold storage, and other mechanical uses, and this by the very same plan as mentioned in the article in the World, viz., floats connected or rather held in position by a pier, these floats to have a lever to each one, one end of each of these levers to be connected to a float, the other end connected to either a piston, a rack or a clutch-rod, and, of course, the lever working on a fulcrum. I showed him how it could be used: first, to compress air; second, raise water to a higher plain; third, compress ammonia; fourth, with the rack or clutch-rod for direct connection with dynamic or other machinery; the first to be used in connection with air engines, the second for turbines, the third for cold storage, and the fourth as stated.

I also spoke about it to a man named Moses, who was the inventor of the "Moses" stove; he had a hardware store on Yonge street, Eglington. I approached him with reference to having tin pump cylinders made for a model, but which I did not get, as I used the clutch-rod. I also spoke to Mr. Oldfield (proprietor of the Anglo-American Novelty Co., formerly on Lombard street, then on Adelaide street east) about the same invention, and roughly described it to him one day in the Yonge St. Arcade. I also mentioned the fact that I had solved the difficulty to G. Clay, accountant, Yonge St. Arcade, and I know I have mentioned it to others.

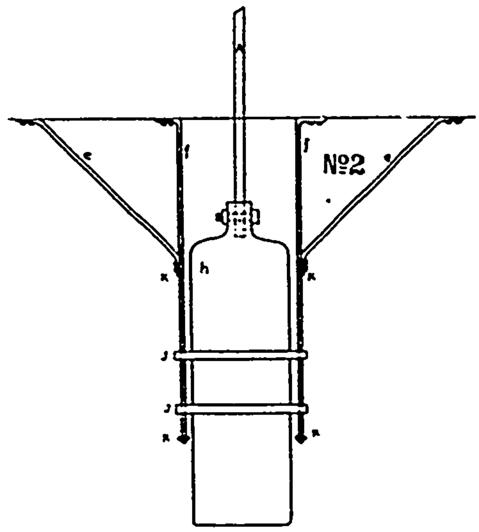
I conceived the idea about ten years ago while watching the landing stage at Liverpool, England, where the ferry-boats run



alongside and discharge their passengers. This landing-stage is thousands of tons, I believe, and is lifted up and lowered down by floats, as the tide varies.

Lastly, I wrote Thomas A. Edison about this matter near the close of the year 1896 or beginning of 1897, but I do not remember giving him any details whatever. I obtained Mr. Edison's address from Mr. Haines, the book-keeper for Matthews Bros. & Co., 48 Temperance street, Toronto, and told him I was writing Edison about an invention. I also told H. Matthews the same thing. However, Mr. Edison never acknowledged receiving my letter. Three years ago, while in charge of the North Toronto Electric Light and Waterworks, I had a model running on this same plan.

I send you tracings of my original apparatus. No. 1 gives a general idea of how the wave motion is converted by rods (of which there may be any number) A, g, into circular motion by friction between it and pulley B. The pulleys b and b' are simply accessories to insure, first, instant release immediately rod commences to descend, and second, a firm grip on B when ascending. As you will see, the pulley b is so inclined that by any upward movement it must press against the rod A and thereby cause it to grip the pulley B; the pulley b is held in position by arm and counterbalance c. The pulley b' is similarly inclined, but in opposite direction to pulley b, so that any downward



movement of rod A tends to move it on its arm downwards, and in so doing throws or pushes the rod A away from pulley B. The governors act through the levers shown on the cam S in such manner that when the required speed is reached the cam presses down on the arm which supports pulley b, and prevents pressing rod A against B. Of course, it must be understood that there can be any number of rods, so as to obtain continuous and steady motion.

Tracing No. 2 is a general idea of floats, of which there may be any number, and also of any size or tons displacement. They may be braced to suit requirements. A is the rod which may transmit the motions through the other levers or direct to mechanism, as, for instance, through B to C, Fig. 1.

The bands, J, J, No. 2, are so constructed as to form runners on guides, f, f. K, K, are stops, which might be provided with spiral springs, to form a cushion and prevent a jar or shock, when the float was lifting and falling its whole capacity, but there would require a harbor to be built around the station, and if the harbor was properly constructed with gates, the "rise" and "fall" could be so modified as to always, except in calms, have the floats rise and fall about the same distance, no matter how stormy it was outside of the harbor.

In conclusion, permit me to repeat that I know this is practicable, although, like everything else, or other first ideas, it can be improved upon. I think I have an improvement myself, but a model of this one has worked, and apparently worked well. From the World's description, Edison's idea is a similar one, and no doubt, as it is connected with his great name, he will get all the honor, and the world will wonder how his brain could grasp or conceive such a "mighty" simple thing, and of course, why it is absurd that any one else could do the same.

Yours respectfully,

WM. CROSS, C.E.

Of the forty-two largest cities in Japan, from Tokio, with 1,368,000 population, down to those of 26,000, electric lighting systems are installed in twenty-four, eighteen being without electric lights.

CORROSIVE AND SCALE-FORMING AGENTS IN BOILER FEED WATERS.

By Wm Thompson.

(Article 4).

Chemical analysis of a boiler feed water not only enables the chemist to determine the quantity of foreign matter present, but also the condition or form in which it appears as an impurity; it also enables him to express with certainty an opinion as to the nature of scale that will be found and quantity that may be expected, and thus judge as to the suitability or otherwise of a water for boiler feed purposes. For purposes of illustration I have chosen a number of characteristic samples of water, all of which have, in some respects at least, different properties.

No. 1 is a sample of water from an artesian well in the eastern portion of the city of Montreal that shows an almost entire absence of lime and magnesia salts, but which is still strongly impregnated with impurities. A partial analysis shows this water to contain:

Total solids per imperial gallon	36.42 grains.
Made up as follows:	
Sodium chloride (salt)	2.32 "
Sodium sulphate	6.85 "
Alkaline carbonates and bicarbonates with traces of silica	27.25 "

The whole of the foreign matter contained in this sample of water consists of soluble salts in chemical solution, that is to say, salts that have a very high degree of solubility in water, and consequently precipitation of impurities as scale-forming agents cannot occur. Although this is positively a non scale-forming water, it cannot be classed as a good or even fair water for boiler feed purposes in its original form. A glance at its composition shows it to be strongly alkaline and liable to cut the boiler and boiler fittings. As a matter of fact this is what occurred in actual practice, and users found it impossible to use the water satisfactorily until impurities had been neutralized by chemical treatment.

No. 2 is a sample of water from an artesian well used to supply the town of Montreal West, and may be classed as a fair boiler feed water. As will be seen, this water is very rich in dissolved solids, and also contains a fair percentage of scale-forming material. Partial analysis shows it to contain:

Total solids per imperial gallon	96.2 grains.
Made up as follows:	
Insoluble suspended matter	1 00 "
Aluminia and peroxide of iron	.20 "
Carbonate of lime	5.20 "
" " magnesia	3.17 "
Sulphate of soda	13.49 "
Chloride of soda	60.60 "
Alkaline carbonates and bicarbonates	12.54 "

Here we have an example of water that actually contains scale-forming agents and at same time material necessary to prevent formation into hard scale when precipitated. This water showed in use results that might be anticipated from its composition, precipitating a heavy insoluble sludge at lowest part of boiler, and after boiler had been in use a short time water became both highly concentrated and strongly alkaline, although the boiler was only evaporating about 700 gallons of water per day; a sample of water drawn from the boiler three weeks after being put in use, analysis showed it to contain an enormous amount of dissolved solids held in solution, composition of impurities being as follows:

Total solids per imperial gallon	2796.36 grains.
Insoluble suspended matter	6.72 "
Chloride of soda	1940.40 "
Sulphate of soda	425.28 "
Alkaline carbonates and bicarbonates.	398.48 "
Hygroscopic water	25.48 "

So strongly alkaline had the water become that brass fittings on boiler were being attacked, and wherever a small leak occurred deposits formed on outside of boiler, which is a marked characteristic of the behavior of the soda salts. At no time, however, during the last four years has any scale been found, a heavy sludge precipitating, having the following composition:

Silica	6.44%
Alumina and peroxide of iron	16.32%
Carbonate of lime	54.92%
" " magnesia	7.40%
Sulphate of soda	2.37%
Chloride of soda	10.80%
Carbonates of soda and potass	1.25%

The presence of the soluble soda salts in the sludge may be explained by remarking that the sludge was of such a consistency that a quantity of water had to be withdrawn at all times with the sludge. Until the composition of impurities contained within this water was known a great deal of difficulty was experienced in its use, particularly by foaming. The only treatment required, however, is to keep the water within the boiler from becoming too concentrated by frequent blowing off, and good results are now being obtained from its use.

Samples 1 and 2 mark distinct classes of feed waters. In No. 3 we have a sample of water of another type, an excellent water for boiler feed purposes and used largely by both the Grand Trunk and Canadian Pacific railway companies, for use in the boilers of their locomotives. This sample was obtained from Brampton, Ont., and is supplied to the town by means of gravitation from a small lake situate a few miles north of the town. Analysis show it to contain but a small quantity of dissolved solids and to be remarkably free from lime and magnesia salts, composition of impurities being:

Total solids per imperial gallon	6.00 grains.
Insoluble suspended matter	.40 "
Carbonate of lime	2.85 "
" " magnesia	.30 "
Chloride of soda	1.20 "
Sulphate of soda	.48 "
Alumina and peroxide of iron (traces)	

This is a type of feed water that tends to make engineers happy and requires but occasional washing out to dispense with either chemical or mechanical treatment.

Samples No. 4, 5 and 6 show examples of scale-forming waters in various forms.

No. 4.—Sample from Walkerton, Ont., shows a water rich in lime and magnesia salts existing in solution in the water as bicarbonates and precipitating as their respective carbonates:

Total solid per imperial gallon	21 grains.
Insoluble suspended matter	.80 "
Carbonate of lime	12.12 "
" " magnesia	6.66 "
Chloride of soda	1.20 "
Also traces of alumina and peroxide of iron.	

Sample No. 5.—Sample of water from artesian well in eastern portion of the city of Montreal:

Total solids per imperial gallon	45.7 grains.
Insoluble suspended matter	2.04 "
Carbonate of lime and magnesia	14.32 "
Sulphate of lime	12.65 "
Chloride of soda	9.38 "
Alkaline carbonates and bicarbonates	5.31 "

Sample No. 6.—Sample of water from factory at New Toronto, Ont:

Total solid grains per imperial gallon	141.6
Insoluble suspended matter	1.00
Alumina and peroxide of iron	.80
Carbonate of lime	27.48
" " magnesia	20.45
Sulphate of lime	37.36
Chloride of soda	54.60

A review of the impurities contained in these various samples shows very clearly how important this part of our subject becomes, and how widely different and varied in quantity are the impurities contained in the various feed waters throughout the country. I have said that when the nature of the impurities present is known that the effects resulting from the use of various waters for boiler feed purposes can be ascertained. This is well illustrated by the results obtained from the use of the various samples chosen for purpose of illustration from a large number of feed waters examined in my laboratory.

No. 1 and 2 I have already referred to at length. No. 3 is a class of water occasionally met with and predominating in some districts, and is a type of excellent water for the purpose indicated, and may be used without previous treatment with safety.

No. 4 is also a good boiler feed water, containing the whole of its impurities in such a condition that a physical change is all that is needed to render greatest portion of impurities insoluble, and consequently in such a condition that mechanical filtration will remove them from the water. As a matter of fact the users complain that while they had no scale in their boilers a very heavy scale formed in the heater, sample of which I received and analyzed with the following result:

Insoluble	.38%
Alumina and peroxide of iron	1.10%
Carbonate of lime	92.08%
" " magnesia	5.60%

Scale was light, very porous, and easily removed, and is a good example of the change taking place as set forth in last month's contribution on this subject when the water is sufficiently heated to drive off excess of carbonic acid and the insoluble carbonates of lime and magnesia are at once precipitated.

Sample 5 shows a type of water that has actually a double effect, a reaction setting up between the alkaline carbonates and the sulphates of lime and precipitating a sludge balance of sulphate of lime bonding with carbonates of lime and magnesia and forming heavy scale.

Sample 6 shows a sample of water that belongs to a class that should not be used for boiler feed purposes if any other water can be obtained, and requires both chemical and mechanical treatment, scale formed from this water, as is to be expected from composition of impurities, being exceedingly hard, tenacious and troublesome.

(To be Continued.)

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To Our Readers. THE series of instructive articles on electricity and steam engineering by Mr. Wm. Thompson, which have appeared in our Educational Department each month during the last year, will shortly come to a close. We have received assurances from many quarters as to their practical value. The object in their preparation was to furnish, in a form to be easily understood by those who had not the advantage of a technical education, the underlying data and principles on which a thorough knowledge of these subjects must rest, and which of itself would prove extremely helpful to those desirous of fitting themselves to intelligently operate electrical and steam machinery. Our readers of this class will no doubt be pleased to learn that this series of articles will shortly be published in the form of a pocket hand-book, at a very moderate price. Further particulars will shortly be given in these columns.

Proposed Greater Britain Exhibition. ARRANGEMENTS are well under way for the holding of what is termed a Greater Britain Exhibition at Earl's Court, London, next year, lasting from May until October. The undertaking, which is under the direct management of the London Exhibitions, Limited, a company formed in 1894, and having a paid-up capital of £145,000, is receiving the approval and support of the Marquis of Lorne, Sir Charles Tupper, and other distinguished British and Colonial statesmen. The object, which is to bring together the products of the various parts of the British Empire, should commend itself to all who wish for a closer commercial relationship between Great Britain and her colonies. The Canadian government will be asked to grant an appropriation to cover the cost of a Canadian exhibit. Attention is called to the fact that exhibits intended for the Paris Exhibition of 1900 might with advantage and little additional cost be first shown at the London Exhibition. In view of the prevailing sentiment on both sides of the water in favor of closer trade relations, Canada should take advantage of every opportunity to make known her resources.

Acetylene Gas. APROPOS of the article published in a recent number of the ELECTRICAL NEWS anent the dangers attending the use of acetylene gas, we reprint from the daily papers the following despatch dated Guelph, March 23: "A show, the Erin & Brennan Co., appeared in the City Hall here last night. There was one real act in the show not on the programme. An acetylene gas generator exploded during the early part of the proceedings. One of the performers was passing the generator with a lighted candle, which ignited the escaping gas. Explosion after explosion followed, and some of the scenery took fire. Mr. Brennan, one of the company, and caretaker Ryde, managed to smother the flames. Ryde had his hands badly burned by carrying the tank down-stairs. The stage carpet, piano cover and a couple of sets of scenery are badly scorched." Apart from the dangerous character of acetylene, it is being found out now that it cannot compete with a fairly reasonable supply of electric light or gas from a central station. In every-day practical operation it costs more than either, with the trouble and stench extra, as witness the following extract from the Kincardine Reporter: "The Teeswater News has just had an interview with Mr. Brick regarding his experience in lighting the Vendome, one of the finest hotels in that section of country. Not being able to make good arrangements for lighting by electricity, Mr. Brick contracted for a 75 light acetylene gas plant, the fittings costing $175. The generator was outside in a separate frost-proof building, partly to meet insurance requirements and partly to obviate the objectionable stench in cleaning it out daily. After a trial of over three months Mr. Brick has discarded the acetylene gas plant, and has had the entire hotel fitted up with 66 incandescent electric lights from the town plant. He claims that electricity is not only cheaper than the gas, but that the objection to the acetylene is its offensive smell, its getting out of order, emitting a sooty discharge from the burners, and the amount of work necessary to keep the generator charged, all saved under the incandescent electric lighting system."

The Rights of Private Lighting and Water Companies.

IN Pennsylvania the Courts have restrained municipalities from entering into competition with private water supply companies. In the New York Legislature a Bill has been introduced which seeks to add the following sub-division to the general corporation law: "Whenever any corporation shall be in the possession of or entitled to any rights, privileges or franchises within the limits of any municipal corporation, and shall be engaged in the exercise of the same or any part thereof, the municipal corporation within whose limits such rights, privileges or franchises are owned or exercised, shall not itself undertake to perform, within any land or territory, within which such corporate rights, privileges or franchises are or may be owned or exercised, the business or purposes to which said corporate rights, privileges or franchises relate, without first acquiring, in the manner prescribed by chapter 23 of the code of civil procedure, the rights, privileges and franchises of said corporation, or to which said corporation is or may be entitled, and also the property of said corporation used in or necessary for the use or exercise of any of said rights, privileges and franchises." Legislation of similar character has already been enacted by the State of Massachusetts and by the British Parliament. With such a precedent before them, it is to be hoped the Ontario Legislature at its next session will accede to the request of the Canadian Electrical Association, representing the electric light and gas companies, for legislation which will render compulsory the purchase by municipalities at a valuation of the plant only of private companies whose business they may desire to assume. It will be observed that no effort is being made on behalf of these companies to prevent municipalities from engaging in the business of supplying electric light and gas. All that is asked is that in cases where a municipal corporation desires to usurp the functions of a private company, they shall be compelled to purchase only the plant of said company at a fair valuation to be fixed by arbitration. Legislation of this character is needed to prevent the wiping out of a large amount of private capital which was invested in electric light and gas plants at a time when such investments were attended by heavy risk and when no one supposed that money of the taxpayers, including, of course, those who had invested their means in the private company, would in some instances be employed to purchase and operate a competing municipal plant.

Steam vs. Heat Engines.

WE often see in the various papers as read at some of the engineering societies statements regarding the great inefficiency of the steam engine, and that there is considerable room for improvement. No just comparison can be made between any machine and a heat engine, and to say that the steam engine is very *inefficient* is only partially correct. Some engines as mechanical devices give efficiencies as high as 90%, which certainly does not leave a very large margin for improvement. The amount of work got out of a heat engine depends entirely on the ABSOLUTE temperatures between which it is worked, and to obtain the whole work from a mass of heated air, it would be necessary to cool it down to absolute zero, which is utterly *impossible in practice.* The work done or given out by a heat engine in one revolution is expressed as follows:

$$W = J H \left(\frac{T_2 - T_1}{T_2}\right)$$

Where J = Joule's mechanical equivalent.
H = Heat units given up.
T_1 = Final absolute temperature.
T_2 = Initial absolute temperature.

From which we get the efficiency as being $\frac{W}{J H} = \frac{T_2 - T_1}{T_2}$. Suppose the initial pressure in a steam cylinder was 100 lbs., and the final pressure 5 lbs., and treating it as a heat engine we have an efficiency of $\frac{797 - 687}{797} = .14$, when 797 and 687 are the absolute temperatures of steam at 100 lbs. and 5 lbs. respectively. Now this same engine may have a mechanical efficiency of 85%. *It is through* no fault of the engine that its efficiency is low, when treated as a heat engine, but is the result of a law in thermodynamics, where only a fraction of the heat supplied is available for being transformed into another form of energy; this fraction is as shown above, viz., $\frac{T_2 - T_1}{T_2}$, Joule's mechanical equivalent being 772 foot lbs. One h. p. hour is equal to 2565 heat units. Taking a very economical plant, where 2 lbs. coal are required per indicated horse power, and that the calorific value of the fuel is 12,000 heat units, we therefore get for every 24,000 heat units in the furnace, 2565 heat units at the engine. But the boiler only utilizes .75 of the total heat units; we therefore have .75 of 24,000 = 18,000 heat units in the boiler, giving us an efficiency of [illegible] = .15 nearly. *Considering this in another way,* we have steam pressure 120 lbs., engine compound condensing, vacuum 26 inches. The absolute temperatures corresponding to these pressures are 810 and 586 respectively, giving an efficiency of 27 [illegible]. Twenty-seven per cent. of 18000 is equal to 4860 heat units, and of this amount 2565 are converted into mechanical energy, showing clearly that the correct efficiency of this engine, working under these conditions, is [illegible] = 52%.

SOME EXPERIMENTS ON THE CONDENSATION OF STEAM.*

By H. L. Callendar, M. A., F.R.S., Professor of Physics, and J. T. Nicolson, B. Sc., Professor of Mechanical Engineering, McGill University, Montreal.

Part I.

As the result of some experiments by electrical methods on the measurement of the temperature changes of the walls and steam in the cylinder of a working steam engine, which were made at the McDonald Engineering Building of McGill University in the summer of 1895, the authors arrived at the conclusion that the well-known phenomena of cylinder condensation could be explained, and the amount of condensation in many cases predicted from a knowledge of the indicator card, on the hypothesis that the rate of condensation of steam, though very great, was not infinite but finite and measureable. An account of these experiments was communicated to the Institution of Civil Engineers in September, 1896, and will, it is hoped, be published in the course of the ensuing session. In the meantime, the authors have endeavored to measure the rate of condensation of steam under different conditions by a new and entirely different method, with a view of verifying the results of their previous work, and also to estimate the influence, if any, of the film of water adhering to the walls of the cylinder.

In considering the condensation of steam on a metal surface it is usually assumed that the surface exposed to the steam is raised up to the saturation temperature corresponding to the pressure of the steam, and that the amount of condensation is limited by the resistance of the water films to the passage of heat from the steam to the metal and from the metal to the water. If the steam contains air, there may also be a considerable resistance due to the accumulation of a film of air on the surface, but it is comparatively easy to exclude this possibility in experimental work.

In the steam engine experiments above referred to, it was practically certain that the water film due to the cyclical condensation never exceeded one-thousandth of an inch in thickness, and that the resistance offered by it was unimportant. At the same time, it appeared clear that the temperature of the surface of the metal at its highest was considerably below the saturation temperature of the steam, a condition which could only be explained by supposing the rate of condensation of steam on a surface to be limited by some physical property of steam itself, apart from the resistance of the condensed film of water. Interpreted in this manner, the experiments led at once to the conclusion that the rate of condensation at any moment was simply proportional to the difference of temperature between the saturated steam and the surface on which it was condensing.

The limit thus found was shown to be capable of explaining many of the phenomena of cylinder condensation in a rational manner, but the method by which it was established was of an indirect and somewhat intricate character, and appeared to require some simple and more direct confirmation.

If the rate of condensation of steam were really infinite, it should be possible by a suitable modification of the surface-condenser method (i.e., by getting rid of the water films on the outside of the tubes) to obtain values of the condensation considerably in excess of those given by the formula deduced from the temperature cycle observations.

To accomplish this it is necessary to eliminate as completely as possible the resistance to the passage of heat through the water films between the steam and the metal, and between the metal and the circulating water, and at the same time to measure as accurately as possible the temperature of the metal.

These conditions led to the form of apparatus which was employed. The resistance to the passage of heat from the metal to the condensing water in this apparatus is practically eliminated by employing a thick cylinder, 5 in. diameter and 2 ft. long, with a screw thread cut on its outer surface. Water from the high-pressure mains is forced to circulate round this surface with a very high velocity in the narrow space between the cylinder and the surrounding tube. In this manner it is possible to obtain a very uniform temperature for the external surface differing but little from that of the circulating water.

If the cylinder is made sufficiently thick, its temperature may be approximately determined at any depth by inserting mercury thermometers. It was intended at first to use thermocouples for this purpose, but the apparatus in this form would have been unsuitable for students' use in the ordinary course of laboratory work, which was one of the primary objects in view in the construction. It would also have been desirable to make the cylinder of nearly pure copper, which would have reduced the resistance of the metal to the lowest point. The authors were compelled, however, to content themselves for the time with cylinders of cast iron and mild steel.

The internal surface of the cylinder, upon which the steam was condensed, was a hole one inch in diameter, drilled in the solid metal. In order, as far as possible, to minimize the resistance of the surface film of condensed water, a revolving brush was constructed of very thin strips of steel to wipe the surface five or six times a second. This wiper was found to wear in a very short time to so perfect a fit, and the water film must have been so energetically stirred, that its resistance to the passage of heat must have been far less than that of the best conducting metal, when there was perhaps some small film present.

Under these conditions, if the rate of condensation of steam were infinite, it should have been possible to obtain a rate of condensation many times greater than the limit deduced from the cylinder condensation experiments above mentioned.

On making the experiment, however, it was found that the wiper made very little difference to the amount of condensation. With the wiper revolving at the rate of 160 per minute, the condensation was increased by about 5 per cent. on the average of several experiments. It may be concluded from this that the drops of condensed water with which the surface is partially covered are in such rapid motion that they do not appreciably obstruct the passage of heat from the steam to the metal. In fact, Prof. Callendar actually found that the drops increased the condensation. A film of the same average thickness, if it were absolutely quiescent, and if its conductivity, as generally estimated, were only one-hundredth of that of cast iron, would no doubt prove a serious obstacle; but, as a matter of fact, the viscosity of water at these temperatures is so small, and the motion so rapid, that the drops cannot be treated as a quiescent film.

The temperature at various distances from the inner surface of the cylinder was determined by means of mercury thermometers inserted to a depth of 8 in. or 9 in. in holes drilled parallel to the axis. From the temperatures so observed the conductivity of the metal and the temperatures of its inner and outer surfaces could be approximately inferred. It was found, however, that the presence of the holes interfered materially with the flow of heat through the metal, and that the readings of the thermometer under these conditions were not altogether trustworthy.

From a number of observations on the cast-iron cylinder a conductivity of 5.5 thermal units Fahr. per square ft. per minute per deg. Fahr. per inch was deduced, a result which agrees very closely with the authors' previous determination by a different method. For the steel cylinder a conductivity of 5.8 was similarly deduced. These results apply to a mean temperature of about 140 deg. Fahr., and are much lower than the values generally assumed for iron.

In order to verify the previous results as to the rate of condensation of steam derived from the steam engine experiments, the temperature of the inner surface of the metal was calculated on the assumption of a rate of condensation equivalent to 0.74 thermal unit Fahr. per second per square foot per deg. Fahr. difference of temperature. The values so found agreed with the observed temperatures within the limits of error of the observations. Owing to the inferior conductivity of the iron the test was not absolutely conclusive, as the difference of temperature between the steam and the surface rarely amounted to as much as 30 deg. With a cylinder of pure copper, and thermocouples for determining the temperature at a given depth, it should be possible to obtain a more certain confirmation by this method.

In performing the experiments a number of variations in points of detail were introduced from time to time. The flow of the circulating water was varied in velocity and directed in different ways. In order to secure uniformity in the distribution of temperature measured in different directions from the centre, the spiral circulation was found to be essential. In the second apparatus the screw thread was at first replaced by a baffle-plate, which was intended to direct the water into a spiral course, but the results found were unsatisfactory.

In some cases steam was admitted from the top of the apparatus and in other cases from the bottom. With the steam supply at the bottom, it was found that condensed water refused to drain down the vertical 1 in. tube in opposition to the current of steam, although the maximum velocity of the steam could not have exceeded 10 ft. per second.

The following set of observations, each of which represents the mean of several taken on similar conditions, will sufficiently indicate the general nature of the results:

The temperatures of the metal at distances of 1 in., 1.5 in. and

* Paper read before the Institute of Civil Engineers, London, England

1 in. from the axis of the bar were observed by means of mercury thermometers, which were very carefully centred by small iron washers in holes filled with mercury. The hole fitting the bulb of the thermometer was 3-16 in. in diameter. The other holes were 5-16 in.

It will be observed that in this particular set of experiments the temperatures at 1 in. in the metal, when calculated to agree with the assumed rate of condensation, are all too low as compared with those observed, whereas the temperatures similarly calculated at 1.5 in. are all too high. This might at first sight appear to indicate a very rapid diminution of the conductivity with rise of temperature; but after making various tests the effect was traced partly to the disturbance of the heat flow caused by the presence of the holes, and partly to differences of density of the bar in directions at right angles. The latter differences were not observable in the case of the cast iron.

The observations taken at different pressures do not indicate any marked difference in the rate of condensation per degree second. These results, so far as they go, are in agreement with the authors previous work, but they hope to obtain more conclusive evidence.

AN ELECTRICAL METHOD OF MEASURING THE TEMPERATURE OF A METAL SURFACE ON WHICH STEAM IS CONDENSING.

By H. L. Callendar, M.A., F.R.S., Professor of Physics, McGill University, Montreal.

Part II

The objects of the following experiments, which were made at the McDonald Physics Building with a different apparatus, was the measurement of the temperature of the metal surface itself by a more direct and accurate method. It was also desired to verify as exactly as possible whether the rate of condensation of steam at atmospheric pressure was the same as at the higher temperatures and pressures at which most of the preceding experiments were made.

The condenser used for these experiments was a very thin platinum tube, ¼ in. in diameter and 16 in. long. The thickness of the tube was only six-thousandths of an inch, and the greatest difference of temperature between its inner and outer surfaces at the maximum rate of condensation observed in the experiments could not have been greater than ¼ deg. cent.

The mean temperature of the metal itself was determined in each case by measuring the electrical resistance of that portion of the tube on which the steam was condensing. The author has had considerable experience in the employment of this method, which, moreover, is very easily applied if suitable apparatus is available.

The platinum tube was enclosed in an outer tube of brass or glass, and steam was admitted to the space between the two tubes. A steady current of condensing water was maintained through the platinum tube. The amount of condensation could be inferred by measuring the flow of water, and observing the difference of temperature between the inflow and outflow. In many cases the condensed water was also measured. Applying a small correction for radiation, the two methods always agreed with one-half of 1 per cent. The pressure of the steam in the outer tube, which was never far from the atmospheric, was observed by means of a mercury column.

The conditions of the experiment as to flow of water and steam, size and length of the external tube, etc., could be varied within certain limits. The following is a summary of the more interesting results obtained:

Condensation Results Summary Mild Steel Bar Water Removed.

Condensation Thermal Units per Square Foot Second.	Steam Temperature Observations.	Surface Temperature Calculations.	Difference, Steam and Surface.	Temperature in Metal at Distances. 1 in. Calculations.	1 in. Observations.	1.5 in. Calculations.	1.5 in. Observations.	2 in. Observations.	Conductivity, K.
	deg.	deg.	deg.	deg.	deg.	deg.	deg	deg.	
20 0	330	303	27	208	214	154	152	113	5.84
17 8	300	277	23	193	198	143	142	109	5.66
15 ½	274	253	21	179	184	136	134	103	5 81

1. With a short length of condenser and a very free escape of steam, the condensation observed was equivalent to 22.2 thermal units Fahr. per square foot per second, for a difference of temperature of 28.5 deg. Fahr. between the steam and the metal surface. This is equivalent to a rate of condensation of 0.78 thermal unit Fahr. per degree second, reckoned per square foot of the surface of the metal. This was the smallest value of the rate observed. The platinum tube was vertical, and the current of steam downwards, conditions which tended to keep the surface of the metal comparatively clear of condensed water.

2. With the same conditions, but with a length of tube nearly twice as great exposed to the steam, the condensation observed was 22.3 thermal units Fahr. per square foot per second, for a difference of temperature of 25.3 deg. Fahr. This gives a rate of 0.88 per degree second. The lower half of the tube was more thickly covered with water than the upper half, the steam also was full of flying spray, which may have assisted in conveying heat to the metal, and in maintaining the same rate of condensation on the lower half of the tube as on the upper half, in spite of the somewhat higher temperature of the circulating water in the lower half.

3. With the same arrangement, but with the steam current reversed and reduced until the escape was as gentle as possible consistently with keeping the tube full of steam and entirely excluding air, a somewhat larger rate of condensation was observed, namely, 23.6 thermal units Fahr. per square foot per second. The pressure throughout the tube was very nearly atmospheric, and the gentle upward current of steam tended to keep the tube very thickly covered with drops and rivulets of water. The difference of temperature was only 22.0 deg. Fahr., giving a rate of condensation of 1.07 thermal units Fahr. per degree second. This is equivalent to 2.25 watts (joules per second) per square centimeter per 1 degree cent., and was the largest value observed throughout the work. It would appear probable that the surface exposed by the drops is so much greater (in the present instance about twice as great) than the surface of metal, and the drops themselves are in such rapid motion, that the increase of surface, by facilitating condensation, more than compensate for any resistance which the water film may offer to the passage of heat to the metal.

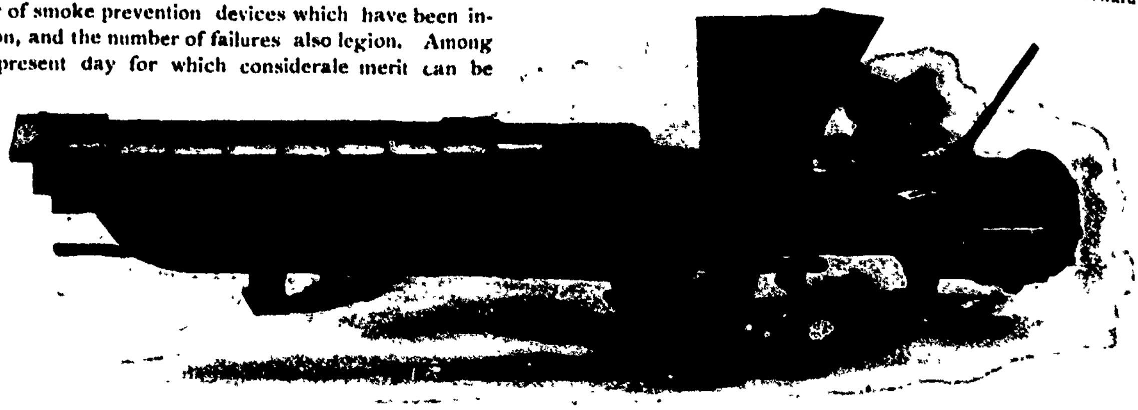
4. To verify this view the outer glass tube was replaced by a much smaller tube, so as to leave very little space for the steam current. The pressure of the steam was thus raised to nearly 4 in. of mercury above the atmospheric at the entrance of the tube, and the surface of the platinum was violently scoured by a spiral rush of steam and spray. Under these conditions the condensation observed was reduced to 19.2 thermal units Fahr. per square foot per second, instead of being increased as might naturally have been expected with so strong a current of steam. The effect of the energetic scouring of the metal surface was shown by a slight rise of temperature of the metal as compared with previous experiments. The observed difference of temperature between the metal and the steam in this case was 19.8 degrees Fahr., giving a rate of condensation of 0.97 thermal unit Fahr. per degree per second.

From these and similar observations in which the conditions of the experiments were varied to a certain extent in points of detail, it may be concluded that the presence of water on a metal surface may tend to increase rather than diminish the amount of condensation. The rate of condensation of steam at 212 deg. Fahr., allowing for the fact that in these experiments the surface was unduly increased by the presence and the motion of the water drops, would appear to be at least of the same order of magnitude as the value deduced from experiments on the cyclical condensation in the cylinder of a working steam-engine, in which the temperature of condensation varied from 290 degrees to 330 degrees Fahr., and the rate deduced was 0.74 thermal unit Fahr. per square foot per degree per second. Since, however, it is impossible that the latter value was diminished to an uncertain extent by a slight film of grease on the hot and dry surface, and since the value deduced from the suface condenser method is, perhaps, a little too large, owing to the presence of the water film, it would be unsafe to conclude that the rate of condensation is the same at different temperatures, although the evidence, so far as it goes, appears at present to point in that direction. Comparing the three different methods of experiment, which all lead to a similar result, it may be regarded as highly probable that the old view of an infinite rate of condensation requires revision, and that the value of the rate of condensation of steam on a metal surface, as determined by the author's previous experiments, is at least a first approximation to the truth. The question at issue is one of fundamental importance in the theory of the steam engine, and the authors have shown in the paper already quoted that, if the law of condensation there proposed be admitted, a number of interesting practical deductions can be made, and problems may be solved which have not hitherto been regarded as amenable to other than empirical treatment.

THE JONES' UNDERFEED MECHANICAL STOKER.

It is over 100 years ago since the first mechanical stoker was made. In 1785 James Watt patented a device for pushing the coal from the front end of the grate, after it was coked towards the bridge wall. It was worked by levers and the prime object was to prevent smoke when using bituminous screenings. Since then the best inventive genius in the world has been striving to perfect a smokeless furnace.

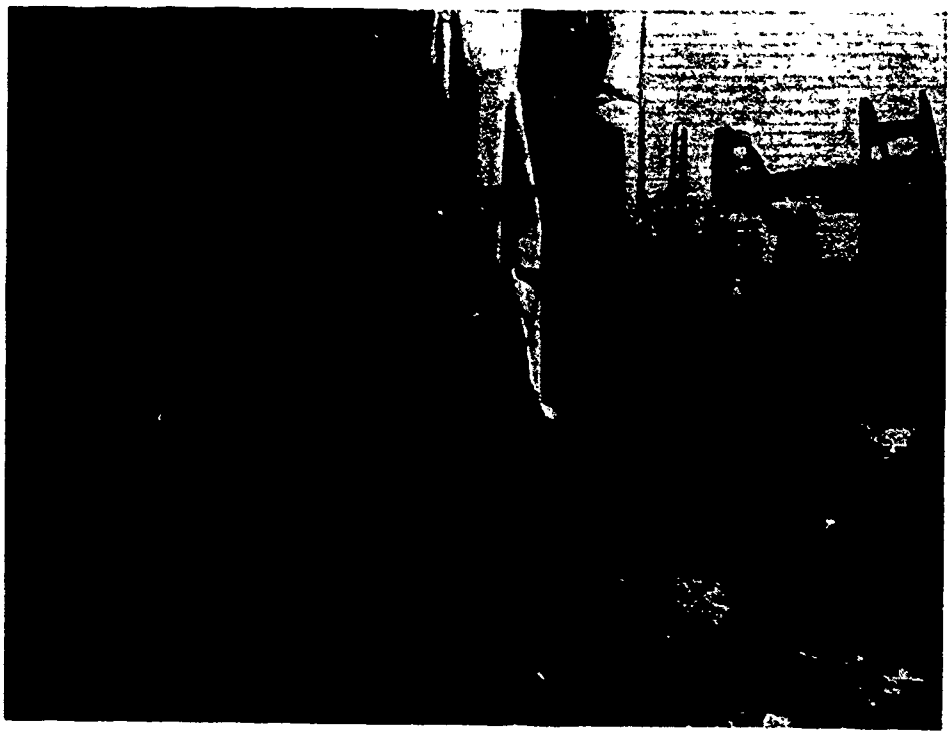
The number of smoke prevention devices which have been invented is legion, and the number of failures also legion. Among those of the present day for which considerale merit can be claimed is the Jones' Underfeed Mechanical Stoker, which is said to be a truly smokeless and economical device, and one which meets the demand for economy which is now so essential in all power plants where steam is used. To give our readers a better understanding of this invention we give some illustrations herewith, as well as some particulars of its construction, operation and application.



Improved Jones' Underfeed Mechanical Stoker.

The stoker consists of a steam cylinder or ram, with hopper for holding the coal, outside the furnace proper, and a retort or fuel magazine, inside the furnace, into which the green fuel is forced by means of the ram; Tuyere blocks, for the admission of air, being placed on either side thereof; the retort containing at its lowest point, and at a point where the fire never reaches, an auxiliary ram or pusher by means of which an even distribution of the coal is obtained.

By means of the rams coal is forced underneath the fire, each charge of fuel raising the preceding charge upward, until it reaches the fire, which point it does not reach until it has been coked, when in its coked state it is forced upward into the fire. The gases being liberated under the fire, and at that point mixed with air, must necessarily pass through the fire and be consumed, thus giving the benefit of all combustible matter in the fuel.



Terauley Street Station, Toronto Electric Light Co.

Air is forced, at a low pressure, through the Tuyere blocks, under the burning fuel, by means of a blower, operated by an independent engine, or from a line shaft, if such arrangement can be made.

As to the operation of the stoker: We will suppose that the furnace is being fired without steam in the boiler. The retort is first filled with coal, level, or a little above the tuyere blocks. Fire is then started by placing kindling or greasy waste, lighted, along each side of the retort and opening wide the air chamber reaching to the tuyere blocks. As soon as sufficient steam is raised to run the blower, air chamber opening is closed, blower is used for furnishing air, and fire will be built up very rapidly.

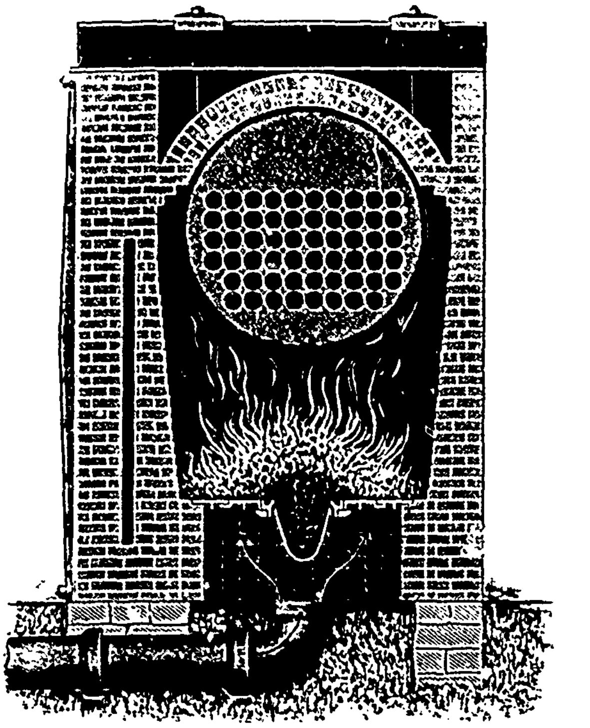
Coal being in the hopper, and the ram plunger at its forward stroke, when more coal is needed the ram plunger is shifted by moving the lever; coal then falls in front of plunger and upon return movement is forced into the retort, this movement being repeated until sufficient fuel is in the retort. After fire is properly started, never make more than two charges of the ram at a time, as by so doing green coal is forced into the fire, which will produce imperfect combustion and consequently smoke.

Air, at low pressure, being admitted into the air chamber and through the tuyere blocks, over the top of the green fuel in the retort, but under and through the burning fuel, the result is that the heat from the burning fuel over the retort slowly liberates the gas from the green fuel in the retort. This gas being thoroughly mixed with the incoming air before it passes through the burning fuel above, results in a bright clear fire, free from smoke, and the complete consumption of all the heat producing elements in the fuel. The retort being air tight from below, and the fuel being in a compact mass in the retort, the air will find its way in the direction of the least resistance, which is upward, consequently combustion takes place only above the air slots, hence the castings of the retort are always cool and not subject to the action of the fire. The incoming fresh fuel from the retort forces the resulting ash and clinker over the top of the tuyere blocks on to the side plates, from whence they may be removed at any time without in the least interfering with the fire in the centre of the furnace, resulting in a high, even temperature at all times.

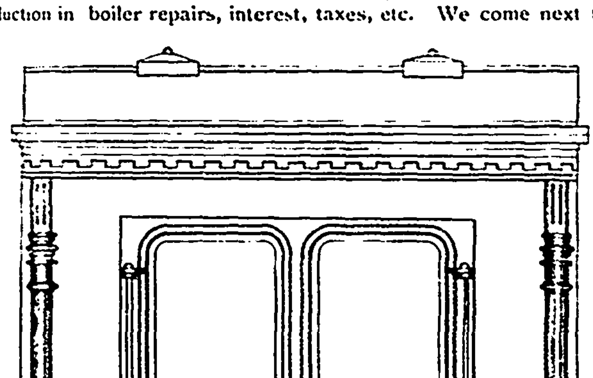
To secure the best results a heavy body of coke should at all times be carried in the furnace, as nearly like the illustration as possible. The amount of coal consumed is regulated entirely by the quantity of air forced in the furnace, so that when little steam is needed the quantity should be reduced.

The Jones' stoker may be applied to practically all types of boilers. It will also burn any kind of bituminous or lignite, slack or screenings, with a substantially smokeless stack. The manufacturers claim that competitive tests have shown a difference between the stoker and ordinary hand firing of from 20 to 35 per cent. in favor of the stoker.

Another advantage claimed for the device is that it removes the necessity of high chimneys, and is therefore economical. To illustrate, let us consider the difference in cost between two power plants, say of 2,000 h. p., one with high chimney, natural draft, and plain furnaces, and the other fitted with the Jones' Underfeed Mechanical Stokers. The cost of the first plant, exclusive of the building, would be approximately (ten boilers, including setting, $36,000, and the chimney, say 100 feet high by 7 in diameter) $40,500. In the second plant it is necessary to put in only eight boilers to get the same results as far as power is concerned, leaving out of the question for the present the increased efficiency, and a short stack of from twenty to thirty feet high being sufficient The cost of the eight boilers, including the setting, would be $28,800, and this, together with the stokers and the chimney, makes a total of $35,800, or a saving in the first cost of $4,700, which is more than the cost of the chimney. There is also a reduction in boiler repairs, interest, taxes, etc. We come next to the saving of coal. Taking the plant as above specified, ten boilers burning say 400 pounds per hour each, amounting to twenty tons per day of ten hours, with hand firing, against eight boilers burning the same quantity per boiler per hour for the same results = sixteen tons daily, or a daily saving of four tons, equal to over $3,000 yearly. We have, therefore, a saving in first cost of $4,700, and a yearly saving of over $3,000.



Cross Section Showing Furnace in Operation.



Size of Opening in Boiler Front to Receive the Jones' Stoker.

Engineers and others who wish to learn more of this invention should address the manufacturers, the General Engineering Company of Ontario, Limited, 80 Canada Life Building, Toronto They have recently issued a hand-book descriptive of the stoker, in which are also found many valuable tables and other useful data.

SPARKS.

A. McDonald, electrician, New Denver, B C., is reported to have gone out of business.

The incorporation is announced of the Rotary Engine Company, of Woodstock, Ont., with a capital of $24,000.

The Hull Electric Co. are building a 400 foot water chute at Aylmer Park, which it is expected will prove a great attraction during the summer months.

The Chateau Frontenac Hotel in Quebec is now heated by four Babcock and Wilcox boilers, which have been installed in the new wing recently completed.

The city council of Halifax, N. S., is now discussing the question of installing a municipal electric light plant. The matter has been referred to the electrician for a report.

The Dawson City Electric Co. is applying for incorporation to supply electric light, heat and power throughout the city and within a radius of 200 miles, as well as to operate an electric tramway.

The Canadian General Electric Company have closed the contract with the Laurentide Pulp Company, at Grand Mere, Que., for two 55 kilowatt moderate speed current dynamos, with marble panels and instruments complete.

A special meeting of the Merchant's Telephone Company was held in Montreal last month, at which it was announced that the company had obtained authority to increase its capital to $1,000,000. The annual meeting will be held on the second Thursday in April.

The London Electric Company are increasing the generating capacity of their station to meet the large demands for light and power, and have placed an order with the Canadian General Electric Company for one of their standard 300 kilowatt single phase alternators and two 160 K. W. direct-connected power generators of their latest type.

The Montreal Cotton Company, of Valleyfield, Que., have just placed an order with the Canadian General Electric Company for two 600 H P. three phase generators, to be direct-connected to turbines. This installation is a duplicate of the generators installed by the Canadian General Electric Company over a year ago. With these four generators and station apparatus the company will have one of the most modern power stations on this continent.

The Hull Electric Company is suing the Ottawa Electric Co. for damages and infringements of the charter granted by the city council of Hull in 1894, by which the Hull company were granted the exclusive privilege for electric lighting. The Ottawa company contend that their right to erect poles within the city of Hull, for lighting purposes, was expressly guaranteed to them by a by-law passed by the city council six years previous to the Hull company's charter. The case is being bitterly fought.

At the annual meeting of the Lachine Rapids Hydraulic & Land Co., held in Montreal recently, the financial statement for the year ending December 31, 1897, showed that in the last two months sufficient revenue had been earned to pay the interest of 6% on the six months bonds. Over 1,000 customers were on the line, and in the neighborhood of 25,000 lights had been installed. It was announced that a five years' contract had been signed with the Imperial Light & Power Company, by which power for lighting, etc., would be supplied by the Lachine Company, and used for lighting the east end. A contract had also been signed with the Standard Light & Power Co., to supply them with power for straight current purposes, and, in turn, the Standard Company had acquired the entire plant, franchise and business of the Temple Electric Co., and would take possession on May 1st

The telegraph line to be built by the C.P.R. between Montreal and Vancouver, referred to in a recent issue, will cost $250,000. The wire to be used will be of copper, 300 lbs. to the mile, and will weigh about 450 tons. It is being manufactured by the Dominion Wire Manufacturing Co., of Lachine, Que., and will be tested at McGill University under the direction of the officers of the company. Mr. Jas. Kent, the Montreal superintendent of the company, gives some interesting details regarding the construction of the line. The short pieces of wire which will be used to tie the telegraph wires to the insulators will have a total weight of 6½ tons. Allowing two inches slack between each pole, owing to it being impossible to draw a line perfectly straight, will add four miles of wire to the line between Montreal and Vancouver. Leaving a small bundle of wire with each lineman for repairs will use up 20 miles of wire. The joints, which it is necessary to make at the end of each bundle, will require one mile of wire.

Mr. H. R. Leyden, manager of the Cataract Power Co., has made a proposition to pump the water supply of the city of Hamilton, Ont., by electric power. He agrees to erect at the beach pumping house electric motors and revolving screw pumps of sufficient capacity to pump 10,000,000 gallons per day, and to erect at the high level pumping house motors and pumps and supply sufficient power to pump from the mains to the high level reservoir 2500 gallons per day. The company will keep the pumps in operation for one month, when the city will be expected, if satisfactory, to pay for them at the ascertained cost, not to exceed $25,000 The price to be paid by the city for electric current necessary for pumping the water required is placed at $13,000 per year for the first 1,600,000,000 gallons pumped in both reservoirs, and 6c cents for each additional 100,000 gallons. The company claims that its offer will meet the requirements of the fire underwriters and save the city more than $20,000 per year.

EDUCATIONAL DEPARTMENT

INTRODUCTORY

After mature deliberation the publisher of this journal has decided to devote a certain amount of space each month to what may be termed an Educational Department, wherein both mechanical and electrical formula and mathematical problems will be discussed, illustrated, and as far as possible rule and example given. At the request of the editor, I have with pleasure undertaken to contribute to this department regularly each month, and before discussing actual mathematical problems, wish to briefly introduce the subject at issue.

The primary object of this department is chiefly to increase the value of an already valuable paper, by placing in the hands of every engineer who has any knowledge of the rudimentary principles of mathematics, such matter as will enable him by a little study to master the most intricate mechanical and electrical formula. Many of our most valuable engineering works and publications from time to time contain formula that is in many cases but vaguely understood, and very often entirely misunderstood, thus rendering an otherwise valuable work practically valueless to the reader.

Just at what particular point our calculations should commence became a matter of serious thought, and past experience had to be carefully considered, bearing in mind the fact that there are many really good engineers whose early education has, through force of circumstances, been deficient, and many others who, through lack of opportunity, have not been able t review their early education for years. Knowing by observation and experience the great necessity of having a thorough elementary education before attempting to digest and calculate problems, and the almost utter impossibility of the student arriving at a satisfactory conclusion of his studies without a thorough knowledge of the principle of mathematics involved, I have decided to commence at a point and carry out the programme outlined in this journal—commencing at the foundation and advancing by easy stages until the principles underlying the most obtuse and difficult formula can be readily explained and easily understood. The advantages to be derived from an education of this kind, coupled with practical mechanical ability, is too well understood to require comment.

The programme which has been outlined for the succeeding nine months will embrace:

DECIMAL FRACTIONS—Definitions and explanation of principles of, and method of reduction to common frections, and vice versa.
SQUARE AND CIRCULAR MEASURE—Definition and explanation and practical demonstrations of.
CUBICAL AND CYLINDRICAL MEASUREMENTS—Definitions and explanations of, with practical hints.
SQUARE AND CUBE ROOT—Definitions and explanations of.
SAFETY VALVE CALCULATIONS—(Spring and Lever Types)—Principles of, with practical demonstrations.
BOILER CONSTRUCTION—Stays, rivets, joints and seams, iron and steel plate—strength of, with formula and practical demonstrations.

It is not the intention to fill these columns with a mass of figures hastily compiled without reference to any particular object; on the contrary, every problem will be carefully thought out, and only such information given as will be of use to you, and an effort will be made, based on experience and a knowledge of the requirements, to make his series of tests complete in every particular.

W. A. THOMSON.

(ARTICLE XII.)

REQUIRED SIZE OF LEADS IN CIRCULAR MILS.

A MIL is $\frac{1}{1000}$ of an inch, and written decimally .001. The area of a circle $\frac{1}{1000}$ of an inch in diameter is termed a circular mil, and a great many wire tables express the area of the cross section of a wire in circular mils written symbolically C. M. Rules for the sizes of wires as met with in engineering practice for given resistances are often based on circular mils, and include a constant for the conductivity of material of which wire is composed. From this, then, we can construct a formula for the calculation of the resistance of wire of whatever material composed, so long as we know the specific resistance of the material.

Commercial copper wire of 90% purity, one foot long and one C. M. in cross section, is said to have a resistance of 10.79 ohms at 75° F. (approximate). In accordance with the rule that the resistance of a circular conductor varies inversely with the square of its diameter and directly with its length, we can construct the following well-known formula for the determination of resistance of copper wire:

$$R = \frac{10.79 \times L}{d^2}$$

Example (10): A commercial copper wire one-half an inch in diameter has a specific resistance of 10.79, what is the resistance per foot?

½ inch = .500 mils.
$.500^2$ = .250,000.
10.79 ÷ .250,000 = .000043 ohms per foot.

Example (11): A copper wire 5,000 feet long, with a cross section of 8,000 C.M., what is its resistance?

$$\frac{10.79 \times 5,000}{8,000} = 6.743 \text{ ohms.}$$

The required cross section of a wire in C. M. is equal to its length divided by its resistance and multiplied by 10.79, or

$$C.M. = \frac{L}{R} \times 10.79$$

The required cross section of a pair of leads in C.M. for a given drop is found to be equal to the product of the length of leads multiplied by number of lamps (in parallel) by 21.58 by 100, minus the percentage of drop, and the whole divided by the resistance of one lamp hot multiplied by the percentage of drop allowed.

$$C.M. \text{ or } d^2 = \frac{L \times 21.58 \times N \times 100 - \%}{R \times \%}$$

or what is the same thing,

$$C.M. = \frac{10.79 \times 2 \times L \times N}{R} \times \frac{100 - \%}{\%}$$

Example (12): Ten lamps are to be placed in multiple at the end of a double lead 100 feet long. The resistance of each lamp when hot being 220 ohms, what must be the sectional area of the wire if a drop of 5% is allowed on E.M.F.?

$$\frac{21.58 \times 100 \times 10}{220} = 98 \times \frac{100 - 5}{5} = 1872 \text{ C.M.}$$

Based on this and following out the principles laid down in Ohm's Law, the following formula is often given as a ready means of determining the required size of wire for house or secondary incandescent circuits:

$$C.M. = \frac{21.58 \times L \times N \times C}{L\,v}$$

Where C.M. = Area in circular mils.
" L. = Length of one side of lead.
" N. = Number of lamps.
" C. = Current required by each lamp.
" L v = Number of volts per lamp loss in line.

When lamps or groups of lamps or other appliances are placed at different distances from the generator, apply principles laid down in example; or, roughly stated, determine first the size of wire required for each lamp or group, as if on independent circuits, starting from the dynamo, then combine all wires running in same direction.

DETERMINATION OF THE MEAN PRESSURE THROUGHOUT THE STROKE WHEN USING STEAM EXPANSIVELY.

Considering recent advances in modern engineering and improved appliances at hand, an article on this subject is perhaps superfluous. There are, however, such important principles involved and such useful information obtainable, that the author feels justified in referring to the subject at short length. Since a large proportion of my readers are operating simple non-condensing engines, the author will deal particularly with this class, and the principles involved can then be readily applied to compound engines of any type.

The engines to which many of us were first introduced had what is styled a fixed "cut-off," which took effect at almost any point between start and finish of piston travel, according to the views the engineer held on the question of working steam expansively. And speed was controlled by means of a throttling device, arranged to reduce or raise the pressure against the piston as occasion required. This type in modern practice is nearly obsolete, and we have in its stead what is termed an automatic "cut-off" engine, arranged to take steam at beginning of stroke at full boiler pressure, and regulating its speed by means of a variable "cut-off"—that is, initial pressure against piston on admission remains constant and varies only as pressure on boiler varies;

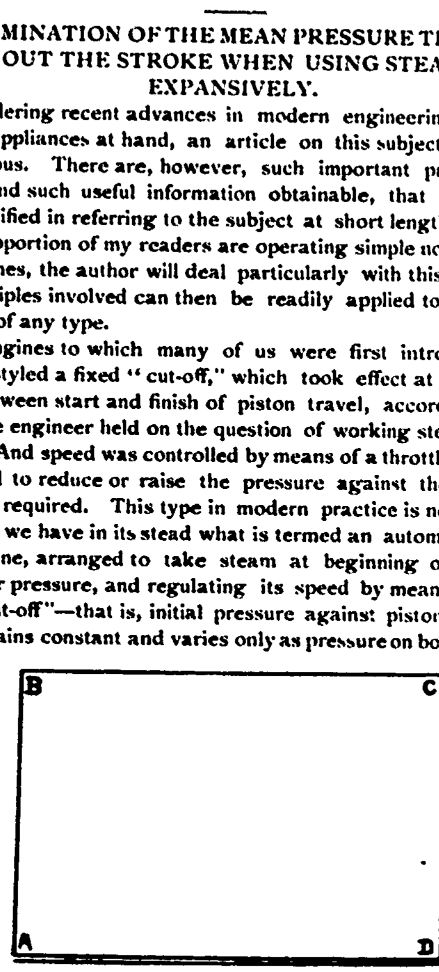


FIG. 5.

—and this pressure is maintained against the piston as it travels within the cylinder to a point of the stroke varying in direct proportion as the load on the engine varies.

Theoretically, then, if we had no cut-off until admission valve closed at the end of the stroke, the pressure of the steam against the piston would remain the same, and a diagram representing the operation could be drawn as represented in Fig. 5, within the letters, A, B, C, D, and the pressure against the piston can be readily ascertained by a simple process at any point of the stroke, and the mean, initial and terminal pressures would at all times be equal, and the mean effective pressure would be initial pressure minus back pressure, and could be equally as readily determined.

Let us now suppose that when the piston has reached a point equal in distance to one-third of its travel, the admission valve closes and cut-off takes place; the piston then travels the remaining two-thirds of the distance by the expansive force of the steam already admitted, and supposing that expansion would take place under isothermal conditions, that is, that the temperature of steam remained constant, it is clear that as expansion increases pressure decreases, consequently the terminal pressure of the steam will be very much less than the initial pressure, and that at any point in the stroke between one-third and the end, the pressure will be less than the point immediately before and higher than the next succeeding point. If, then, we know the initial pressure of our steam and the point of cut-off, and can by any means determine the pressure at the respective points of the stroke, we can by finding the mean of these pressures thus determine the mean pressure on the piston. For this purpose, then, we re-arrange Fig. 5 as illustrated in Fig. 6, and divide this into

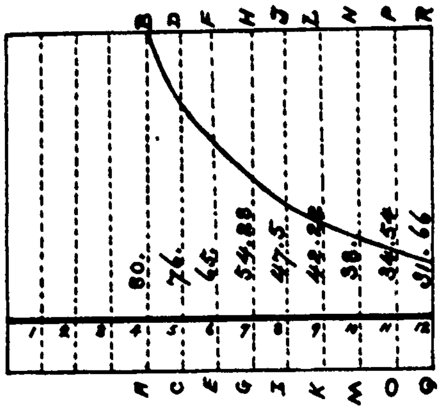


FIG. 6.

any even number of points, taking care that one of these points shall coincide exactly with and intersect point of cut-off.

To do this we first divide the cylinder into an equal number of parts by subtracting the numerator from the denominator of the point of cut-off expressed as a fraction, and if the result is an even number above six, the denominator of the fraction is the number of equal parts into which the cylinder can be divided so that one of the ordinates will exactly intersect the point of cut-off.

Example: With steam cut off at $\frac{3}{15}$ of the stroke, what number of parts must the cylinder be divided into?

As per rule, $15-3=12$—an even number above six—therefore cylinder must be divided into 12 equal parts. It will, however, very frequently be found that when the numerator is subtracted from the denominator that either an odd number or an even number less than six is the result. In either case, double, treble or quadruple both the numerator and the denominator, and if this does not answer, increase fraction until you get a fraction giving the desired result.

Example: Suppose steam is cut off at $\frac{1}{3}$ stroke, into how many equal parts must cylinder be divided?

Proceeding as per rule, $3-1=2$, an even number less than six, which will not answer.

$\frac{1}{3}\times\frac{2}{2}=\frac{2}{6}$, which is still too low; we continue the process until we reach

$\frac{1}{3}\times\frac{4}{4}=\frac{4}{12}=12-4=8$, an even number higher than 6, and cylinder can then be divided into 12 equal parts.

Fig. 6 then represents a cylinder, and we proceed to divide into 12 equal parts, with cut-off taking place at $\frac{1}{3}$ of the stroke. Each of the dotted ordinates in this diagram then represents the position of the piston expressed in $\frac{1}{12}$ths of piston travel. Point of cut-off, or $\frac{1}{3}$ of stroke, will equal 4 of these parts, and the pressure of steam at 1st, 2nd, 3rd and 4th positions of piston remains constant.

When piston is in position, A, B, at 4, cut-off takes place, and at Q, R, exhaust valve opens. If steam then was expanding under true isothermal conditions, the lines, c, d, e, f, g, h, etc., show the gradual decreasing pressures of the steam due to expansion and pressures represented by letters, A, B, Q and R, show the total value of the steam during expansion.

To find the pressure of the steam at any one of the positions of the piston during expansion, multiply absolute initial pressure of steam by number of ordinate at point of cut-off, and divide this result by the number of ordinate at which pressure is desired.

Example: With steam admitted at 80 lbs. gauge pressure, find the pressure at each of the ordinates in diagram.

$80+15=95$, absolute pressure.

$95\times4=380$, value of steam previous to cut-off.

Then pressure at C D $=\frac{380}{5}=76.$ pounds.
" " " E F $=\frac{380}{6}=65.$ "
" " " G H $=\frac{380}{7}=54.28$ "
" " " I J $=\frac{380}{8}=47.5$ "
" " " K L $=\frac{380}{9}=42.22$ "
" " " M N $=\frac{380}{10}=38.$ "
" " " O P $=\frac{380}{11}=34.54$ "
" " " Q R $=\frac{380}{12}=31.66$ "

To find total value of steam during expansion we require to find area of space enclosed by A, B, Q and R.

For this purpose we adopt the Simpson rule, which is: To the first and last ordinates add four times the sum of the even ordinates and twice the sum of the odd ordinates; one-third of this sum equals the area.

Then 4 or A B =		95	pounds.
5 or C D = 76	× 4 =	304	"
6 or E F = 65	× 2 =	130	"
7 or G H = 54.28	× 4 =	217.12	"
8 or I J = 47.5	× 2 =	95	"
9 or K L = 42.22	× 4 =	168.88	"
10 or M N = 38	× 2 =	76	"
11 or O P = 34.54	× 4 =	138.16	"
12 or Q R =		31.66	"
	3	1255.82	
Value during expansion,		418.60	"

Before expansion, 380 pounds.
During " 418.60 "

Value during whole stroke, 798.60 "

If, now, we divide by number of ordinates used, we get mean pressure against the piston throughout the stroke.

$798.60\div12=66.55$ pounds.

If the engine piston was running against a perfect vacuum, then mean pressure throughout the stroke would be the mean effective pressure on which to calculate power developed by any engine in doing work, but this rarely, if ever, happens; therefore the absolute back pressure against the piston must be deducted, and we get

Mean pressure − back pressure = mean effective pressure.

Example: Find mean effective pressure on the piston of a non-condensing engine when mean pressure is 66 pounds per square inch and back pressure two pounds above the atmosphere.

$2+15=17$ pounds absolute back pressure, and $66-17=49$ pounds mean effective pressure of steam on piston.

When principles of calculation are understood, formula for calculation can be considerably shortened by use of logarithms.

1st. The hyperbolic logarithm of the ratio of cut-off increased by 1 and multiplied by terminal pressure equals mean pressure.

2nd. The hyperbolic logarithm of the ratio of cut-off increased by one and multiplied by initial pressure, and result divided by ratio of cut-off, equals mean pressure.

3rd. Second rule minus absolute back pressure equals mean effective pressure throughout the stroke.

Example of Rule 1: Cut-off takes place at $\frac{1}{3}$ of stroke; the ratio of cut-off therefore is $3\div1=3$, and the hyperbolic logarithm of 3 is 1.09861,

$\therefore$ $1.098+1\times31.6=66.39$ pounds, mean pressure.

Example of Rules 2 and 3:

$$95\times\frac{1.098+1}{3}=66.4 \text{ pounds, mean pressure.}$$

$$95\times\frac{1.098+1}{3}-17=49.4 \text{ pounds, mean effective pressure (M.E.P.)}$$

In addition to finding the mean pressure by process of calculation, we require also to find the mechanical efficiency gained by cutting off steam in comparison to steam being admitted during the whole of the stroke. This can be found by dividing the mean pressure by the terminal pressure absolute. Then $66.4\div31.6=2.098$; or expressed briefly, the mechanical efficiency is the hyperbolic logarithm of the ratio of cut-off plus 1.

Finally, on this subject, we want to find the co-efficient of efficiency or a number expressing the practical efficiency of the steam, including the effect of expansion as compared with the duty of the same steam without cut-off or expansion and loss by back pressure.

Rule:

$$\frac{\text{Mean effective pressure}\times\text{Length of stroke}}{\text{Absolute pressure}\times(\text{Length of admission}+\text{Clearance})}=\text{The co-efficient of efficiency.}$$

Example: Find the co-efficient: Gauge shows 80 pounds; stroke 12 inches, cut-off taking place at $\frac{1}{3}$ of stroke, and mean effective pressure is shown to be 49 pounds, piston having $\frac{1}{4}$ inch clearance.

$80+15=95$, absolute pressure.

$$\therefore\ \frac{49\times12}{95\times(4+.25)}=\frac{588}{403.75}=588\div403.75=1.45 \text{ co-efficient.}$$

ELECTRIC RAILWAY DEPARTMENT.

DOVER MUNICIPAL ELECTRIC TRAMWAYS.

We have been favored with a copy of a pamphlet containing an illustrated description of the Dover Municipal Electric Tramways, constructed by Messrs. Dick, Kerr & Company. It will be remembered that about one year ago Mr. J. A. Rutherford resigned his position as chief engineer of the Canadian General Electric Company to accept the management of the electric traction department of this well-known engineering firm.

The city of Dover was one of the first in England to adopt electric tramways on the overhead wire system. The pamphlet states that when, early in 1896, the Council was considering the question of railway construction, a comparison of the capital cost of building tramways for gas and electric traction was given as follows:

	Gas.	Electricity.
Cars (capacity 40 passengers)...	£5,600	£ 4,620
Trailers..	660	660
Machinery....	1,750	....
Line equipment..	..	7,500
	£8,010	£12,780

For working the respective systems offers were made of 6½d. per car mile for gas, and 6d. for electricity, the latter to be reduced to 4½d. if the mileage exceeded 240,000 car miles per annum. The saving of a half penny per car mile, it was considered, would much more than pay the interest on the larger capital required for construction.

The road was constructed during the fall of 1896 and following spring and summer. The rails used are of the girder type, weighing 87 lbs. per yard, and are 30 ft. long and 6 in. deep. The gauge of the tramway is 3 ft. 6 in., which was determined by the extraordinary deference of the framers of the Tramways Act of 1890. With the exception of a short distance the tramway is single track. The conducting system is of the usual character.

Owing to the shortness of the line, it being only about 3½ miles, no feeders were provided. The current is distributed from a central switch pillar, about 4 feet high, of cast iron, and divided internally into two chambers. The rolling stock consists of eight motor cars and two trail cars. Power is obtained from the Dover Electric Supply Company. The fare charged is only one penny.

ELECTRIC RAILWAYS AND BICYCLES.

Major I. B. Brown, in making his annual report on the street railways of Pennsylvania, states that the receipts of the state street railways have considerably fallen off within the past twelve months. He regards the use of the bicycle by both business people and pleasure seekers as the main source of the reduction in the traffic of many street railway companies. He finds that in cities where the hills are steep and less favorable conditions for bicycle riding exist, the railway companies have not been affected by it to the same extent, but in many places it cannot be gainsaid that the bicycle has become a most formidable competitor of the street railway. In order to secure substantial confirmation of this view an observation was made in a leading street of Harrisburg about two months ago. The observation covered two days, from 7 o'clock in the morning to 6 in the evening. During that time 6,078 persons passed a given point, 1,962 in the cars and 4,116 on bicycles, i.e., 67.7 per cent. on bicyles and 32.3 per cent. on the cars, or more than two to one in favor of the wheel. The figures secured at Harrisburg are by no means exceptional.

The Toronto Street Railway Co. purposes carrying out a number of extensions this season. It is probable that the line will be extended to Oakville, and also that the City and Suburban Electric Railway will be purchased and operated as a separate road, as is now done in the case of the Mimico branch. The City and Suburban Company have 12 miles of rail laid between Toronto Junction, Weston and Lambton.

TORONTO RAILWAY COMPANY'S ASSESSMENT CASE.

The long-standing litigation over the assessment of the poles, wires and tracks of the Toronto Railway Company was settled last month by the Court of Appeal, judgment being given in favor of the city.

When the city made the assessment on Ward 1 last year, the company appealed to the Court of Revision, which sustained the assessment. Then the company appealed and brought the matter before a bench of three judges, composed of Judge McDougall, County Judge of York, and the senior judges of the adjoining counties, Dartnell, of Ontario, and McGibbon, of Peel, who decided in favor of the company, Judge McDougall dissenting. In the meantime the Assessment Department went on and assessed the poles, wires, etc., of the company in the other wards of the city, and in each case the company appealed to the Court of Revision against the assessment, the Court of Revision, in view of the judgment of the three judges in the case of Ward 1, sustaining the appeal of the company. This placed the city in the position of being the appellant against the decision of the Court of Revision, and an appeal was taken to Judge McDougall, it being deemed unnecessary to call in the other two judges in this instance. Judge McDougall, after hearing argument, reversed the decision of the Court of Revision and held that the company was liable for assessment. Then the company appealed from this decision to the Court of Appeal, with the above result.

By the decision the assessment of $452,277 against the company in Wards 2 to 6 is confirmed for 1898, which will probably yield between $7,000 and $8,000 in taxes. Next year a further addition to this assessment of about $85,000 for the First Ward will be made, making a total assessment of about $540,000.

SPARKS.

The International Radial Railway Co. will apply to parliament for an extension of time for the completion of its line to Guelph.

The Halifax Electric Tramway Company will spend about $50,000 in improving their plant. They have just installed two large generators.

Lowe & Farrell, of Hamilton, have been given the contract for stringing the power wire from Decew Falls to Hamilton, for the Cataract Power Company.

Messrs. Peters, Peters & Ings, on behalf of the local gas company, have made a proposition to the city to build a street car system in Charlottetown, P.E.I.

It is reported that Messrs. A. Tremblay & Frere, of Herbertville, Que., have purchased property at St. Alphonse with a view of constructing an electric railway there.

The Smith's Falls, Rideau and Southern Electric Railway Company applied at a recent meeting of the Smith's Falls council for permission to lay rails and erect poles in that town.

E. F. Hutchings, of Winnipeg, and others, ask power from the legislature to construct an electric or steam railway from Winnipeg along the east side of Red river to St. Andrew's rapids.

At the annual meeting of the Sandwich, Windsor and Amherstburg Electric Railway Company, the statement of receipts presented showed a marked increase over those of the previous year.

A by-law has been given its first reading in the St. Catharines city council authorizing the construction of an electric railway between that city and Port Dalhousie. Mr. H. C. Symmes is interested.

The projectors of the Hamilton, Chedoke and Ancaster Electric Railway Company state that the line will be built from Hamilton to Brantford, providing the city council buys the Mountain Drive for $12,000.

H. Abbott, of Vancouver, William Whyte, of Winnipeg, and others, have petitioned the provincial legislature for the incorporation of the Mountain Tramway and Electric Company, to construct an electric railway.

The Halifax Chronicle says that the electric tramway scheme from Halifax to Bedford, N.S., has been killed, so far as the Halifax and Bedford company is concerned. Their charter has been amended so as to enable them to build a tramway only from Three Mile House to Bedford, and to supply electric lighting between the same two points.

The Council of Peterboro', Ont., again discussed at a recent meeting the proposed extension of the electric railway to Chemong and Lakefield. The promoter of this road is Mr. D. A. Starr, of Cornwall, who estimates the cost at $350,000. The council resolved to submit a by-law to the ratepayers to guarantee interest on one-third of the company's expenditure for 10 years at 5 per cent., the sum guaranteed not to exceed $100,000.

By an agreement entered into upon the commencement of the road, Mr. J. H. Beemer had a two years' option for the purchase of the Quebec Street Railway. It is now said to be his intention to purchase the road, and to consolidate it with the Quebec, Montmorency and Charlevoix Railway. The motive power of the latter road will at once be converted from steam to electricity. Later on the extension of the Quebec, Montmorency and Charlevoix will be made to Murray Bay.

Mr. A. H. St. Germain gives some particulars of the proposed auto-car service to be established this summer between Toronto and Richmond Hill. The initial car will be a passenger and parcel van, capable of receiving 25 passengers. It will be fitted with electric light and buttons for use of conductor and passengers, by which warning may be given the motorman to turn to the right or left. Mr. Germain claims that the car will develop sufficient power to ascend the heavy grades between Toronto and Richmond Hill, at a speed varying from 6 to 12 miles per hour, carrying a full complement of passengers. The electrical equipment is the invention of Mr. W. J. Still, mechanical engineer.

TRADE NOTES.

The Perth Water Works Co. is installing two-phase "S.K.C." motors.

A. Gagnon, Victoriaville, Que., are adding one of the Jenckes Machine Co.'s standard boilers to their equipment.

Henry Morgan & Co., of Montreal, have placed an order with the Royal Electric Co for a 20 K.W. direct current generator.

The Canadian General Electric Company have sold to Mr. Alex. Dobson, of Beaverton, one of their standard 20 k. w. Edison dynamos.

Messrs. Ness, McLaren & Bate, electrical supplies, have recently removed their factory and salesrooms to 419 St. James street, Montreal.

Larkin & Sangster, contractors, Iroquois, Ont., have purchased from the Canadian General Electric Company a 35 light arc dynamo, with lamps.

The Brantford Electric & Operating Co. is installing a 60 K.W. "S.K.C." and a 40 light T-H arc machine received from the Royal Electric Co.

The Canadian General Electric Company are furnishing to the Linde British Refrigerating Co., Montreal, two 50 h. p. and one 15 h. p. induction motors.

The Robb Engineering Co. has received an order for two Robb-Armstrong engines, 150 horse power each, for the electric railway at St. Thomas, Ont.

The Canadian General Electric Company have closed a contract with the corporation of Port Arthur for a railway car body equipped with G. E. 1000 motors.

Senator Poirier, of Shediac, N. B., has placed an order with the Robb Engineering Co. for a 60 horse power engine and boiler for running his flour and shingle mills.

The Canadian Pacific Navigation Co., Victoria, B. C., have purchased from the Canadian General Electric Co., for one of their steamers, a multipolar direct connected sett, with marble switchboard.

W. J. Fletcher, of Markham, proprietor of the electric light plant there which was recently destroyed by fire, has decided to reconstruct the plant, and has purchased from the Royal Electric Co. a 20 K.W "S.K.C." generator.

The Canadian General Electric Company have recently closed a contract with the managers of the Longue Pointe asylum for one 110 k. w. multipolar railway generator and one freight motor car, equipped with G. E. 1000 motors.

The Kenneth Mining and Development Co., at Rossland, are making an addition to their equipment in the shape of a 7 x 10 double cylinder hoisting engine, with boiler and all appliances complete, supplied by the Jenckes Machine Co.

The American Hard Fibre Co., Newark, Deleware, announce that Mr. H. M. Grant, who has been travelling in the interest of the fibre trade for the past 18 years, has recently connected himself with that company.

The Shipton Electric Light and Power Co., of Danville, Que., have received a Crocker turbine from the Jenckes Machine Co., Sherbrooke, who are proceeding with the installation of the same, together with the penstock and draft tube.

The Peoples Electric Co., Windsor, Ont., are making extensions to their electric system, and have placed an order with the Canadian General Electric Company for all the material required, including over 1000 light capacity in transformers.

William McVicar, McVicar, Ont., is putting a Dake steam feed into his mill. This feed was built by the Jenckes Machine Co., Sherbrooke, with whom the Phelps Machine Co., Eastman, Que., formerly Canadian manufacturers of the Dake engine, have been amalgamated.

The Jenckes Machine Co., Sherbrooke, are furnishing the Canadian Rand Drill Company with a handsome compound Corliss air compressor, weighing some 33 tons, together with a large air receiver and other accompanying apparatus, bringing the total weight up to about 40 tons.

The Robb Engineering Company, of Amherst, N. S., recently completed a Robb-Armstrong compound engine for an electric installation in a European city; also three of the same type, 200 h.p. each, for another foreign order, and two of 225 h.p. each for the Rathbun Co., of Deseronto.

The Electric Reduction Co., Buckingham, Que., are proceeding to develop their water power, and as a first step have placed an order with the Jenckes Machine Co., Sherbrooke, Que., for a pair of their 45" Crocker turbines, to be installed complete, with wheel cases, draft tubes, governor, etc.

W. Doherty & Co., Clinton, Ont., have commenced work on their new factories, which they expect to have completed by May 1st. Their new works are to be lighted throughout by electricity, for which purpose they have closed a contract with the Canadian General Electric Company for a 500 light dynamo, two 10 h. p. motors and all wiring material required.

Mr. Thos. Proctor, superintendent electric light and water works, Fort William, Ont., in renewing his subscription to THE NEWS, writes: "I consider your paper indispensable to the electrical profession.

It is said that the St. Clair Tunnel Company contemplate converting the motive power for the tunnel from steam to electricity. The matter is understood to be under consideration by Mr. Jos. Hobson, chief engineer of the company, of Montreal.

PERSONAL.

Mr. J. Gibson, city electrician of Toronto, has recently undergone a severe illness.

The Light Commissioners of Fort William, Ont., have appointed Mr. Thos Proctor as electrician for the town.

Mr. J. H. Ward has resigned his position as electrician for the St. Marys Electric Light Company. His successor is Mr. A. Cahoun, of Mitchell.

Mr. Harry H. Denis has been appointed superintendent of the Hull Electric Co., to succeed Mr. Chas. Aird, who will probably go to British Columbia.

Mr. T. E. McLelan, manager of the Berlin and Waterloo Street Railway, has resigned his position. His successor is Mr. H. Hilburn, who has been connected for some time with the Montreal street railway.

The many friends of Mr. Chas. F. Ernst, formerly of New Hamburg, Ont., and who has represented the National Carbon Co. in Canada for many years, were pained to learn of his death shortly after the first of the year.

Mr. Henry Holgate, manager of the West Indian Electric Co., of Kingston, Jamaica, returned to Montreal last month on a business trip. He states that arrangements are being completed for building the new electric railway in Kingston, and that work will commence in April. He will shortly return to Jamaica.

It is with pleasure we announce the recovery of Mr. J. A. Kammerer, general agent of the Royal Electric Co., of whose serious illness mention was made in a recent number. On the first inst. Mr. Kammerer was able to leave for the Southern States, where we trust his hopes of rapidly regaining his old-time health and energy may be fully realized.

A NOVEL IDEA.

THE International Correspondence Schools, of Scranton, Pa., have had fitted up a handsome railway car, containing sleeping and other living accommodation, library, etc. It is the purpose that this car, manned by a staff of teachers and students, shall be located for a time in the vicinity of large manufacturing establishments and afford those interested a practical demonstration of the method by which the work of the schools is carried on.

MOONLIGHT SCHEDULE FOR MAY.

Day of Month	Light	Extinguish.	No. of Hours
	H.M.	H.M.	H.M.
1	A.M. 12.40	A.M. 4.00	3.20
2	" 1.00	" 4.00	3.00
3	No Light.	No Light.	...
4	No Light.	No Light.	.
5	No Light.	No Light.	.
6	No Light.	No Light.	.
7	P.M. 7.30	P.M. 10.30	3.00
8	" 7.30	" 11.30	4.00
9	" 7.30	A.M. 12.20	4.50
10	" 7.30	" 1.00	5.30
11	" 7.30	" 1.30	6.00
12	" 7.30	" 2.00	6.30
13	" 7.30	" 2.30	7.00
14	" 7.30	" 3.00	7.30
15	" 7.40	" 3.20	7.40
16	" 7.40	3.40	8.00
17	" 7.40	" 3.40	8.00
18	" 7.40	" 3.40	8.00
19	" 7.50	" 3.40	7.50
20	" 7.50	" 3.40	7.50
21	" 7.50	" 3.40	7.50
22	" 8.30	" 3.40	7.10
23	" 9.10	" 3.40	6.30
24	" 9.50	" 3.40	5.50
25	" 10.20	" 3.40	5.20
26	" 10.50	" 3.40	4.50
27	" 11.00	" 3.40	4.40
28	" 11.10	" 3.40	4.30
29	" 11.40	" 3.40	4.00
30	....	" 3.40	3.00
31	A.M. 12.40	....	
		Total.....	151.40

SPARKS.

It is said to be the intention of the Kent Mills Company, of Chatham, Ont., to install new boilers.

The Bell Telephone Company recently made some improvements in their exchange at Huntsville, Ont.

The Montreal Street Railway Company is building twenty motor cars for the Kingston, Jamaica, street railway.

The city council of Victoria, B. C., recently invited tenders for another dynamo for the electric light plant.

The Northern Electric & Manufacturing Company has been granted a Dominion charter. Mr. C F. Sise is president.

Ephraim Arnold, whose son was killed by an electric shock, has entered an action for $2,000 damages against the Hull Electric Co.

The C. P. R. intend to erect a new station at McAdam Junction, N. B., and to install a private electric light for lighting the same.

A by-law will probably be voted on by the ratepayers of Toronto to provide $40,000 for converting No. 2 engine at the waterworks plant to high duty, including boilers.

Mr. Spittal, of Dundas, Ont., is organizing a company having for its object the installation of an electric plant for lighting the streets of that town.

The town council of Pembroke, Ont., has appointed a committee to report on the cost of installing and maintaining an electric, gas or other lighting plant for the town.

D. Maxwell and Sons, St. Marys, Ont., are installing an electric plant for lighting their factories, and have purchased for the purpose a 350 light Edison dynamo, manufactured by the Canadian General Electric Company.

Messrs. Price Bros., of Quebec, have ordered from the Canadian General Electric Company a complete electric and steam plant for the Assinitoine block, Winnipeg, Man. The generating plant will have a capacity for 400 lamps.

Mr. W. H. Pearson, jr., of Toronto, has entered an action against Mayor Johnson, of Belleville, who at the last meeting of the city council charged Mr. Pearson with interfering to prevent the sale of the gas stock and electric railway to an English syndicate.

The St. Philemon Telephone Company has been incorporated, with a capital of $1,500, to construct a telephone line in the counties of Bellechasse, Dorchester and Montmagny, Que. Among the promoters are Dr. Jos. Cote and Geo. A. Lamarre, of St. Valier.

The present contract with the Hamilton Light & Power Co., for lighting the streets of Hamilton, expires in less than two years. Alderman McAndrew has therefore moved in council that a committee be appointed to consider the advisability of establishing a municipal plant.

It is the purpose of the Metis Telephone Company, now seeking incorporation, with headquarters at St. Octave de Metis, Que., to build a telephone line in the counties of Matane and Rimouski. J. L. Pinault, advocate, of Quebec, and Thos. LeBel, of Fraserville, are interested.

The St. Thomas Gas Co. have ordered from E. Leonard & Sons, of London, three 100 horse power boilers, from Goldie & McCulloch, of Galt, an engine, and from the Northey Company a steam pump, to enable them to supply power for the electric railway.

The Canadian Electric Water Power Co., of Ottawa, are applying for incorporation, with a capital of $100,000. The purpose is to establish water works and manufacture electrical machinery, and the promoters are: Hon. John Haggart, W. A. Allan, A. Charlevoix, Sir Sanford Fleming, and R. G. Code.

The District Telegraph Company has been incorporated at Winnipeg, and asks the city for permission to string wires. The provisional directors are: Wm. Hespeler, John Galt, R. J. Campbell, Frank Drummond and F. W. Huebach. The company will expend a considerable sum of money in installing a plant.

The Canadian Developing Company, Victoria, B. C., are building three steamers to trade between Vancouver and Stikeen river. These are to be equipped with the most modern systems of electric lighting, the company having placed an order with the Canadian General Electric Company for 3 direct-connected units to meet the requirements.

The Ottawa Electric Light Co. have been given the exclusive privilege of supplying light and power in the city of Ottawa, on the condition that the price of light be reduced 40 per cent. This is the result of an application made by the Deschennes Electric Light Company to be allowed to supply light and power to the citizens.

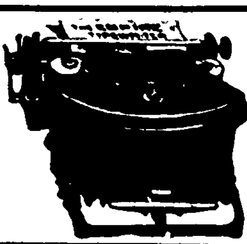
The Ontario Rolling Mill Company, Hamilton, Ont., are rapidly rebuilding their works recently destroyed by fire. They intend installing the most modern system of electric lighting throughout, and have placed an order with the Canadian General Electric Company for one of their latest types of multipolar direct current dynamos, having a capacity for 300 lights.

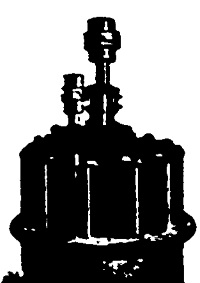
The Lachine Rapids Hydraulic & Land Co., of Montreal, have invited tenders for a new switchboard, to be placed in the sub-station at the corner of McCord and Seminary streets. They have also purchased two 150 k.w. synchronous motors, which will be used in the old Temple plant for the purpose of replacing the present steam plant and getting the power direct from the rapids.

The contract with the Lindsay Light, Heat & Power Co., for lighting the streets of that town, will expire in the near future, and the council is considering the question of installing a municipal plant. The Fire and Light Committee has recommended that a committee be appointed to report on the cost of the same, while the Mayor has been authorized to advertise for tenders for lighting.

The town of Parrsboro, N. S., recently completed its electric light plant, installed under the superintendence of Mr. George White-Fraser, of Toronto. The engines and boilers were supplied by the Robb Engineering Co., of Amherst; alternator by Munderloh & Co., Montreal; arc plant by Thompson Electric Co., Hamilton; transformers by W. A. Johnson Electric Co., Toronto; lamps by R. E. T. Pringle, Montreal; supplies by Canada General Electric Company, Toronto. Most of the apparatus were subjected to a thorough test and found satisfactory. The cost of the plant, which is the first to be installed by a municipality in the maritime provinces, was slightly less than $11,000.

The Ingersoll Packing Company have contracted with the Canadian General Electric Company for a complete installation of incandescent lamps, arc lamps, motors and generator for their factories at Ingersoll, Ont. It is said that this contract was awarded after very mature consideration of the relative merits of two-phase alternating as against direct current machinery for isolated lighting and power service. The generating apparatus will consist of a 25 kilowatt 125 volt multipolar dynamo of the Canadian General Electric Company's latest and most approved type.





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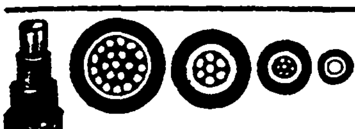

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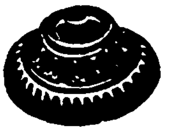

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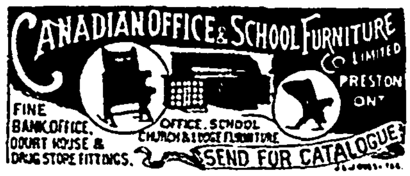

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