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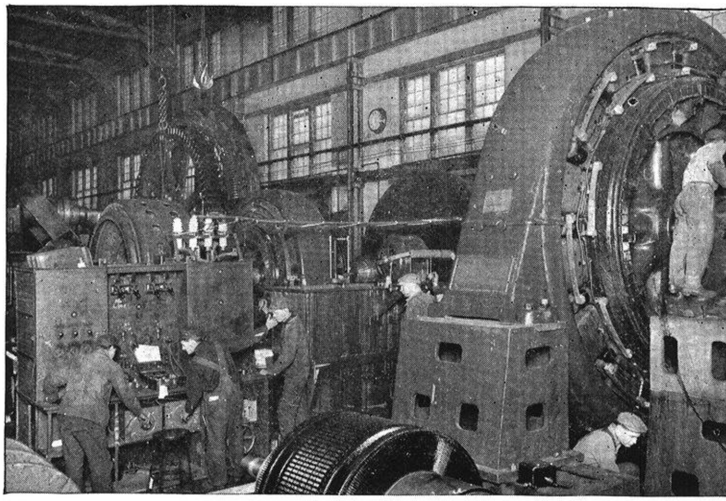
The Wisconsin Engineer

DECEMBER, 1913

Vol. 18 No. 3

Student - Engineers - Course



Testing the Largest Hoist

Some very interesting tests were made last winter on the electrical equipment for the largest mine hoist ever built. The large motor (at the right of the picture) is to be direct connected to the hoisting drum and must be reversible. Current for this motor is furnished by the motor-generator set, and the motor is controlled and reversed by controlling the field current of the generator.

The heavy fly wheel on the motor-generator set compensates for the peak loads of the hoist. Its action is controlled by the automatic regulator which consists of a motor operated water rheostat connected in the secondary of the induction motor driving the set. As the load increases, the resistance of the water rheostat is increased. This allows greater slip in the induction motor so that the fly wheel carries the overload.

All these tests were made by student engineers. The Student Engineers Course of the General Electric Company offers an excellent opportunity for the engineering graduate to secure practical experience. See future issues of this publication for further information.

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The Wisconsin Engineer

VOL. XVIII DECEMBER, 1913 NO. 3

THE LENTZ SYSTEM APPLIED TO STEAM ENGINES.

SIEGFRIED ROSENZWEIG.*

The wealth of the nations is directly influenced by the conservation of the natural resources, and hence largely depends upon the use of coal and other fuel in manufacturing. If we stop to consider that the value of coal now used throughout the world in manufacturing amounts to some hundreds of millions of dollars annually, and if we bear in mind of what cultural and economical importance it is to make one pound of coal do the work that two pounds of coal did before, it becomes at once apparent that the great engineering problem of our present time is to perfect in our prime movers the transformation of energy into power.

The important question of economy in a reciprocating steam engine no doubt deserves first consideration on account of the millions of horse powers which are now produced by the expansive force of steam in this type of prime mover.

Thermodynamics teach us that the efficiency of an engine increases when the temperature limits between which the engine works are increased. That occurs in a steam engine when steam enters the cylinder at the highest temperature and leaves it at the lowest possible. Hence, in order to obtain economy in a steam

* This is an abstract of a lecture delivered before Ithaca Section A. S. M. E. on Jan. 17th, 1913. Mr. Rosenzweig is with the Erie City Iron Works.

engine three factors are of greatest importance; first, high steam pressure, second, high superheat, and third, low vacuum.

The owner of a power plant is not only interested in the economy of the engine but also in the commercial efficiency of the whole plant. He has to investigate if the expenses for creating and maintaining the high steam pressures and superheats are justified by the final results. That these factors are indeed conducive to plant economy will become apparent from the following explanations.

The greater the steam pressure in a steam engine, the greater is its capacity to develop power. By increasing the steam pressure from 100 to 200 lb. we can double the output of the engine or can do the same work as before with a considerably smaller amount of steam and effect, for instance at average cut-offs, a reduction in steam consumption of about 30 per cent. Steam at 200 lb. pressure contains but 14 B.t.u. per lb. more than steam at 100lb.: so if the coal has 14000 B.t.u. per lb., only 1/1000 part of a pound of coal is necessary to raise the steam pressure from 100 to 200 lb. As also the high pressure boiler costs very little more than the low pressure boiler, these facts forcibly point towards the adoption of high steam pressure. Modern stationary engines use boiler pressures ranging between 175 to 200 lb.

That the use of superheated steam raises the efficiency of an engine is generally acknowledged. The reasons for it are various, chief among them is the reduction of initial condensation and the leakage past valves and piston. As these two items represent from 25 to 50 per cent. of the total steam consumed in an engine, their reduction is of utmost importance.

When dry saturated steam enters the cylinder, it has to come in contact with surfaces which have just been in contact with cold exhaust steam and which are covered with a film of moisture. As water serves as a ready means of transferring heat from the steam to the metal a great quantity of the incoming steam is wasted by condensing.

The use of superheated steam reduces this initial condensation. Furthermore experiments have shown that superheated steam, on account of its smaller density, is a poor heat conductor and that quite naturally this property becomes more and more marked the higher the superheat is.

Prof. Doerfel of the University of Prague in Austria found that by increasing the superheat from 46 to 256 deg. Fahr. the loss during the admission period decreased from 8400 to 1900 B.t.u. Higher superheat will probably, apart from radiation, prevent almost entirely the loss of heat due to the exchange of heat between cylinder walls and steam. These experiments were confirmed by another authority, Seemann, who found that by superheating from 0 to 360 deg. Fahr. the heat given up to the cylinder walls decreased from 36.2 to 9.3 per cent. Another experiment showed that with a superheat of about 210 deg. Fahr. it made no difference as to the initial condensation whether the engine was running condensing or non-condensing, though in the former case the temperature drop due to the expansion of steam amounted to 195 deg. against 135 deg. Fahr. in the latter.

These experiments which were confirmed by many other authorities show conclusively that it is advisable to use high superheat in order to obtain highest economies. The author from his own experience has found that a superheat of from 200 to 250 deg. Fahr. was quite commercial and gave very satisfactory working results. The higher initial cost for installing superheaters in a power plant was easily counter-balanced by the smaller piping, as superheated steam allows of considerably higher steam velocities, by the greatly reduced heating surface in the boilers due to the vastly superior economy in the steam engine, by the greater safety of the power plant due to the absence of water in the pipes and engine, and by the greatly reduced coal consumption.

To give a few examples I may mention the power plants of the electricity stations in Vienna, Austria, and Rome, Italy. The former has 20 piston-valve engines of 1000 h.p. each. When the superheaters were installed, the high pressure cylinders had to be reconstructed and were fittd with Lentz valves and gear. The outlay of about $80,000 was recovered within two years from the saving of coal. In the power station at Rome the installation of Lentz engines and superheaters increased the output of the plant by about 30 per cent.

The introduction of superheat further simplified greatly the design of steam engines so that compound engines with highly superheated steam successfully replaced triple and quadruple expansion engines, thus producing a great saving in initial cost, floor space and running expenses.

The application of superheat was restricted for various reasons chiefly on account of the bad effect of the high temperature on valves unsuitable for superheat, but these obstacles were never sufficient to blind engineers as to the merits of superheated steam. Owing to the expansion of the metal all valves which have to rely upon the surrounding walls for steam tightness are unsuitable for superheat. For high steam pressures and high degrees of superheat a balanced and frictionless valve has been used, and the deficiencies of the slide, piston, and Corliss valves can only be remedied by the adoption of the balanced, multiple-seated poppet valve.

Of the many American authorities who favor the introduction of the poppet valve, I may only mention R. S. Piggot who, in an article on "The Revival of the Reciprocating Engine" in the Engineering Magazine, said: "Superheat will eliminate the condensation and most of the leakage; poppet valves are practically entirely tight and are the only valves suited for superheat; it follows that the poppet valve in some form must become the standard valve."

The advantages of the poppet valve are no rubbing surfaces, hence no lubrication and its adaptability for high temperature; small weight and a practical balance, hence its adaptability for high speed and high steam pressure; no possible wear, consequently the economy of the engine maintained for an indefinite period.

In this paper I should like to make you acquainted with probably the best representative of modern reciprocating engines, the Lentz engine. Considering that engines of this type have been built in sizes up to 10,000 h. p. aggregating more than 3,000,000 h.p. and that this engine has to a certain extent revolutionized modern steam engine design, it well deserves to have a whole paper devoted to it.

Fig. 1 shows the valve gear side of a Lentz engine. A lay shaft is running along side the engine, driven from the main shaft by a pair of bevel gears. All the eccentrics are keyed on this lay shaft, each separate eccentric operating one valve by means of eccentric strap, rod and lever. In such a way the different

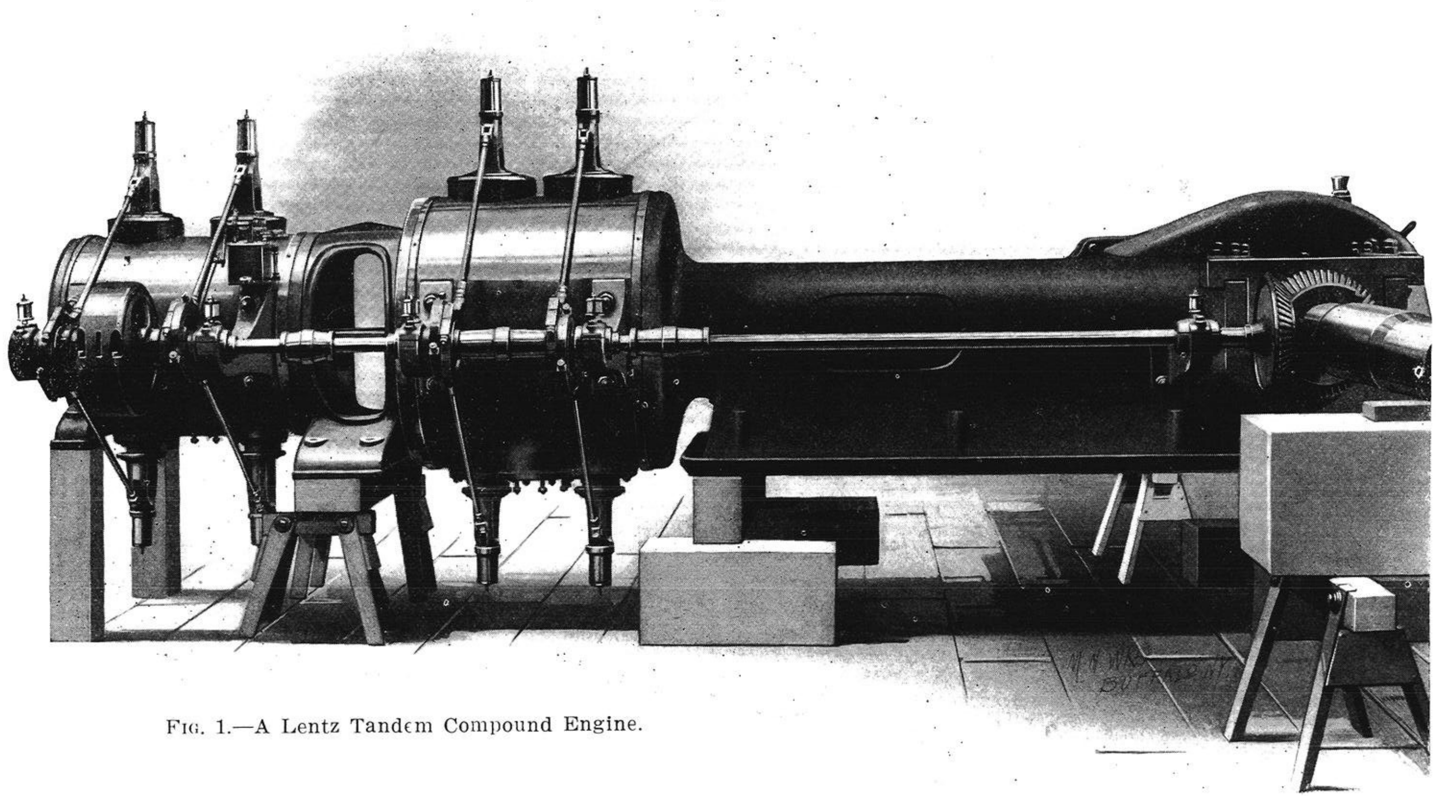


Fig. 1.—A Lentz Tandem Compound Engine.

valves are entirely independent from each other and can be set very accurately according to the requirements of steam distribution.

Fig. 2 shows the different parts of the internal valve gear, the valve, the spindle with its grooves, and spindle guide with roller and cam lever. All the parts as pins, bushings, rollers and cams are case-hardened so as to prevent even the slightest wear.

The principle of the poppet valve is that by resting with its two faces on the corresponding seats in the cylinder it prevents the flow of steam from the steam chest into the cylinder. Admission and cut-off are effected by breaking and re-establishing the contact of the seats. The valve is entirely balanced but for the width of the seat, which even in the larger sizes does not exceed ⅛ in., and hence takes very litte power to operate. The valve gear consists only of a roller and cam lever. The latter is oscillated by means of the eccentric rod and is so curved that it opens the valve and closes it in a very rapid manner. No dash pots are used as the whole operation is entirely positive. On account of the noiseless operation of the valve gear and its great simplicity it is possible to operate the Lentz engine safely at high speeds. A limit has not been reached at even 350 r. p. m. A feature is the absence of any spindle packing, as the spindles are simply ground into cast iron bushings and provided with grooves, thus producing a labyrinth system in which the condensed steam and oil collects and by which the escape of any steam is successfully prevented.

A similar principle is used for the piston rod packing, which is made entirely of cast iron rings but so arranged as to follow the floating action of the piston rod.

A section through the cylinders of a tandem compound engine is given in Fig. 3. The low pressure cylinder is placed next to the bed. This arrangement gives the high pressure cylinder a chance to expand freely without being obstructed by the distance piece and the low pressure cylinder. The opening in the distance piece is made large enough to remove the back cover and piston of the low pressure cylinder without disturbing the alignment of the engine.

All the low pressure and high pressure exhaust valves are driven from fixed eccentrics, the high pressure steam eccentrics only being influenced by the governor.

Fig. 2 shows also the arrangement of the high pressure steam eccentric. The eccentric is arranged slideable on a block which is keyed to the shaft. When the load changes, the governor slides the eccentric on the block, and alters the angular advance and the throw of the eccentric according to the requirements of the load, while the linear lead remains constant. The governor

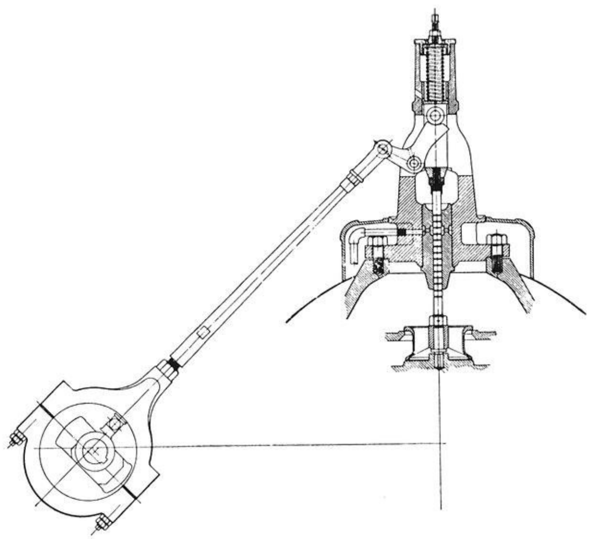


FIG. 2.—Section through Valve.

is placed right between the two steam eccentrics and influences their position without the help of belt or chains.

The governor itself is shown in section in Fig. 4, and assembled in Fig. 5. It consists of two pendulums pivoted to a support which is keyed on the shaft. By means of links the pendulums are connected to the governor inertia body which can move freely around the shaft, being connected with the shaft only by a flat circular spring which counter-balances the centrifugal forces of the pendulums. The potential energy stored up in the inertia body is converted to kinetic energy of motion as soon as the slightest change of load and consequently of speed occurs. As the inertia forces and the centrifugal forces act in

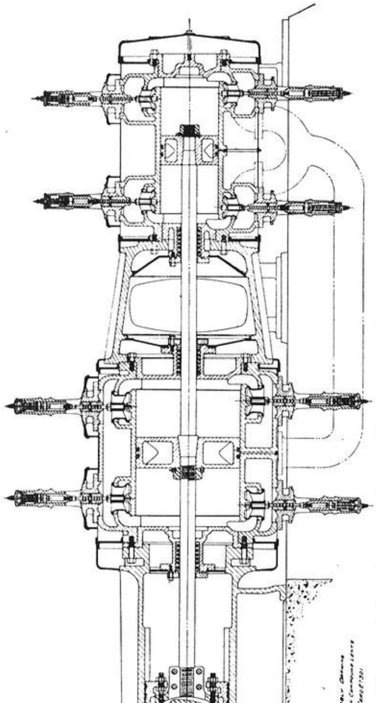


FIG. 3.—Longitudinal Section of Lentz Tandem Compound Engine.

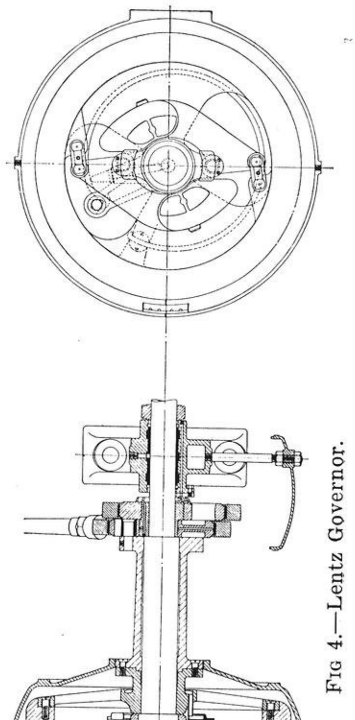


FIG 4.—Lentz Governor.

the same sense their combination produces a governor of a very sensitive and instantaneous action.

It is possible to change the speed of the engine while in motion by means of a radial pin which presses against the spring and changes its tension. The radial pin can be moved by means of a shaft and hand wheel which is placed at the end of the lay shaft.

Extensive tests have been carried out on a Lentz simple engine having 15 in. dia. cylinder and 21 in. stroke. This engine showed a steam consumption of 19.2 lb. per i.h.p. per hour with an average steam pressure of 145 lb. gage. an average superheat of 47 deg. Fahr. and a back pressure exhaust of 2 lb. This performance gives a Rankine efficiency of practically 76 per cent.

A tandem engine carefully tested gave the following results. The first test with saturated steam, 170 lb. boiler pressure, and 26 in. vacuum, gave 366 i.h.p. with a steam consumption of 12.3 lb. per i.h.p. per hour. The second test with the same conditions as before but with superheated steam of 150 deg. Fahr. showed a steam consumption of 10.4 lb. per i.h.p. per hour. These results were obtained from an entirely new engine within two days of first running.

The Lentz system has also been extensively used in connection with semi-fixed engines, a combination of an engine with boiler, superheater, condenser, air pump, feed-water heater and feed pump, in other words a compact, high class and self-contained power plant which is extensively used in isolated plants in Europe and South America. On account of its compact arrangement and the absence of any piping and losses incurred by it, the economy of these engines is remarkable. One of these engines was tested by Prof. Grassmann of the Technical College of Carlsruhe, Germany. The 200 h.p. unit gave a steam consumption of 7.4 lbs. and a coal consumption of 0.92 lb. per brake h.p., figures which probably stand as world records. The mechanical efficiency of the engine was 93 per cent and the combined efficiency of boiler and superheater 82 per cent.

I come now to the application of the Lentz valve gear to marine engines. It took years of hard work before Lentz was able to succeed on this line. As a matter of fact there were steamers on the American Great Lakes and on some of the Swiss Lakes fitted with poppet-valve engines but on account of their slow speed and unwieldy valve gear they were not regarded as sufficient proof as to the adaptability of the poppet valve for high class marine engines running at high speed.

In order to ascertain the advantages of the Lentz gear on marine engines, the Compagnie Generale Trans-Atlantique ordered in 1906 from the Societe de Saint Nazaire, the famous French Navy Yard, two identical cargo boats, the "Garonne" fitted with ordinary triple expansion engines, and the "Rance" with similar engines, but with the Lentz valve gear and the boilers with Pielock superheaters. The trials of these two vessels were carried out under conditions as similar as possible, the same kind of coal being used in both cases. The reduction in coal consumption due to the superheater and Lentz valve gear amounted to 20 per cent. In consequence of these results the company installed the Pielock superheater and the Lentz valve gear on five other steamers, aggregating about 30,000 h.p. Soon afterwards seven German merchandise steamers followed the lead set by the French company. Three years ago Lentz engines were installed in a small ship of the German navy, two triple expansion engines of 800 h.p. each.

A comparison between a Lentz torpedo boat engine and a Zoelly marine turbine was afforded at the Brussels Exhibition in 1910. Both engines approximately developed 6500 i.h.p., the Lentz engine at 250 r.p.m., the turbine at 600 r.p.m., which of course is a considerably less economical propeller speed than the former.

There was hardly any difference in floor space between the two engines but the weight of the turbine, 57,000 lb., was about 2000 lb. more than the weight of the reciprocating engine, while the condensing apparatus of the turbine weighed about 30 per cent more.

That the marine turbine for navy purposes is yet far from being a success note the following article which appeared in "Power" a short time ago:

"When it was recently announced that the Navy Department had decided to return to the reciprocating engine, as a drive for battle ships, we expressed astonishment that this should be done at a time when every other naval power was using the steam turbine exclusively. That the action of the department was based upon fact and sound reasoning, however, is shown by the comparative steaming results from the two sister ships, the "North Dakota" which is equipped with turbine engines, and the "Delaware" driven by standard reciprocating engines.

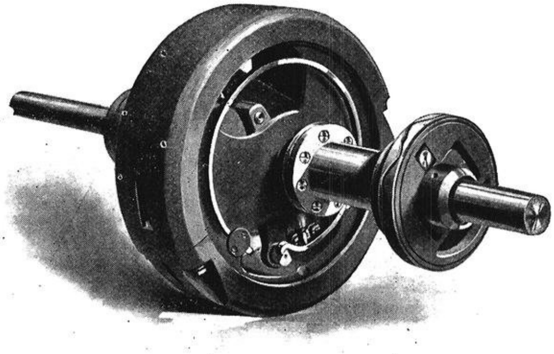


Fig. 5.—Lentz Governor.

An opportunity for comparison of coal consumption under identical conditions, was recently afforded when the two ships were steaming with the North Atlantic fleet, the North Dakota in position directly astern of the Delaware. We are officially informed that average results for ten days show that using coal from the same collier, employing the same auxiliary engines, and steaming at the same speed of 12 knots under identical conditions of wind and weather, the 'North Dakota' consumed 43 per cent more coal than the 'Delaware.'

It has always been understood that the turbine shows its best efficiency when it was being driven at full speed, under which condition its coal consumption is as good, if not better than that of the reciprocating engine. At anything less than full speed the turbine consumption becomes relatively larger and at cruising speed considerably so. But it has to take such a test as this, made under sea-going conditions, to show just how extravagant is the coal consumption of the turbine under cruising conditions."

The first factory to apply the Lentz poppet valve gear to locomotive engines was the Hannover Machine Factory of Hannover, Germany, the first application being a tank engine which was fitted with this innovation in 1905. On the same occasion the engine was fitted with a Pielock superheater and the engine achieved in service a saving in coal of 19.5 per cent and a saving in water of 30.5 per cent as compared with similar tank locomotives, fitted with slide valves and working with saturated steam.

As no faults were found with the Lentz gear of this engine, which is still used in heavy regular train service, two further locomotives were fitted in 1906 with the Lentz gear. The two locomotives in question, a four-cylinder balanced express locomotive of the Atlantic type and a six-wheel coupled tank locomotive, were exhibited at the Milan International Exposition in 1906.

The whole valve gear is enclosed in a dust proof casing and runs entirely in oil. All four valves are operated by a single eccentric valve and one single cam shaft.

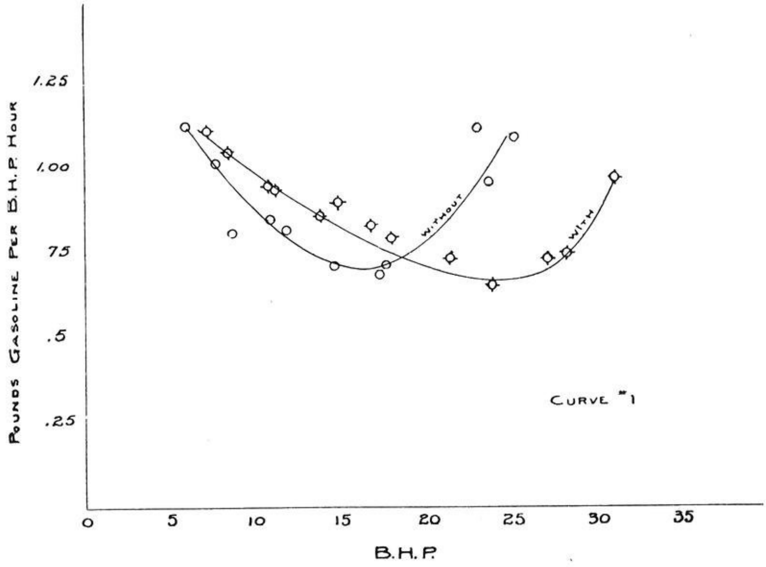
The express locomotive has since done about 200,000 miles without having its valve gear exchanged, a remarkable performance considering the high speed of the engine which is running nearly 300 r.p.m., and the hard service and strains to which the locomotive is subject.

On account of these splendid performances it is expected that the poppet valve locomotive will find extensive use. There are at present about eighty locomotives of the Lentz type running in the different states of Europe.

A FUEL SAVING DEVICE FOR OIL ENGINES.

E. R. ADLINGTON.

The waste of oil fuel entailed in the present method of carburetion in oil engines has been investigated by Mr. M. E. Chandler '13, and Mr. E. K. Kellogg '13, in a thesis worked out in the University of Wisconsin laboratories. The results obtained show that marked economy is obtained above moderate loads by the use of a recarburetting device.



In order to make clearer the operations of the recarburetter, a description of the recarburetter with reference to its present imperfections will be helpful. A carburetter is an appliance for vaporizing liquid hydrocarbons by passing air either over the surface or through the mass of the liquid; or by atomizing the liquid and mixing it with air. The air thus becomes saturated with the vapors of the hydrocarbon. This mixture is usually too rich in hydrocarbons to explode satisfactorily, therefore more air must be added to it before passing to the engine cylinder.

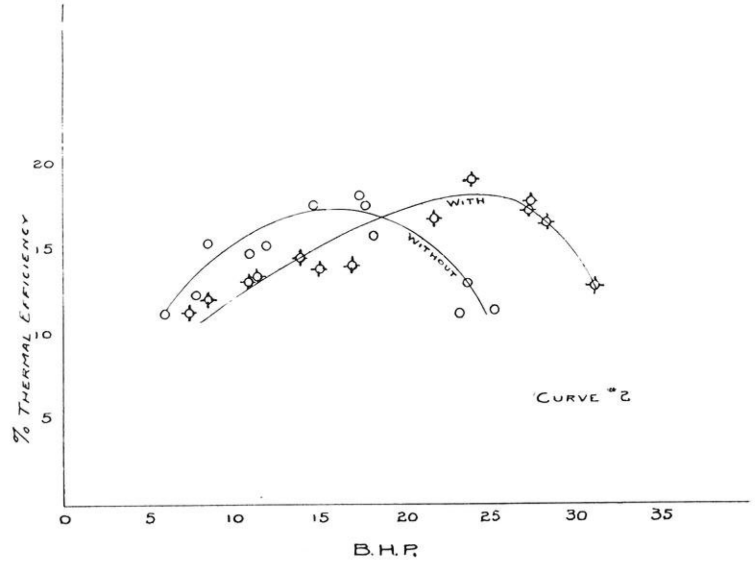
Carburetters may be divided into three classes as follows:

(1) SURFACE CARBURETTERS:—Those in which a large surface of the hydrocarbon, generally spread out in thin layers, is exposed and over which the air is compelled to pass.

(2) FILTERING CARBURETTERS:—Those in which the liquid fuel is placed in a reservoir, of great depth in proportion to width, and the air is compelled to pass up through the body of the liquid.

(3) SPRAY CARBURETTERS OR VAPORIZERS:—Those which vaporize or atomize the hydrocarbon and inject it into a current of air.

Although the surface carburetters were at first used, they have now become obsolete, and the spray carburetter has replaced them. The objection to the surface and filtering carburetters are: Plain surface evaporation requires a very large surface in



order to evaporate the gasoline at a sufficient rate to supply an average commercial engine. Again, gasoline is not a homogeneous substance as it is a mixture of comparatively light and heavy products from petroleum distillation. When it is evaporated from the surface, the lighter constituents pass off first, and therefore in time the carburetter contains only the heavier portion of gasoline, which will not evaporate at a sufficient rate to supply the air with the amount of hydrocarbon necessary for explosion. Further objection to carburetters of this type is that the rate of evaporation of gasoline varies greatly with temperature, and it is difficult to supply the heat necessary to maintain the desired temperature, for the evaporation lowers the temperature of the gasoline. Such heat is supplied by warming the air before it enters the carburetter by passing it through a jacket on the exhaust pipe. As the speed of the engine varies this temperature varies, thereby causing the richness of the mixture to fluctuate with the speed of the engine.

The advantages of the spray carburetter are many. In this type of carburetter the gasoline is delivered to the air in the form of a jet or spray, which is drawn from the supply by the suction of the air current. When the air is sufficiently warm this spray is evaporated and a fairly constant mixture of air and gasoline vapor is obtained. The spray carburetter takes up very little room and therefore can be used to great advantage on marine and automobile engines where space is limited.

The usual form of spray carburetter used to-day consists of a receptacle in which the gasoline level is kept constant by a float-actuated needle valve. From this gasoline receptacle a small tube extends into an air passage of circular form. The suction of the engine piston causes an onrush of gasoline and air through this passage and there is a partial mixture of the two. This process is wasteful of gasoline and requires many adjustments in order to obtain the correct mixture under different conditions. The mixture also varies greatly with the speed since the supply of gasoline depends upon the suction as well as the pressure. This causes too rich a mixture at high speeds. The greater part of the inefficiency of the carburetter may be traced to the nonuniformity of the gasoline and air mixture. Gueldner says, "To-day the fundamental principle of gas engine operation is to have pure and uniform mixture and most rapid combustion."

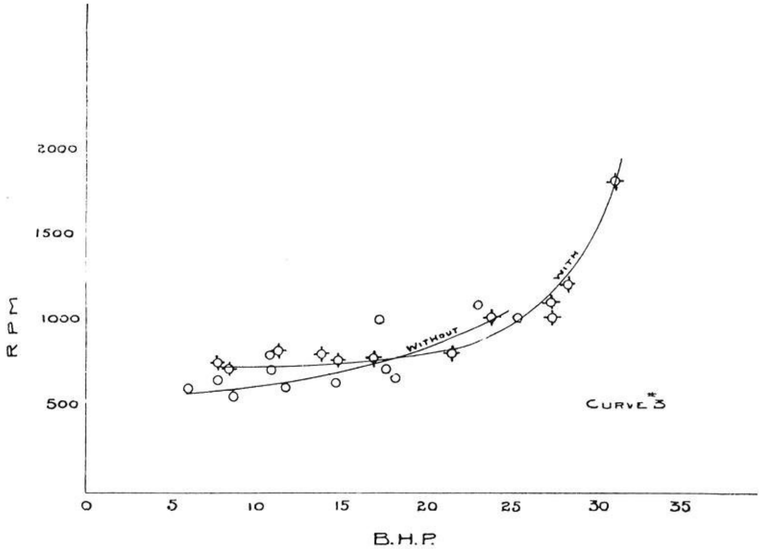
The recarburetting device described in this test aimed to accomplish this condition by means of a rapidly revolving fan placed in the intake pipe which thoroughly remixes the gas mechanically. It was supposed that the high velocity of the fan wheel caused by the inrush of air and gasoline vapor would further mix the two and break any remaining gasoline globules into minute particles and induce further vaporization.

The test was made with a four cylinder automobile engine with vertical cylinders of the L head type cast in pairs. The cylinders were cooled with city water which was allowed to circulate through the jackets and go to waste. Ignition was obtained in two separate ways: (1) by a set of dry batteries, a coil and timer; and (2) by a magneto driven from the cam shaft operating in connection with a separate coil and timer. Each system was connected to its own system of spark plugs.

The engine was loaded by means of a prony brake and the speed kept constant. Gasoline was measured in a graduated tank hung free of the motor frame and was sampled at each filling, the average heat value being 20,285 B.t.u. per pound. Thermometer wells were placed in the inlet and outlet of the water jackets and the discharge was weighed at intervals. The carburetter used was a Schebler, Model L. Twelve recorded runs were made without the recarburettr and thirten runs were made with the recarburetter in use. Very careful adjustments of the carburetter were made for low, medium and high speds. The following curves illustrate the results obtained.

Referring to curve I, it will be seen that the pounds of gasoline per brake horse power for both tests when plotted against brake horse power have the same general characteristics. For some reason the curve with the recarburetter falls slightly above the curve for the carburetter alone for powers less than about eighteen horse power. This is due, no doubt, to a failure to fully adjust the carburetter for the lower speeds. However, under greater loads and speeds, the saving as shown by these curves is really remarkable. The curves are plotted with a very large vertical scale, hence for low powers the difference between the two curves is not as great as it appears to be, while from eighteen horse power up, the difference is very noticeable and is indeed unusual at the highest powers shown.

In curve II is shown thermal efficiency plotted against brake horse power. Again the results point favorably toward the recarburetter. Not only are higher thermal efficiencies obtained but they are obtained at powers which would be used the greater part of the time in practice.



In curve III is shown revolutions per minute plotted against brake horse power. It will be seen from this that the revolutions per minute for the two tests compare very favorably. The important fact brought out here is that with the aid of the recarburetter it was found possible to obtain and to hold a higher speed when developing the higher powers.

In view of these results the authors feel that they have brought out the following points in favor of a recarburetter:

1. Reduction in gasoline consumption.
2. Increased engine capacity.
3. Higher speed at Maximum loads.
4. Greater thermal efficiency.

Like many devices for increasing the efficiency of engines, this will also have to overcome the natural scepticism with which they are all viewed. However, the increased capacity which this device gives to an engine is enough to warrant its use, even if it did not add to economy of gasoline.

SOME SOURCES OF ERROR IN GAS CALORIMETRY.

By O. L. Kowalke.

Previous to five years ago the quality of municipal gas was judged according to two standards,—the candle power and the calorific. In the spring of 1908 the Railroad Commission of Wisconsin called into conference the representatives of gas companies to determine the proper standard for quality of gas. It was shown at the conference that practically all gas sold was used for producing heat, and that the calorific standard was the most logical one. The question now arose as to how the calorific value should be determined, what calorimeters were best suited, and what the proper conditions for testing were. As a result of this conference, the staff of the Chemical Engineering Department in co-operation with the Committee on Calorimetry of the American Gas Institute made an extended series of tests of the efficiency of various calorimeters on the market, and the factors affecting their accuracy.

The American Gas Institute adopted the following definition of heating value:—(See Proc. Am. Gas Inst., Vol. III, 1908, p. 383).

"The heating value of a gas is the total heating effect produced by the complete combustion of a unit volume of the gas, measured at a temperature of 60 degrees Fahrenheit, and a pressure of 30 inches of mercury, with air of the same temperature and pressure, the products of combustion also being brought to this temperature."

"In America the unit of volume is the cubic foot and we recommend that the heating value be stated in terms of British thermal units per cubic foot of gas."

The present discussion deals particularly with continuous flow calorimeters,—namely, calorimeters through which the cooling water, gas and air flow continuously. There are several other efficient types of calorimeters whose operation is radically different from the continuous flow type, but since the latter has the widest use the discussion will be confined to it.

It is apparent that there are several sources of error in a heating value determination, namely;—measurement of gas, correction to standard volume, temperature measurement, radiation losses, incomplete combustion, air humidity, and excess of air.

The gas supplied to the calorimeter is measured in a wet test meter. Aside from leaks in the case of the meter and incorrect water level, there are other sources of error. The temperature of the gas passing the meter must be accurately measured; hence the thermometer should read to single degrees, be quick to respond to changes in temperature, and be installed at the point where the gas leaves the measuring drum. An error of one degree in the measurement of the temperature of the gas means an error of about 1.8 B.t.u's. per cubic foot of gas.

Should the gas entering the meter be not saturated, there would be considerable evaporation during an extended series of tests, and the meter should be "slow" in its registration. The following data will illustrate this point. A meter was passing gas at the rate of 7 cu. ft. per hour, for six hours, with the gas and the meter at 80 degrees Fahrenheit. At the beginning the meter was 2.5 per cent fast and at the end was only 1.7 per cent fast. Had the meter not been checked, the results at the end would have been 0.8 per cent larger than at the beginning, a matter of about 5 B.t.u.

The standard unit volume of gas is one cubic foot of saturated gas at a temperature of 60°F. and 30 inches of mercury. It is seldom possible to meter gas under these conditions, but by proper corrections of temperature, barometer, and vapor pressure, the gas can be brought to this standard. The formula for making the correction is given as $\frac{17.64\,(h-a)}{460+t}$, where

h=barometer in inches of mercury

a=vapor tension at observed temperature, (t)

t=gas temperature observed, in degrees Fahrenheit.

Suppose that in the winter the temperature of the gas in the mains is 45°F. and that the gas is saturated. The gas is brought into the testing room where the temperature is 70°F., where it would now be only 41 per cent saturated. Were the gas saturated at 70°F., and the barometer at 29.5 inches of mercury, the correction factor according to the above formula would be 0.955.

Since the gas would be only 41 per cent saturated the correction factor, according to the formula above, would be 0.971 and would involve an error of about 10 B.t.u. During the winter it is necessary to pass the gas through a saturating bottle before passing the meter.

It can also be shown that an error of one-tenth of an inch in reading the barometer will mean an error of about 2 B.t.u. The gas coming from the main to the meter is usually under a pressure of from 2 to 6 inches of water. Each inch of water pressure corresponds to 0.073 inches of mercury which, for accurate work, should be added to the barometer reading. Failure to do so will mean a loss of about 1.5 B.t.u. for each inch of water pressure to which the gas is subjected.

The temperature of the water at the inlet and outlet must be accurately known; and the thermometers should show accurately the temperature difference. This will mean that a given interval on the scale of one thermometer should correspond exactly to the same interval on the scale of the other. It is practically impossible to build thermometers so that the bore is perfectly uniform. and the scale etched on the thermometer may not always accurately indicate the correct temperature.

Suppose that in a test the following data were obtained:—

Gas consumed (corrected)=0.1883 cu. ft.

Weight of water heated=7.39 lbs.

Observed average temp. of inlet water=65.38°F.

  Correction for bore=.33

Corrected temperature at inlet=65.05°F.

Observed ave. temp. at outlet of water=80.86°F.

  Correction for bore=.17

Corrected temperature at outlet=80.69°F.

Corrected rise in temp.=15.64°F.

Hence $\frac{15.69 \times 7.39}{0.1883}$=613.8 B.t.u. Had the correction for bore in the thermometer not been made the apparent rise would have been 15.48°F. and the heating value 607.5 B.t.u.

For work of great precision a further correction for the emergent stem of the thermometer is necessary. If the stem of the thermometer extends out of the bath in which the bulb is immersed, and if the surroundings of the stem are cooler than the bath, the reading will be low. The correction formula given in "Circular of the Bureau of Standards No. 8—1911", p. 15, is:

Stem correction=0.000088 N(T°—t°)

N=number of degrees emergent from bath

T=observed temperature of bath

t=mean temperature of emergent stem (taken as room temperature)

For a bath temperature of 85°F, room temperature of 70°F, and the stem submerged to the 32° mark, a correction of 0.06 degree must be added, which is equivalent to about 2 B.t.u.

Loss or gain of heat by radiation may be of considerable magnitude. In the following table is given the gain or loss in B.t.u. absorbed from or given to the room during the time required to burn one cubic foot of gas. To obtain these data no gas was burned in the calorimeter, the room temperature was kept at 70°F., but the temperature of the water flowing through the calorimeter was varied.

Temp. Water Flowing	B. t. u. Gain	Loss
40° F	8.0	
50° F	5.0	
60° F	3.5	
70° F	0.0	
80° F		2.0
90° F		2.0

When gas is being burned in the calorimeter, there is some heat loss by conduction down the stem of the burner. This loss is small as compared to the heat radiated down the combustion chamber from the flame. The Bureau of Standards has suggested the use of shields on the burner stem, so arranged as to admit air for combustion, but to prevent heat radiation downward. Numerous tests in the Chemical Engineering Laboratories have shown that the loss in B.t.u. due to the absence of radiation shields is about 3 B.t.u. per cubic foot of gas. The burner should be well up in the combustion chamber and the flame should be above the point where the water enters the calorimeter.

Incomplete combustion also produces an error. The flame in the combustion chamber should never touch the walls of the chamber. Such a condition will keep the gas below the ignition temperature.

The magnitude of the error due to humidity and excess of air supply is not generally appreciated. Gas at room temperature and saturated with vapor enters the combustion chamber, together with an air supply at room temperature and room humidity. The gas is burned, forming carbon dioxide and water vapor, with the liberation of heat; and the products of combustion are cooled by the calorimeter water to a temperature about equal to that of the water at the inlet. During the cooling the water vapor is condensed to a liquid; and the products of combustion pass out of the calorimeter saturated with water vapor at the exhaust temperature. The amount of water condensed is equal to the amount formed during combustion only when the water entering with the gas and air is equal to the amount carried out by the products of combustion. Should the air and gas entering contain less water than the products leaving, then some of the heat of condensation of the water formed during combustion is lost. It is usually the case that the air and gas entering carry less water than the products leaving. In extreme cases, the water required to saturate the products may be more than the sum of that brought in by the air and gas, and that formed during combustion. In this case no water is condensed.

During the summer months the air is at an average of about 75°F. and perhaps 60 per cent saturated. In the winter air from out-of-doors, perhaps at 20°F. and 50 per cent saturated, is brought into the room and heated to 75°F, but no moisture is added. This air is now only about 12 per cent saturated. Hence in the winter this error due to humidity is apt to be much greater than in the summer.

It can be shown that during the combustion of a carburetted water gas, coal gas, or mixed gas, there is a contraction in volume. In a certain carburetted water gas (which may be taken as typical), the dry air needed for combustion of one cubic foot of dry gas is 5.286 cu. ft. The volume of the products of combustion, dry, is 5.037 cu. ft.

Total volume before combustion is 1.00 + 5.286	= 6.286 cu. ft.
" " after " "	= 5.037 " "
Contraction	= 1.249 cu. ft.
	= 19.8 per cent.

Should the excess of air amount to 40 per cent, the contraction would be 15.3 per cent. The contraction in volume due to combustion makes it possible to operate a calorimeter with an exceedingly small error when the humidity is about 80 per cent, for room temperatures from 60° to 80°F. and for air excesses from 20 per cent to 60 per cent.

The following tables show the loss or gain in B.t.u. per cubic foot for a carburetted meter gas when burned with air of various degrees of humidity, temperature, and percentages of excess. The amounts of heat lost are indicated with a minus sign and the amounts of heat gained with a plus sign.

TABLES SHOWING LOSS AND GAIN OF B. T. U.

Table 1. Air 20 Per Cent Excess

Room Temp. F°	100%	80%	Humidity 60%	40%	20%
60	+1.1	+0.01	—1.0	—2.3	—3.5
70	+1.6	—0.01	—1.6	—3.2	—4.8
80	+2 2	—0.03	—2.2	—4.4	—6.6
90	+2.9	—0.03	—3.0	—6.0	—9.0

Table 2. Air 40 Per Cent Excess

Room Temp. F°	100%	80%	Humidity 60%	40%	20%
60	+1.1	—0.2	—1.6	—2.9	—4.2
70	+1.5	—0.3	—2.2	—4.0	—5.9
80	+2.1	—0.4	—3.0	—5.5	—8.0
90	+2.9	—0.6	—4.0	—7.5	—11.0

Table 3. Air 60 Per Cent Excess

Room Temp. F°	100%	80%	Humidity 60%	40%	20%
60	+1.1	—0.4	—1.9	—3.4	—5.0
70	+1.5	—0.6	—2.7	—4.8	—7.0
80	+2.2	—0.8	—3.7	— 6.6	—9.5
90	+2.9	—1.0	—5.0	- 9.0	—12.9

The amount of excess of air will vary with different calorimeters and also with the method of operation. The following percentages of excess of air have been obtained from the old style Junkers calorimeter:—53%, 57%, 46%, 11%, and 200%. In one test the improved Junkers Calorimeter showed 41% excess of air, while in another the Doherty Calorimeter showed an excess of 70%. The amount of excess air can be controlled by the damper on the exhaust flue. One way of doing this is to watch the indications of the outlet water thermometer while the damper is being manipulated, leaving the damper in that position which corresponds to the highest reading on the thermometer.

In conclusion it will be noted that some of the errors in gas calorimetry are of considerable magnitude. Most of the errors are in the same direction, and the cumulative effect is an error of several per cent. By careful attention to the details of operation, the result obtained with a continuous flow calorimeter can be made equal to the total heating value of the gas.

HIGH EFFICIENCY INCANDESCENT LAMPS

F. A. Kartak, E. E.

The developments that have taken place during the last few years in the manufacture of electric incandescent lamps are a result of the excellent class of industrial research which has been carried on at the research laboratories of the lamp factories. The difficulties that have had to be met and overcome have been so numerous and of such a nature as to be eliminated only by the most careful and exacting precautions.

For many years after the introduction of the carbon filament incandescent lamp by Edison, carbon held the field undisputed as the filament material, and it has not been until recent years that other materials such as tantalum and tungsten have been employed. As the best performance obtainable even with the most efficient type of carbon lamp—that having a metallized carbon filament and known as the Gem lamp—is not better than 2.5 watts per candlepower for a normal life* of 800 hours, search was made for a material having a low vapor tension as well as a high melting point. This search led to the use of a number of the heavier and highly refractory metals, but those which have stood the test of service are tantalum and tungsten. Both metals have high atomic weights and are suitable for high temperature operation. Tantalum lamps are finding a somewhat limited field, as their use is restricted to operation on direct current circuits, due to a peculiar property of the metal.

Tungsten, on the other hand, has a higher melting point (about 3100°C), is quite plentifully found in nature, and may be used with both direct and alternating current. It is, however, an inherently brittle metal. In the earlier tungsten lamps, it was not possible to draw the filaments, but the metal had to be finely powdered, mixed with a binding material, squirted through a die, and then the binder burned out and the particles

* The normal life of an incandescent electric lamp is not taken as the operating life until such time as the filament ruptures, but until such time when the candlepower has decreased to 80 per cent. of the initial value.

of metal sintered together to form the filament. This naturally led to a fragile filament. Due to improvements in the refining process in the metallurgy of tungsten, it has been possible since 1911 to convert tungsten into a ductile form, so that wire for tungsten filaments may now be drawn, resulting in a mechanically stronger filament. The yearly improvement in filament strength is shown graphically in Fig. 1*. The great increase in

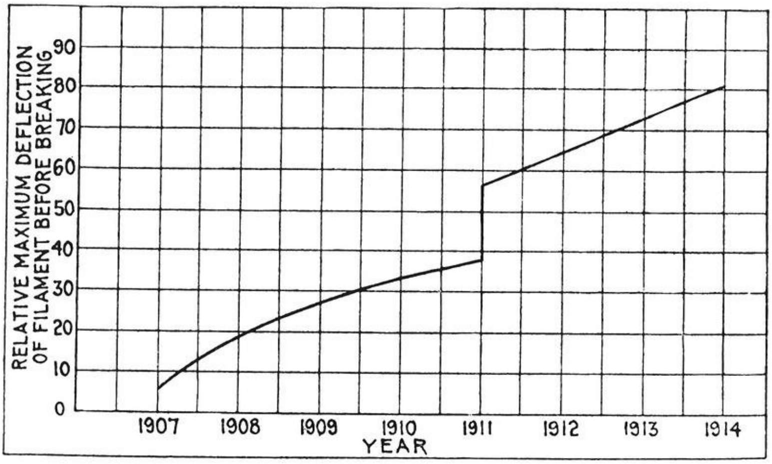


Fig. 1.

strength in the year 1911 is due to the introduction of the drawn wire filament at that time. The increase in the strength of filament as shown in the above figure, implies also a gain in the uniformity and homogeniety of the filament structure, resulting in an increased efficiency for the same life performance.

As the efficiency at which a filament may be operated is limited by the rate of decrease of candlepower, it was found desirable to provide means for preventing the blackening of the bulb which is the principle cause of the decrease in candlepower. It appeared at first that this blackening might be due to the chemical action of residual gases, such as oxygen, hydrogen, and water vapor, which were not entirely removed by the pumping pro-

* Harrison and Edwards, Illuminating Engineering Society Convention, Sept. 1913.

cess. The amount of such gases would in any case be very small, as the pressure in the bulb of an ordinary vacuum lamp is of the order of 0.001 mm. of mercury. Tests showed that at very much lower pressures—lower than can be measured by the most sensitive vacuum gauges—the blackening still occurs. Extended investigations* carried on to determine the effect of different gases on the disintegration of the tungsten filament, showed that unless great care is taken at the time of pumping the lamps to free the walls of the bulb from adhering gases by heating that serious blackening or short life occurs. The most important gases which may remain due to having been present in the atmosphere are oxygen, hydrogen, nitrogen, carbon dioxide, carbon monoxide, and water vapor. Of these, it was found that at the operating temperature of the filament, oxygen reacts with the tungsten to form WO_3, which deposits on the bulb, but is invisible because of its light color. With the small amount of oxygen which may be present, this deposit is of no serious consequence. Hydrogen and nitrogen appear to be chemically inert. Carbon dioxide and carbon monoxide produce a slight amount of blackening which may be neglected. Water vapor, which clings very tenaciously to the walls of the bulb, has a very marked effect. Even a small amount of it will cause serious blackening by acting as a catalytic agent, decomposing in the hottest regions at the surface of the filament to form free hydrogen and allow the oxygen to combine with the tungsten to form WO_3. This oxide is split up again in the cooler zones at the walls of the bulb by the action of the free hydrogen to form water vapor and deposit metallic tungsten on the glass. The water vapor so formed again attacks the filament with a repetition of the process. Thus a small amount of water vapor may ultimately cause a large amount of filament material to be deposited on the walls of the bulb. It appears practically impossible to remove the last traces of water vapor, even by heating the lamp bulbs to temperatures as high as 500°C, but it is improbable that with lamps which are pumped with the bulbs at high temperatures that the free water vapor which exists under normal operating conditions can cause serious blackening.

* Langmuir, A. I. E. E. Proc., Oct. 1913.

As vacuum lamps operated at specific consumptions (or so-called efficiencies) of 0.95 and 1.0 watts per candlepower still show short lives even when care is taken to remove as much water vapor as possible by heating a high temperatures, it is reasonable to attribute the deposit of filament material, not to chemical action but to physical evaporation. One of the means provided in the vacuum type tungsten lamps now being manufactured for the prevention of blackening is the use of chemical compounds known technically as ''vacuum getters''. These ''getters'' are introduced into the bulbs at the time of manufacture and are slowly vaporized during the operation of the lamps, combining with the black deposit of tungsten to form a light colored and nearly transparent deposit. This means a slower rate in the decrease of candle-power, and hence, for the same useful life, permits of efficiencies as high as from 0.95 to 1.1 watt per candlepower. The getter is usually placed on the mounting hooks of the filament.

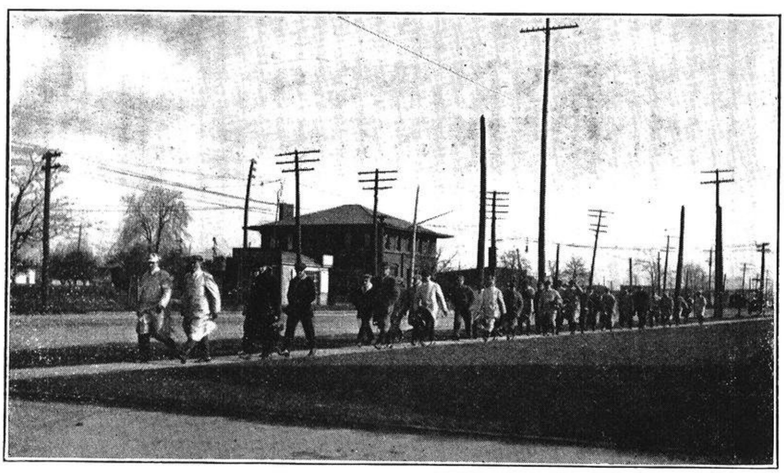
Since the use of the ''vacuum getter'' did not promise any great improvement in the increase of efficiency and since the decrease in luminous output is due to the deposit of filament material by physical evaporation rather than by chemical action of the residual gases, it has been found possible to obtain increased efficiencies in the larger sized lamps by neutralizing to some extent the vapor tension of the tungsten. The rate of evaporation of filament material when operation in a vacuum is much greater than it would be at increased pressures. By surrounding the filament with an inert gas at higher pressure—usually at a pressure of about one atmosphere—the rate of evaporation is greatly reduced with, however, a consequent additional energy loss due to conduction and convection currents in the gas. The gain in luminous output, due to a somewhat increased temperature, is much greater than the increase in energy loss, so that a gain in efficiency is obtained even though this gain is a differential one. By the use of nitrogen as the inert gas, it has been found possible to produce lamps in the larger sizes (1000 watts and upwards) with efficiencies ranging from 0.4 to 0.5 watt per candle. Lamps of 2500 watt capacity and having a candlepower of 5000 have been constructed for 110 volt operation, and the manufacturers stand ready to build even larger lamps. Up to the present, the use of nitrogen is restricted to the larger lamps, since to limit the convection losses, it is necessary to use a filament of considerable diameter which will have the desired heat storage capacity. Lamps are now being built more ruggedly by the use of helically coiled filaments which give additional strength due to an elasticity and greater heat storage capacity due to compact arrangement. As might be expected, the nitrogen lamp bulbs run very hot and the bulbs must be specially designed to take care of the heat radiation.

THE EASTERN TRIP.

By Ivan A. Hickelhaupt.

Before we start this little narrative, we wish to assure the readers that we are an absolutely unprejudiced party and that such events as we tell of came to our notice directly—if we miss any of the "good ones" put us wise and we'll run an appendix or sequel next month.

In the first place the bunch, fifty-five strong, left Madison on or about the fifteenth of November. Being uncertain as to the exact hour of departure we can only say that it was about the middle of the night—at least that. At any rate we were just getting to sleep when the alarm clock recalled us from our dreams of "cons", "exes", long "overdue reports" etc., to the material conviction of the biggest engineers trip in years.



Well, as before said, we got started—and all in a bunch at that. The three hours between Madison and Milwaukee went like a shot. Some of the boys frolicked, others sang, Bob wrote a couple of songs, and everybody did everything but sleep (this was true throughout the whole trip).

At West Allis the horrible crew left the train and took an electric for Allis-Chalmers Plant, the first big job of the season.

The Allis-Chalmers Plant was good. Most of the boys left there convinced that it was some plant, and it was. We saw a lot of things that were interesting, walked about seven miles, and learned more about shop arrangement and management than we ever dreamed existed. They treated us mighty nice and if we were not cherishing a fond dream of sometime being engineer of a peanut wagon, we would not mind working for that outfit.

It was a pretty gay gang that took the special electric for the Blatz Hotel and a big dinner that noon. At the time we felt that we had done a mighty hard day's work, but four days later Allis Chalmers looked like a sweet dream of healthy youth compared with some of the hikes we had taken.

At the Blatz we were entertained royally by the alumni. They certainly treated us fine—speeches, good food and "some soup."

We learned all about the big things that we are to run up against about next June and how to approach them. And seriously we got a whole lot out of it—we mean the speeches not the dinner.

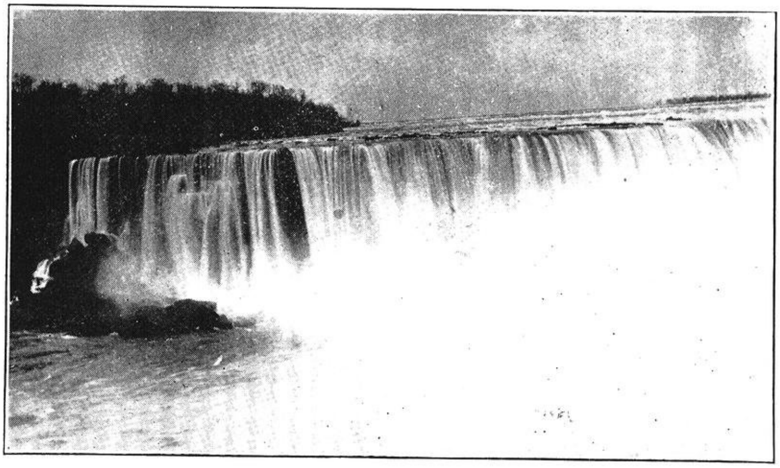
At two o'clock we left for Chicago, and after spending about one hour and forty minutes there as well as $1.60, we jumped the Michigan Central for Niagra Falls. Right here we made a mistake, we should have each gone by a separate road and thus gotten some sleep. But we didn't and although it was quite an overload we managed to do without sleep that night. In the first place that was some trip. Next Michigan beat Penn. After that three ladies came through the car. And then Schmidty and Willie Miller decided to get up and look for the falls (out loud). Moreover Christy swears that there was no Chinaman on board, and when we say "swear" we mean "swore". Withall it was well worth the money. The only trouble being that on such occassions we do not favor continuous performance.

At Niagra Falls we stopped at the Imperial and its genial host Mr. Greenwood certainly showed us a good time. In the morning we sneaked off in groups to see the falls. *(Editor's Note: the following nineteen pages of description have been omitted because of lack of space). In the afternoon we took the gorge trip and met "Shorty, the man with the dollar necktie." By the way we entertained the Penn football team and about a hundred rooters Sunday noon. They were a might fine bunch and good sports. Resolved that we favor a game with Penn. Sunday night was spent in many ways—some of which we will not mention—but mostly in sleep.

Bright and early Monday morning we were up. Now when we say "bright and early" we use it in a modified sense—it really wasn't bright because it was too early to be bright. Get me? Anyway we got up, not because we wanted to, but because we were called. During the ensuing day we saw lots of things as follows; The Niagara Falls Power Company, The Acheson Graphite Company, The International Paper Company, The Niagara Falls Hydraulic Company, The Ontario Power Company, and last, but by no means least, The Shredded Biscuit Company.

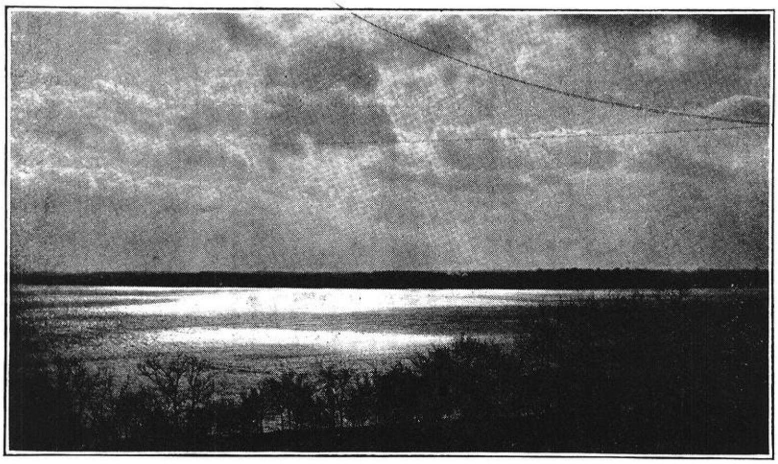
Boys, you oughta seen the girls.

Later in the afternoon we left for Buffalo, a short ride of about half an hour. At Buffalo, we staid at the Statler Hotel and she certainly was a bird. They were just about the nicest people we met. They have some town there, too. Not so very large but full of electric signs. If you ever get to Buffalo, take a tip from the Engineers and eat at the Tech. Tuesday we started work again and again we started early. About this time, the trained observer noted signs of lassitude in the movements of a few of the hitherto agile members of the crew. Oh, not so very shaggy—but just a little bit. To say the least the boys were commencing to sleep when they hit the hay and to leave it with great reluctance in the morning.



Of course primarily we went to Buffalo to inspect and this is what we saw: The Cataract Power Company's Terminal Station. The Spencer-Kellogg Company's Oil Factory, The Buffalo Smelting Company, and the Electricals (dogone 'em) saw Wheat's Ice Cream Factory. Also we saw and went through the Pierce Motor Car Company. Good night, but that was a very, very long walk. Dad Hinkley passed away, and many of the younger members were carried out. It was here that the "Old Frame" club sprang into existence. Coming back from this trip Jack Corley fell through a window. Now some of the on-lookers think that the boys were rough-housing but we have it straight that he was so tired he just naturally toppled over and the window was in the way.

That night we played around—that is to say, all those who were not too stiff. Some went to a show, and some to bed. A choosen few went to a tango party. But that's a long story. At eleven-fifteen we left for Pittsburg, and when we left we hated to go.



But when we got there we were glad we came.

For real dirt and smoke, Pittsburg has got this world and parts of the next cheated in forty ways. That is the town where a man is looked on with suspicion if he wears a clean collar and is exiled from society if there are no cinders behind his ears. But they have a great old bunch of alumni there and we take, off our hat with a flourish to the gang that helped us drive away dull care on Wednesday evening.

At Pittsburg, we saw among other things, The Entire Westinghouse out-lay, The National Tube Company, The McKeesport Tinplate Works, and the Mesta Machine Company.

On Wednesday night in this same smoky town the Alumni gave us the time of our young lives at a very smoky smoker. A smoker is very appropriate in Pittsburg—preferable in fact to the surrounding atmosphere. There were speeches and songs and yells and when it was all over the old boys told us confidentially that we were the best bunch they had ever seen, as well as a lot of other things that natural modesty forbids our telling.

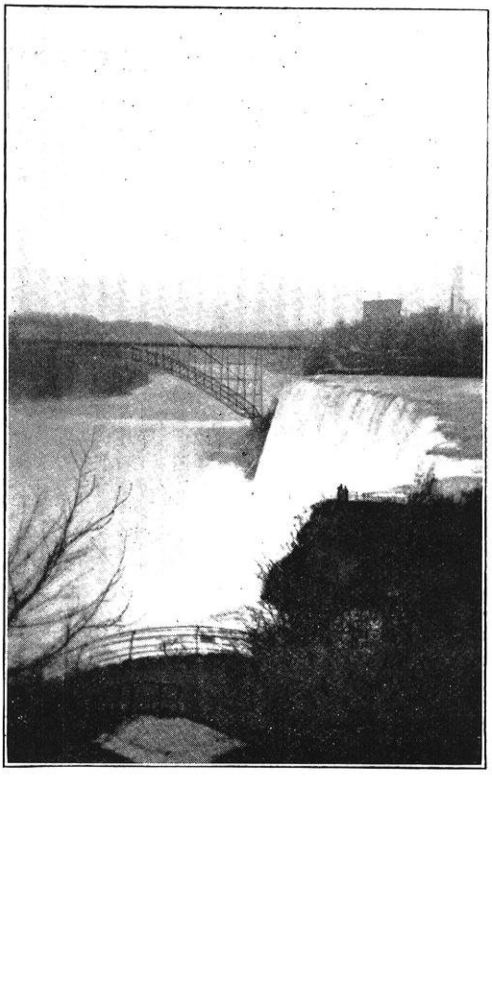
Thursday evening we took the train for Gary and fell asleep early in the evening trying to figure out just how it was that we beat old Father Time out of an hour in changing from Eastern to Central time. We arrived at a very hazy conclusion and awoke with a start to commence our last days work at the Indiana Steel Company.

Gary was discovered in the cold blue light of morning to be a rather desolate looking burg planted among the sand dunes south of Chicago. We can't give a very detailed description of this same town due to the fact that the same dust and sand was blowing in great quantities and every time we tried to get a mere conception of the landscape we got a piece of pig iron or a broken bottle in our eye. At any rate the gang voted to black-ball Gary as a permanent place of residence. The Indiana Steel Company has an enormous plant there. We walked just about sixteen miles and then quit to go to dinner with a sneaking idea that we had not seen it all.

After lunch we took the train for Buffington and while there went through the Universal Portland Cement Company's plant. That was indeed a dusty trip but a well managed one. The main trouble seemed to be that the cement caked and set on the fellows faces and necessitated the use of a stone crusher instead of a wash-rag.

The same evening we arrived in Chicago—all-in but happy. It certainly seemed good to get back among friends and as we walked down the streets and met Wisconsin men and saw Wisconsin colors we were pretty well satisfied with our "army efforts" and mighty glad that we were going to see the best team win the next day. Well, the best team did win the next day even if the gamest team lost—but that's another story.

Saturday morning the Mechanicals took in the Northwest Station of the Commonwealth Edison Company, and the Electricals descended on the Chicago and Automatic Telephone Exchanges. It certainly was a dream of an inspection after the stuff we had been going through. Before going on we want to get in a couple of words about the big breaking up banquet that we had at States restaurant on Friday night. There we met a few of the loyal old boys—Engineers of the former classes—and the whole bunch cut loose for the last time with all the songs and yells we knew. Mr.



State staged some mighty good cabaret and the original Wisconsin girl sang for us. Some GIRL. And when the bunch broke up that night, believe us, we knew each other.

We've got a big hunch that a long time from now when we are all out taking our little part in the practical stuff—when we're a long way from Wisconsin and the old gang—perhaps while we're waiting for a sporting edition of the Chicago game—we are going to think about the trip and the bunch and we're going to consider the coin we dropped about the best little investment we ever made because it got us acquainted with the finest old gang of scouts in the school. And after all, it seems as though a fellow can get a lot farther with a bunch of good friends behind him than he can with all the scholastic honors in the world. What do yuh think? Ain't it so?

Before we get into this deep stuff too far we better end the narrative of the great Trip, and it's not a cheerful ending at that. Chicago licked us—they sure did, but the fellows fought and the Wisconsin spirit was there. It was a great game and the greatest and most revealing part of the whole thing was to see a thousand Wisconsin men get up after a 19 to 0 game with Chicago at the long end, and sing the Varsity Toast.

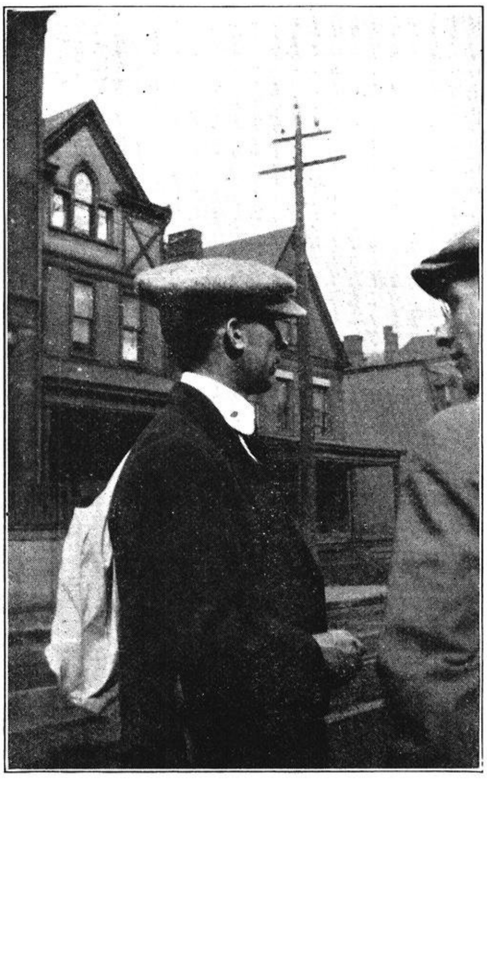
Yes, Chicago won and Wisconsin won—Chicago—the game, and Wisconsin—respect. Next year, if the boss will let us we're coming back to see Wisconsin win both.

SENIOR ENGINEERING INSPECTION TRIP

By H. E. Kranz, '14

We, of the Western Party of Electrical and Mechanical Engineers, left Madison Sunday afternoon, November 16th, going to Milwaukee.

The following morning we visited the Falk Company plant where heavy castings and machines are manufactured. We had heard of many uses of Sapolio, but its use in finishing fine turbine gears was a new one on us. An item of special interest was a 3/8 inch spindle of a pinion of the herring-bone type designed to transmit ten horse-power at a speed of 21,000 R. P. M. Its



use was in connection with wireless telegraph work to develop high frequencies. We saw workmen cut off a 6x13 in. riser on a steel casting in four minutes with the oxygen-hydrogen flame. That a highly developed faculty of observation is not confined to the college trained man was evident when we found a furnace tender who could tell, by inspection, the amount of carbon in a sample of steel within two hundredths of one per cent.

On Monday afternoon we visited the shops of the Chicago, Milwaukee and St. Paul Railroad. These shops are used for the repairing of locomotives, and passenger and freight equipment, also for the construction of freight cars. In one section of their foundry they are equipped to turn out 400 car wheels per day. After viewing the remains of passenger coaches that had been through wrecks, no doubt remained in our minds in regard to the supremacy of the steel coach.

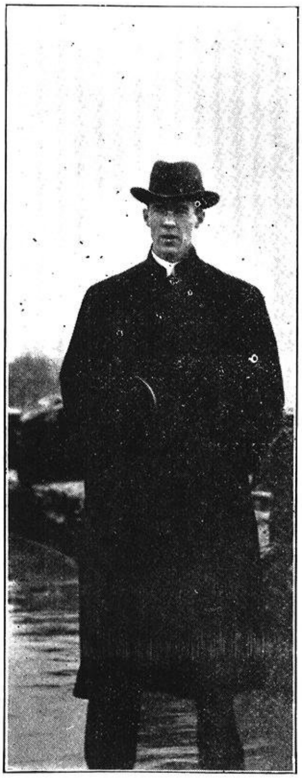
Tuesday morning we visited the Commerce Street Power Station. They have a unique plan here to secure boiler-room efficiency. The company sets a standard of 32,500 B.t.u. per kilowatt output and 40 per cent of any increase the men may make over this, by careful firing, is added to their wages, smoke fines being deducted. The men have been able to increase their wages materially. This is the plant that distributes the majority of the electrical power developed at the Kilbourn dam.

We then visited the Cutler-Hammer Company, who manufacture various electrical controlling devices. Here we saw the Thomas Gas Meter, that is to be installed at Madison, being tested and had its operation explained to us.

We were guests of the Allis-Chalmers Company at dinner at their fine club house and then inspected the plant. W. D. Bliss, '13, was right on hand and assisted in explaining the intricacies of the plant to us. A large variety of electrical, steam, gas and water-power machinery is manufactured. A 2,000 H.P. tandem, compound reversing engine, to be used in the new steel mills near Duluth, was in the process of construction.

Wednesday morning we left for Kenosha where we inspected the Thos. B. Jeffrey Co. automobile factory, following through the process of manufacturing the cars. We now know a car from the glare to the smell. One of the special exhibits was a Bliss press "capable of exerting a pressure of 3,000,000 pounds per square inch.'' Some of the party thought that ciphers were handled rather carelessly by our guide in making this statement.

The plants of the Badger Brass Mfg. Co., where we witnessed the processes of drawing and spinning, and the American Brass Co., where they manufacture brass, copper, and german silver plate and tubing, were also visited.



Chicago was the next stop on our schedule. We reached there Wednesday night, stopping at Hotel Sherman.

Thursday morning we inspected the plant of the Western Electric Company, manufacturers of telephone apparatus and the second largest manufacturers of electrical apparatus in the world. This is the company that developed the multiple drill press and the full automatic screw machines, a large number of both of which are used in this factory. The fine lighting and ventilation, the extensive application of safety devices, and the welfare work were notable features of this factory. A fine dinner awaited us at the club rooms of the company employes on completing the inspection.

The Fisk and Quarry Street stations of the Commonwealth Edison Company were also visited. The combined output of these plants is over 200,000 kilowatts. Curtis vertical turbo-generators of 12,000 K. W. and 14,000 K. W. capacity are used exclusively.

The party took the train to Buffington, Indiana Friday morning to inspect the Universal Portland Cement Company's plants. The combined output of these plants is 250 car-loads of cement per day. Power for the operation of the cement plants is generated by gas engines using the waste blast furnace gases of the steel companies at Chicago and Gary. The blast furnace slag, which is one of the raw materials used in the manufacture of Portland cement, is also obtained from these steel mills. Special caps and dusters were furnished us, which were much appreciated, as a cement mill is of necessity a dusty place.

The Indiana Steel Company at Gary was our next stop. Here we met the eastern party about to leave for Buffington. After inspecting the steel plant which usually employs about 9,000 men, but was then in only partial operation, we returned to Chicago.

That night some of the party visited the Tribune Building and witnessed the process of getting out the morning edition of one of the big dailies.

The electrical engineers of both parties visited both the Chicago Telephone Co. and the Automatic Telephone Co. Saturday morning. Much interest was displayed in the operation in the latter and in the operators in the former.

The final number on the schedule was the Chicago game.

The faculty members in charge of the party were Mr. Goddard of the Mechanical Engineering department and Mr. Kelso of the Electrical Engineering department.

The Wisconsin Engineer.

John W. Young, *General Manager.*

C. M. Osterheld, *Editor.*
I. A. Bickelhaupt, *Features.*
C. N. Hitchcock, *Ass't Editor.*
C. E. Broders, *Photographer.*
E. R. Adlington, *Revisor.*
F. D. Bickel, *Departmental Notes.*
Harlow Bradley, *Advertising.*
J. F. Harper, *Local Circulation.*
E. L. Andrew, *Foreign Circulation.*
MacLean Houston, *Exchange Mgr.*
William Kiley, *Secretary to General Manager.*

ALUMNI REPRESENTATIVES

J. G. Wray, '93, Chief Engineer Chicago Telephone Co., Chicago, Ill.
A. C. Scott, '02, Professor of Electrical Engineering, University of Texas, Austin, Texas.
A. J. Quigley, '03, Sales Engineer, Agutter-Griswold Co., Seattle, Wash.
R. T. Herdegen, '06, A. O. Smith Co., Milwaukee, Wis.
Frank E. Fisher, '06, Electrical Engineer, Diehl Mfg. Co., Elizabethport, N. J.
R. H. Ford, '06, '09, Electrical Engineer, General Electric Co., Lynn Mass.
J. E. Kaulfuss, '08, Instructor of Civil Engineering, University of Maine, Orono, Maine.
**M. D. Cooper, '08, Electrical Engineer, National Electric Lamp Association, Cleveland, Ohio.
Minn.**
F. E. Bates, '09, '10, Civil Engineer, Drafting Dept., Kansas City Terminal Ry. Co., Kansas City, Mo.
F. C. Ruhloff, '12, Mechanical Engineer, The Bucyrus Co., So. Milwaukee, Wis.
Hale H. Hunner, '09, Civil Engineer, Meriden Iron Co., Hibbing, Minn.

EDITORIALS

In a few more days we will be going home for the Christmas holidays. To some of us this will be our last visit home as college students; while many others will see the old home for the first time since entering college.

Going home is one of the greatest joys a college man can have, especially if he has done himself and his people credit in the way he has handled his work. Even if he hasn't he will find the same cheerful welcome that the man maintaining an ''Ex'' average will receive. But how unfair to the people that have faith in us, how unjust to expect them to maintain their confidence in us if we do nothing to merit it!

We don't believe in resolutions, but we do believe in effort. Let's get a start now! The new year can only be happy if we are tolerably successful, and this can be accomplished by application. We have made our mistakes, we appreciate that now to some extent and will appreciate it fully after spending a few evenings with the members of our family. We are coming back to make good, back to end up strong; we are going to be better men and stronger students for that trip home.

So in parting, we extend to the Agric, the Chemist, the Hill Student—even to the inhabitants of the Law Barn—in fact, we extend to all a MERRY CHRISTMAS and A HAPPY NEW YEAR.

We wish to announce several articles which will soon appear and which we are sure will be of great interest to our readers.

Prof. Smith's article on ''Road Maintenance'', will appear in our next issue.

Prof. Kowalke will write another article of peculiar interest to chemical engineers.

Do you understand the importance and principles of the gyrostat? Prof. Maurer will clear these matters up next month.

Are you looking forward to that Karapetoff article? It's ready for you.

THE SENIOR INSPECTION TRIPS.

We are publishing two accounts of the Senior Inspection trips in this issue. They are written by different men, and on entirely different lines. We believe you will enjoy both of the articles, and will be interested enough to read them through to the,—but to get to the point.

There was something to the trip besides a good time, and jolly fellowship, and midnight tours, or largest engines, smallest turbines or highest, widest, and longest buildings, and that something is what we wish to emphasize.

A great many of the fellows that left here November 15th did not have the vaguest idea of the working conditions or the organization of a big factory. "Welfare work," "safety first," and "profit sharing schemes" were nothing more or less than a term applied to some unknown equation about a factory or manufacturing plant. The abundance of windows, electric lights, white walls, and high roofed buildings in some plants as compared to the dark damp, low-ceilinged sheds in others opened many a man's eyes to what people will put up with to earn a living. And some of these people earn their living! Ten or twelve hours at a swift, mechanical-like operation are anything but pleasant and it made some of us see why there is such an intense interest in any movement that attempts to benefit the working-man.

The business which is running in sharp competition with others in its own line of industry invariably showed the efforts that were being made to provide clean, sanitary, and cheerful sursoundings for its employees. The arrangement of the shops to cut down time and distance between operations, and to facilitate the manufacture of a certain article in the shortest possible time in the best possible manner, and at the lowest possible cost. At some plants, after walking through them, the observer could sit down and see a perfect picture in his mind of the layout of the plant.

In contrast to this would be the well-established business either protected by natural location, an abundance of capital, or some such factor, that did not have to make a price to meet competition but merely turn over a reasonable dividend each year. Buildings a decade old, floors full of holes, windows broken and full of dirt, loose belts, wabbly shafting, and almost any sort of layout. In one plant that employed over one thousand people one of the observers was unable to note a single wash-basin or even a pail for the men to wash up in.

We are not writing this article as a criticism of any of the plants that were visited, nor are we attempting to disclose any thing that is not already known to a great many people. but what we are trying to do is to show to what extremes conditions go in some places. When an Engineer makes up his plans for a piece of construction work, or designs a large factory, he cannot do the work justice unless he has first-hand knowledge of labor conditions, the nature of the population, and the general economic condition of the surrounding country. One would never build a steel mill in central Kansas, yet a branch automobile factory would have a wonderful location there. The parts could be made in the home factory, and then boxed and shipped to the branch for assembling. A case has been called to our attention where an Electric Light Company bought apparatus that would develop 1500 KW and the highest peak load the town ever had was 250 KW. Our reader will smile, and think, well that wouldn't happen to him, yet he might be the next person to go ahead and build a large factory in a residence town.

It is this sense of proportion and judgment and understanding of human nature which so many people do not have, and which is so important, that we believe was emphasized by the Senior Inspection Trips. When Inspection trips can do such a service their value cannot be over-estimated.

AN ANNOUNCEMENT

Our organization has not been running the way we expected it to run, in fact it has gone just about the reverse to what it should go.

We believe that when a man is working on this magazine he ought to be getting some good business experience out of it. One of the first things in business is responsibility, and that is something that has been sadly absent in the staff of the Wisconsin Engineer. There are a few men on the staff that can be depended upon to not only do what they are requested to do, but also to use good judgment and lots of common sense when up against a new proposition. Those are the kind of men that we are always on the watch for, but they are few and far between. Accordingly, if we must take men that are not up to this standard, we must train them and educate them in our business until they will be on a par with the first-mentioned type.

This is our third issue, and we should be pretty well organized by this time, and every man ought to realize just how important he is to the magazine. When A neglects to get copy for an ad, or B forgets to look up a photograph, or C fails to turn in an article, the entire paper is held up for this one man. As a result the good work of eight or ten others is wiped out. One drop of ink will spoil a glass of water.

For these reasons, we feel justified in announcing that the next failure of any member of the staff to perform a duty assigned to him, will result in his immediate dismissal. The Wisconsin Engineer will most likely suffer from the loss of the member, but we believe that in the end the magazine will be so much bettered that it is worth the cost.

THE WISCONSIN ENGINEER
By JOHN W. YOUNG,
General Manager.

MECHANICS DEPARTMENT

An investigation is being carried on for the Ft. Wayne Electric Company, Madison, Wis., on steel used by them for their rock drills. The object of this series of experiments is to determine just what heat treatment and chemical treatment the steel should have to produce a drill which will stand up well in practice. At present three different steels are being tried out. Some of the variables which are being experimented with are as follows: Quenching with oil through various temperatures; quenching in water through various temperatures; quenching in oil and drawing the temper various amounts; quenching in water and drawing the temper; quenching in oil heated to different temperatures; quenching in water heated to various temperatures; and forging at different temperatures before heating and quenching. Both tensile and fatigue tests are being made. This investigation is being carried on by Professor Kommers, and the fatigue tests are being made on a machine which he has recently designed.

In addition to the above investigation, this department is cooperating with two national associations in experimental work. In conjunction with the National Association of Cemet Users, a series of tests is being arranged to determine the effect of sands differing in fineness upon the strength of concrete made from a given coarse aggregate. Experiments on this important question are also being carried on at a number of other laboratories in different parts of this country.

With a committee of the American Society for Testing Materials the Mechanics Department is co-operating in standardizing methods for testing drain tile. The tests which are being standardized are for strength, absorption and durability. The methods of making the strength and absorption tests are being determined at the Engineering Experiment Station of the Iowa State College at Ames, Ia. The standardization of the durability test is being conducted in this department. At present the method of performing the durability test consists in subjecting the tile to alternate periods of freezing and soaking in hot water. After ten freezings and soakings, the specimens are then tested for strength, so that the loss in strength may be determined. Together with these durability tests, the absorption test and the scratch test for hardness are being made. Both cement and clay tile are being experimented upon, and variables in the method of manufacture have been entered into the series of experiments.

ELECTRICAL DEPARTMENT

SPECIAL INVESTIGATION

In most of the cities of the state in which street lighting contracts exist, we find that the contract specifies a unit cost of so much per lamp per year with a certain schedule of burning but with very little said as to the illuminant other than its general type and perhaps its wattage consumption, and nothing as to the mounting height or the character of the Illumination produced. In too many cases, we find that even if the illumination produced along the street were adequate for seeing purposes, the blinding glare of a high power illuminant suspended but a short distance above the street defeats the purpose of the installation. Very little data is available upon which to base adequate street lighting specifications, and in order to determine satisfactory minimum mounting heights for different types of commercial street illuminants, special investigations will be carried on within the next few weeks in the neighborhood of the Electrical Laboratories. The work will be under the direction of Mr. A. J. Sweet of the firm of Vaughn, Meyer, and Sweet, Consulting Engineers, Milwaukee, Wis., who is working jointly with Mr. J. N. Cadby of the Railroad Commission and Prof. Bennet and M. Kartak of the Electrical Engineering Department. In order to eliminate the effects of personal errors, a large number of observers will be used, most of whom will be men taking the course in Illumination and Photometry.

HYDRAULICS DEPARTMENT

Mr. Robert S. Drew, B. S. in C. E. Wisconsin 1913 was recently elected to the scholarship made vacant by the resignation of Mr. Max Rather. Mr. Drew was Chief Engineer of the Civil Engineers Summer Camp at Devil's Lake this summer.

A store room for the hydraulics laboratory is being erected just north of the tank house and adjoining the laboratory on the east.

ALUMNI NOTES

The University is now getting out a set of return cards for a new alumni directory. These cards will go out in about a week, and we urge every alumnus to respond promptly to the inquiries.

After the majority of the cards are in we are going to run a special feature, giving all changes and advances that have been made in the alumni department, by classes. In this way you can look up any of your old schoolmates, or friends that you may be interested in.