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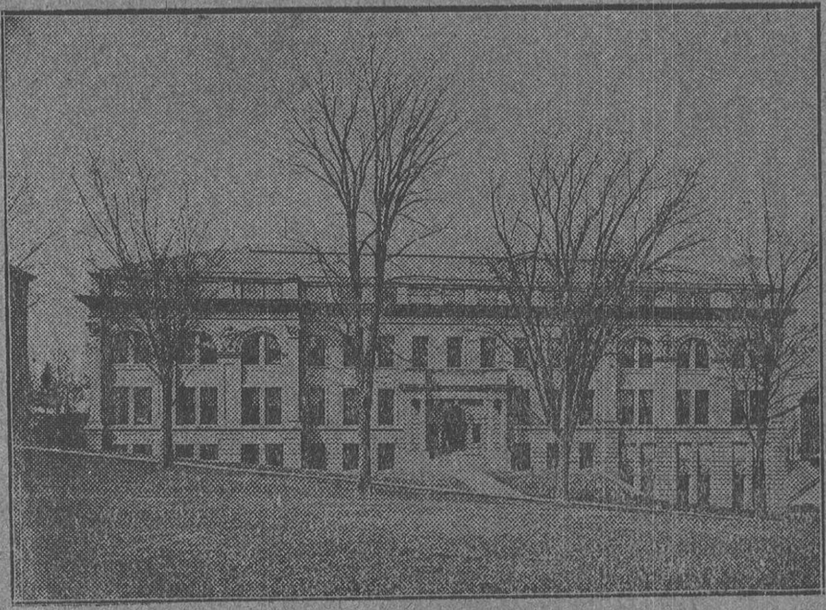
THE
WISCONSIN ENGINEER

Vol. 8 APRIL, 1904 No. 3



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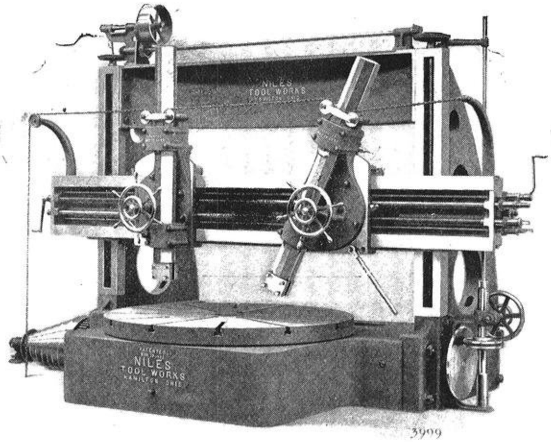
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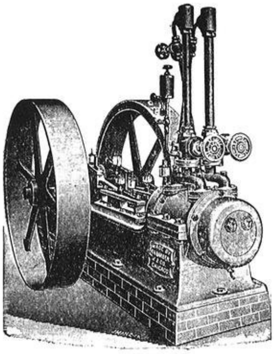

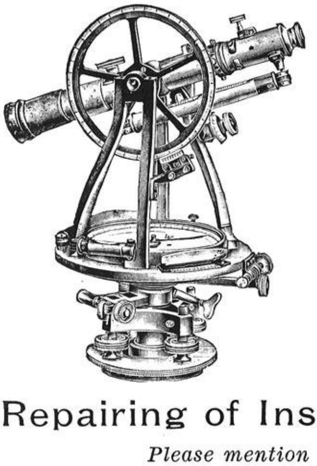

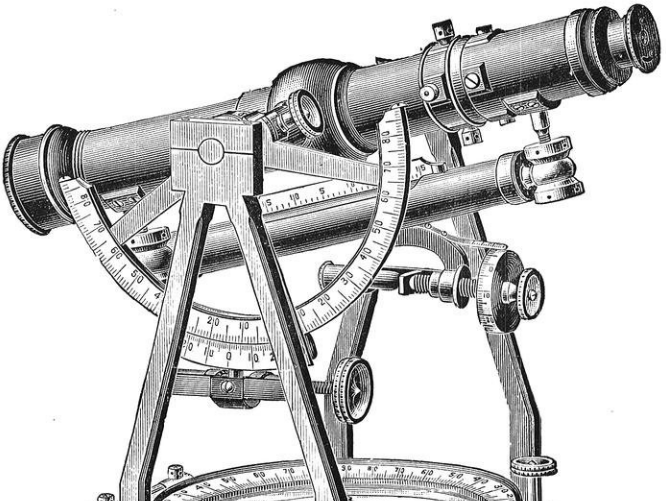
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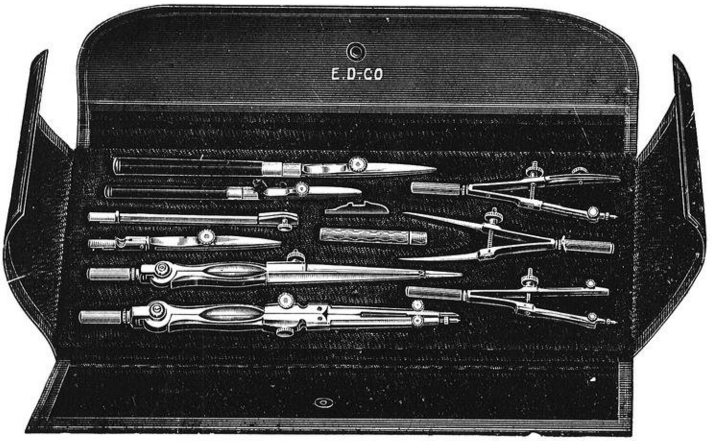
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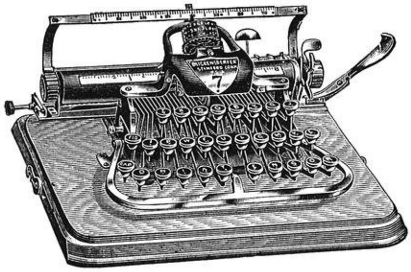

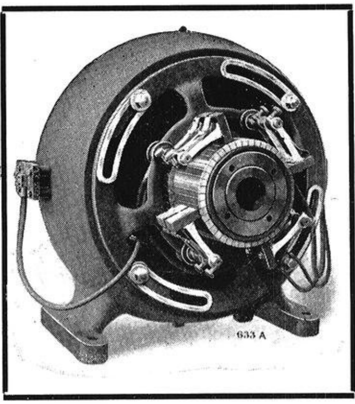
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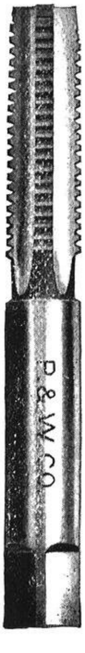
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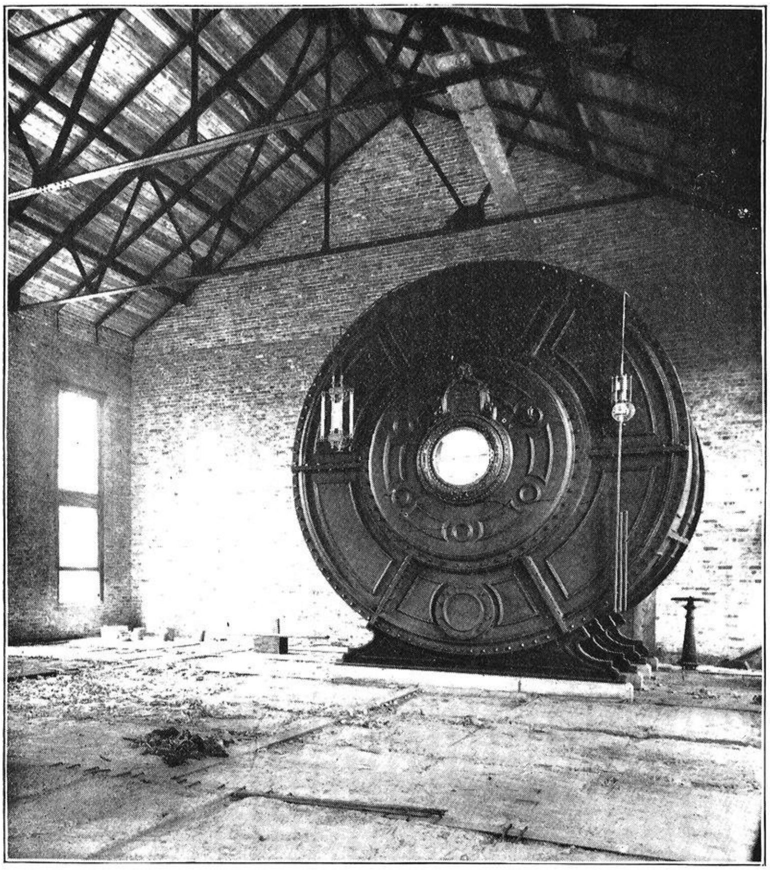


Station Meter at Laclede Gas Works, St. Louis.

THE WISCONSIN ENGINEER

VOL. 8 APRIL, 1904 NO. 3

GAS ENGINEERING.

[A lecture before the students of the University of Wisconsin, by W. A. Baehr, '84, February, 1904.]

Gentlemen:—When I first undertook to give you a talk on Gas Engineering, it was with the idea of adding my mite towards the better understanding of this profession by people not connected with it. It is difficult at present to assign a good reason why the gas business should be considered mysterious in any way, since in all companies with whom I have been associated, it has been the invariable custom to welcome visitors to the works and shops, and to carefully explain all the steps in the process of manufacture and distribution, believing that a broad, liberal, and open policy is superior and more conducive to the good will of the public than the old idea of concealment.

It is therefore, with pleasure that I will try to give you an insight into the engineering features of a business which, in point of magnitude, ranks among the largest industries of the United States and of the civilized world.

GAS ENGINEERING.

It would be extremely desirable if I could define Gas Engineering for you, but it is rather difficult. You will agree with me after the lecture, that a gas engineer has need of civil, mechanical, electrical and chemical knowledge, and I will therefore leave the definition of this profession to crystallize in your minds during the progress of the lecture.

DIVISION OF SUBJECT.

We naturally divide Gas Engineering into two parts, viz: Manufacture and Distribution. The former embraces all the steps from the crude to the finished product, while the latter takes the gas from the outlet of the works and leads it through various paths and apparatus to the consumer's burner.

MANUFACTURE.

Under this head we will consider the following great divisions, viz: Natural and Artificial Gas. While natural gas has been, and still is, an important economic factor among the industries of this country, of course not considering it actually manufactured, yet it is declining slowly but surely, and I will only say of it that it is composed largely of methane, or CH_4, and has a high heat value, one cubic foot being able to develope approximately 1000 B. T. U. upon combustion in air. There is at present no artificial gas which has such high thermalvalue, and is at the same time a large commercial success. But as the art is constantly advancing, and because of closer association, I will confine my efforts to explaining the production of Artificial Gas.

Under this subject, and stated in the order of their importance, we can group the following kinds of gases:

1. Coal Gas.
2. Water Gas.
3. By-product Coke Oven Gas, such ovens being distinguished from the bee-hive type.
4. Producer Gas.
5. Oil and Pintsch Gas—Lowe Oil Gas.
6. Blast Furnace Gas.
7. Acetylene, wood gas, garbage gas, etc.

Taking these up in order, we will first consider the manufacture of—

COAL GAS.

This art is about a century old. William Murdoch, in England, between the years of 1792 and 1798, was engaged in experimenting with different coals, and in divising apparatus for their distillation. In 1797–8, lighting by coal gas became an accomplished fact, for Murdoch, by means of his experimental plant, first lighted up his dwelling house, and a short time later a considerably larger building at Birmingham.

From these first attempts, coal gas manufacture has successively progressed up to the present time.

The coal used for gas making purposes is mostly of the caking bituminous variety. In England and on the Continent some cannel coal is used, and non-caking, or even lignite coal can be made to yield gas. These latter two varieties do not give the requisite quantity or quality of gas, nor do they yield any valuable by-products except some tar and ammonia.

It has been found by repeated tests that it is best to use the lump coal, in preference to mine run or slack, on account of increased gas yield and better resulting coke.

The successful carrying on of coal gas manufacture, and the fact that the gas works must run day and night, and all the year round, makes it necessary to have a large coal stock on hand all the time. Furthermore, plants which receive their major portion of coal by water, such being usually the cheaper method of transportation, are limited to a certain portion of the year during which the water transportation facilities are available. Thus a large stock of coal is bound to accumulate, and I can best illustrate this by stating the storage capacity of a few prominent coal gas works:

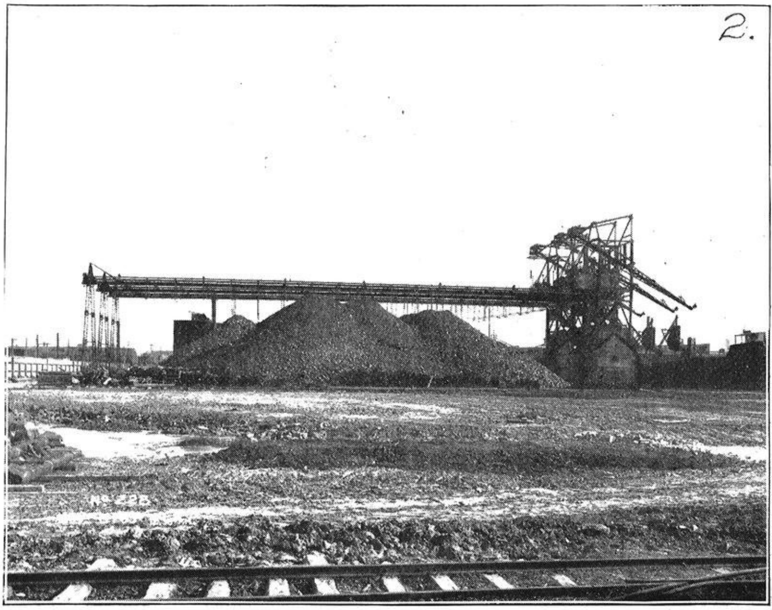
	Population.	Coal Storage Capacity.
Denver...............	150,000	10,000 tons.
Milwaukee............	300,000	125,000 "
St. Louis (Old works)..	700,000	150,000 "
St. Louis (New works)..		probably 500,000 "

At $3.00 per ton, you can readily see the immense amount of money tied up in coal stock.

In modern works, the coal is handled by the most approved machinery, and in some plants, hand labor is practically eliminated.

The distillation of coal is now carried on in clay retorts, usually of a horizontal "D" section. Formerly cast iron retorts were used, but these would not stand the high heats necessary to drive all the gas out of the coal.

The average size horizontal retort in use to-day is probably 15"x26" in cross-section by about nine feet long inside. Such a retort will distill 2000 lbs. of coal per day in six charges, thus taking four hours to burn off one charge. In very recent installations, single retorts take as high as 800 lbs. of coal per charge, and the figure is constantly growing.



Coal Handling Machinery at Milwaukee Plant.

In most works, the retorts are open only at one end, but they are also made with both ends open and are then called "through" retorts. These present an important advantage inasmuch as the coke can be pushed out of them by a comparatively simple discharging machine, which at the same time is readily arranged to act also as a charging machine. In those plants where the retorts are open at one end only, the charging and discharging machinery becomes more complex.

It is an open question today among prominent gas engineers as to whether machine-operated horizontal, or inclined retorts are best. The new Milwaudee gas works is designed with horizontal retorts operated entirely by machinery, and Mr. Brown, Engineer of the Milwaukee Gas Light Co., states they figured a saving of $30,000 per year over inclines. It is undeniably true, however, that inclines are used largely abroad, and some new installations are being erected in this country. Retorts for inclined benches are sometimes as much as twenty feet long, and carbonize a great deal of coal per day. They are usually operated entirely by machinery, and the usual inclination is 32° or 33° from the horizontal.

The number of retorts per bench varies from one to ten. In settings of two retorts per bench, the arrangement is either one alongside the other, or one over the other. Where there are three, usually there is a lower tier of two retorts with one over them.

With four retorts per bench, the usual design is to place them in two vertical rows of two each. With five, the arrangement is similar to four, except there being a fifth retort between the two vertical rows of twos.

We may well call a bench of sixes, or six retorts per bench, the most common and widespread arrangement. Here the retorts are arranged in two vertical rows of threes, and this bench has long been a favorite one among gas men, on account of its ease of regulation and simplicity of construction.

Formerly, benches of eights were built with two outside vertical rows of three retorts each, and one vertical row of twos in the center. This gave rise to a very wide containing arch, and in order to obtain the advantages of the style of construction and of operation of the sixes, foreign Engineers designed a type known as vertical eights. In this design, there are two vertical rows of four retorts each, and you can readily see that the containing arch is narrowed to practically the same width as for a bench of sixes.

The first objection to these vertical eights was, that the upper rows of retorts were so high above the operating floor that they could not be charged by hand. Late improvements in drawing and charging machines have made mechanical operation so certain and cheap, that the objection as to height disappears.

Benches of nines are built with three vertical rows, three retorts each, and benches of tens with two vertical rows of fives. The types can be extended almost indefinitely.

Leaving the upper portions of the benches, we can consider the lower or fire-containing part. Here is the really interesting portion of bench work, and we can divide the various types into the following general classes, viz: isolated generators, and those having one generator or furnace for each bench.

By an isolated generator, we mean a gas producer set in a place by itself, away from the stack of benches, and generating a producer gas which is conducted to the benches and burned around the retorts. The success of this type of construction is dependent somewhat upon the nearness of the producer to the benches, as the gas must not be allowed to cool during its passage. There is an important advantage in isolated generators, inasmuch as one such producer can serve several benches, and thus by means of dampers, the heats in each bench can be closely regulated.

Isolated generators are used somewhat abroad, but have made no headway in this country, but I believe there is a great possibility of their being further developed, and especially so, since they offer such unlimited facilities for recuperation being carried to its limit, even if iron recuperators are necessary, clay being the style now used. In the other type, where each bench has its own furnace, or generator, the division of design is very pronounced, and is based on fundamental principles of thermo-chemistry. We divide such benches into the following kinds:

1. Direct fire-benches.
2. Half depth recuperative benches.
3. Full depth recuperative benches.

A direct fire bench is one in which the air for combustion is drawn directly under the fire, and in which the carbon burns directly to CO_2, according to the equation—$C + O_2 = CO_2$ The retorts are thus heated like an ordinary steam boiler, by the passage of the hot products of combustion around them, and by the heat radiated from the fire. Each pound of carbon in burning to CO_2 thus produces 14,544 B. T. U.

Theoretically 11.54 pounds of air are required to burn one pound of carbon to CO_2, assuming that air consists of 23 parts by weight of oxygen, and 77 parts by weight of nitrogen. Theoretically then the flame temperature of C burning to CO_2, assuming constant specific heats for the gases at all temperatures for ease of calculation, is as follows:

$$\frac{14544}{3.66 \text{ x } .2164 + 8.88 \text{ x } .244}$$

$$(CO_2 \text{ x sp. ht.} + N \text{ x sp. ht.})$$

$$= \frac{14544}{.792 + 2.167}$$

$$= \frac{14544}{2.959} = 4915° \text{ F.}$$

I wish to explain right here, that I am satisfied that the specific heat of gases increases with increase of temperature, but for the purposes of this lecture, it would only result in confusion were I to attempt to use such calculations, and I therefore, use constant values so your minds may be kept clearer concerning the relations of the various parts of the art. In this lecture, therefore, I will use the following heats of combustion:

C to CO_2 = 14544 B. T. U.
C to Co = 4400 B. T. U.
CO to CO_2 = 4348 B. T. U.

Also the following specific heats:

CO_2	.2164
N	.244
Air	.2379
H_2O vapor	.48

Now the losses which occur in a direct fired bench, are due to several causes, as follows:

1. To over ventilation of fires.
2. To loss of heat in flue gases.
3. To other losses by clinkering, radiation, opening of doors, etc., all of which I will call the X losses.

Concerning the first class of losses, it is well known that in practical direct firing, it is impossible to get along without using considerably more than 11.54 pounds of air per pound of carbon. Therefore the flame temperature is reduced by just the proportion of excess oxygen and nitrogen heated from atmospheric temperature to the temperature of the escaping waste gases.

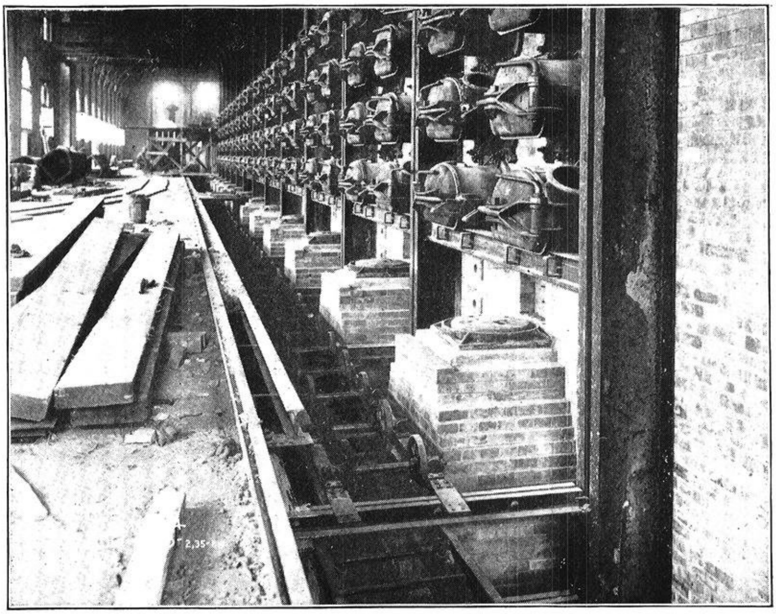
The second class of losses, or the sensible heat carried away by the flue gases, is due to the fact that in direct bench firing there is no way to keep the stack temperature below about 1500° F., thus wasting all the sensible heat of these gases from a temperature of half the above up. I am glad to say that direct fired benches are becoming rare.

Before passing to the second great class of benches, it is necessary that you fully comprehend the difference between the terms recuperative and regenerative. A recuperative bench is one in which both the primary and secondary air, or the secondary only, are preheated by passing through a flue, or set of flues, without reversal in direction, and continuously; the transfer of heat being accomplished *through* the walls of the flues.

Now, a regenerative bench would have its primary and secondary air preheated by passing intermittently through a set of flues which are also intermittently heated by the passage of the waste gases. The point is that the transfer of heat is not accomplished *through* the walls of the flues, but by contact on same surfaces as were touched by the waste gases. In the ordinary coal gas construction, regenerative benches are not used at all, but in some forms of by-product coke ovens, they are used. Bearing in mind then that recuperative benches are those used, we can easily define half depth and full depth benches as follows:

A half depth recuperative bench is one in which the secondary air only is preheated, whereas in a full depth bench both the primary and secondary air are preheated.

With these definitions, I can now proceed to explain modern gaseous firing. This consists of a deep furnace below the bench in which the carbon is first converted into CO_2 in the lower layers of the fuel bed, and this CO_2 on passing up through the incandescent carbon decomposes to CO. The air which is admitted below the fire is called primary air.



Benches.

The CO from the fuel bed passes up through the furnace arch opening and meets the secondary air, which has been preheated by passing in through the recuperators. Surrounding the retorts is the combustion chamber, and here the CO burns to CO_2.

Now when water is admitted below the fire in the ash pan, it vaporizes, and in passing through the fire decomposes to H and O. The oxygen first unites with C to form CO_2, and this in turn decomposes to CO. Thus the gas issuing from the furnace contains N, CO and H. The H in the combustion chamber immediately burns to H_2O vapor again. The water in the ash pan is used to aid in preventing clinkering, and I will now explain a new rational method of clinker prevention, which I think will appeal to all.

Clinkers form because when a fire burns too rapidly a high local temperature is produced, and the ash fuses. Now, in gaseous firing, we burn the carbon to CO_2 in the bottom of the fuel bed and form clinkers. By passing H_2O vapor up with the primary air, as soon as this vapor comes in contact with the hot spots, it is decomposed. This decomposition is an endothermic re-action; that is, heat is absorbed and thus clinkers prevented.

Again, in gaseous firing, we aim to produce CO in the generator, and do it by forming CO_2 in the bottom of the fire. Now when CO_2 decomposes to CO, the reaction is also endothermic, consequently the point is, why can we not introduce CO_2 below the fire; in other words, get just what we want there, and then by having the aforesaid endothermic reaction taking place, prevent the ash from fusing? This is exactly what we can do, and our old friend Siemens, of regenerative furnace fame, did the same thing. He derived his CO_2 from the waste stack gases, but he introduced it by means of a steam jet, and defeated the very object he was after. He put his fire out. However, Mr. Henry L. Doherty, formerly with the Madison Gas & Electric Co., has solved the introduction of the hot CO_2 by means of an air jet, and he deserves the credit of making the use of hot CO_2 for clinker prevention possible. You see we do not wish to use water under the fire, because the high specific heat of H_2O vapor causes too many B. T. U. to be carried out of the chimney with the waste gases. I regard this use of the CO_2 of the waste gases as one of the most important advances of gaseous firing of modern times, as by preventing clinkers we can run gas producers at extremely high tension, that is under heavy blast pressure.

Before leaving the subject of recuperative benches, I will state that gaseous firing has several great advantages over direct firing, among which are the following:

1. The excess of air per pound of carbon is reduced to a minimum.
2. The recuperation enables us to recover a large part of the sensible heat of the waste gases.
3. Regulation is rendered easy.
4. Wear on benches is greatly reduced.
5. There is a great saving in operating expense.

To show the comparative theoretical thermal efficiency of a half depth and a full depth bench, I will give the following calculation. The temperatures in different portions of a bench were determined by means of a Le Chatelier pyrometer and are as follows:

Temperature just above fire.................... 2000° F.
Temperature in combustion chamber............ 2500° F.
Temperature of waste gas, top of recuperator..... 1500° F.
Temperature of waste gases, bottom of recuperator 750° F.

For full depth bench.

Heat produced.

1 lb. of C with 2.66 lb. O and 8.88 lb. N to 3.66 lb. CO_2 and 8.88 lb. N = 14544 B. T. U.

Losses.

3.66 lb. CO_2 from 60° to 2500° F.
$= 3.66 \times .2164 \times 2440$ = 1932 B. T. U.
8.88 lb. N. from 60° to 2500° F.
$= 8.88 \times .244 \times 2440$ = 5287 B. T. U.

Gross loss = 7219 B. T. U.

Recovered by absorption in secondary air which would be

$5.77 \times .2379 \times 2440 = 3349$ B. T. U.

The flue gases would have a specific heat of .236 and the temperature of the escaping gases at the bottom of the flues where secondary air is admitted would be

$$2500^\circ - \frac{5.77 \times .2379 \times 2440}{12.54 \times .236} = 2500^\circ - \frac{3349}{2.959}$$

$$= 2500^\circ - 1132^\circ = 1368^\circ \text{ F.}$$

Then the heat recovered by absorption in the primary air would be

$$5.77 \times .2379 \times (1368 - 60) = 1795 \text{ B. T. U.}$$

The final temperature of the escaping gases would be

$$1368^\circ - \frac{5.77 \times .2379 \times (1368 - 60)}{12.54 \times .236}$$

$$= 1368^\circ - \frac{1795}{2.959} = 1368^\circ - 606^\circ = 762^\circ \text{ F.}$$

Then the net loss of heat = 7219 − (3349 + 1795) = 2075 B. T. U.

Therefore the theoretical thermal efficiency of a full depth bench, not allowing for radiation, opening of door, etc., would be

$$(14544 - 2075) \div 14544 = 85.73\ \%.$$

For a half depth bench the heat produced and the gross losses are the same as for a full depth bench, as is also the heat recovered by absorption in the secondary air. But there would be no recovery in the primary air, and therefore the net loss for a half depth bench would be

$$7219 - 3349 = 3870 \text{ B. T. U.}$$

The theoretical thermal efficiency, with previously mentioned omissions, for a half depth bench would then be

$$(14544 - 3870) \div 14544 = 73.39\ \%.$$

In operating any kind of a furnace, I will add that there is only one way to do so correctly, and that is by flue gas analysis. We usually determine the percentage by weight of CO_2, O, CO, and N. Knowing that air consists of very nearly 23 parts of O and 77 parts of N by weight, we know that this relation of O and N must be maintained in all the flue gases.

Before leaving the subject of coal gas manufacture, I will add that the average composition of coal gas is as below in per cent by volume.

CO_2	1.5 %.
CO	7.0 %.
O	0.5 %.
Illuminants	7.0 %.
CH_4	34.0 %.
H	46.0 %.
N	4.0 %.
	100.0 %.

WATER GAS.

We will next consider the manufacture of water gas. I can only take the time to explain the operation of a modern Lowe water gas set. There have been many forms of water gas apparatus, but that named above is the one most widely used now. Such a set consists of: First, a generator, or vessel built of an iron shell, with a firebrick lining, and containing a deep bed of incandescent fuel. Second, a carburettor, or vessel consisting of an iron shell, lined with firebrick and filled with a checker work of firebrick. This vessel has an open chamber near the top into which the oil is sprayed. Third, a superheater, or vessel built similar to the carburettor, but without the oil chamber.

To explain the operation of such a set, we will first assume it cold, but with a coke or anthracite fire started in the generator. By means of a fan blower a blast is turned under this fire, and the carbon in the lower portion burns directly to CO_2. This, on passing up through the fuel bed, is wholly or partly decomposed into CO, the amount depending largely upon the velocity of the blast. In the Dellwick process, this blast velocity is high, and the fuel bed is shallow, so that the carbon is kept in the form of CO_2.

When the producer gas (for such it is) reaches the top of the generator above the fire, it consists principally of N, CO, and some CO_2. By means of a large firebrick lined connection, this mixture is conducted to the top of the carburettor. Here an additional blast opening introduces fresh air, and a portion of the CO in the producer gas burns to CO_2 in the carburettor. The resulting mixture passes out of the carburettor and into the bottom of the superheater, where still another blast admits enough air to burn the remaining CO to CO_2. The final waste gases then pass out of the stack valve at the top of the superheater and escape into the atmosphere, or pass through a Green economizer, or other contrivance to heat boiler feed water, or for other purposes.

This process of blasting, or blowing, is continued until the entire fuel bed in the generator is at white heat, the carburettor being then full of a checker-work of fire-brick at a glowing red heat, and the superheater to a slightly lower color than the carburettor. The set is now ready to make gas.

The blast is first shut off all the vessels, then live steam is turned into the generator below the fire, and the stack valve on top of the superheater is closed. The resulting reactions are very instructive. The H_2O is first decomposed by the incandescent heat into H and O. This reaction is endothermic, that is, heat is absorbed in doing that work. The hydrogen passes up through the fire unchanged. The oxygen, on the other hand immediately combines with carbon to form CO_2, and every pound of carbon thus burning delivers 14,544 B. T. U., the reaction being exothermic. The CO_2, however, on passing upwards through the fire, decomposes into CO with an endothermic reaction, and this CO appears on top of the fire mechanically mixed with the hydrogen. This mixture is the so called blue gas, or uncarburetted water gas, and is merely one form of producer gas, having a calorific value of about 350 B. T. U. per cubic foot.

You will note that the reactions in the generator are mostly endothermic, and in fact the fire is cooled very rapidly under the admission of the steam, a run generally being 7 to 12 minutes, at the end of which time it is necessary to blast up again.

Coming back to the blue gas, so called because it burns with a blue flame in the air, we find it passing into the top of the carburettor. Here it meets with a spray of oil. This is sometimes the crude oil, but more often a gas distillate, which is obtained from crude oil after distilling off the gasolines and kerosenes, and before the heavier lubricating oils appear. The fraction coming off between these two extremes is neither fit for illuminating or lubricating purposes, but is simply a fuel oil, excellent for boiler use, but I believe is now mostly directed towards making gas.

This oil, on coming into the top chamber of the carburettor, vaporizes under the intense heat, and, mixing with the blue gas, starts down through the carburettor. The lower portion of the carburettor and the entire superheater are merely heated checker-work for the purpose of "fixing" the gas. By the term "fixing," we mean to render permanent under ordinary conditions. It has been found that oil or coal gas, if not subjected to sufficient heat, on coming to atmospheric temperature partially condenses into liquid hydrocarbons, and it is to render these hydrocarbons permanently gaseous that "fixing" chambers are employed. This, of course, involves a change of the hydrocarbons into different series, and components of series.

The practical result of adding the oil, is to make carburetted water gas, which is luminous and of higher calorific value than the blue gas. The average heat value is from 600 to 650 B. T. U. per cubic foot, and it can be made up to 35 or even 40 candle power, although that is beyond the customary limit, which is 25 candles.

When the set has been making gas for a certain number of minutes, it becomes too cool for economical operation. The oil is then shut off, next the steam, and then the stack valve is opened. Thereupon, the blast is turned under the fire, and the whole operation is begun over again.

On account of the steam striking the under side of the fire, and cooling it too rapidly, it is now customary to make a so-called "down run" every second or third time. This simply means that the steam passes down through the fire, the connections on the machine being arranged so as to permit this. As often as the fire requires it, fresh coke or coal is admitted into the generator, the ashes and clinkers being taken out at the bottom. In places where anthracite is reasonably cheap, it is largely used, but probably the large majority of plants use oven or gas coke. Bituminous coal can be mixed with the coke, or even a small proportion of lignite, but the latter does not work well.

In order to give you an idea of the capacity of a water gas set, I will say that an 8′ 6″ set, with a grate area of 30 square feet has a capacity of roughly 25,000 cubic feet of gas per square foot of grate. An 11 foot set in St. Louis, operating on gas coke, can produce roughly 35,000 cubic feet of gas per square foot of grate area, or with anthracite coal as high as 42,000 cubic feet, all per day of 24 hours.

As I wish to take up the treatment of gases as a separate subject a little later on, we will now pass to the manufacture of

BY-PRODUCT COKE OVEN GAS.

By-product coke ovens are an outgrowth of a desire to secure an economical arrangement of apparatus to utilize the gas, tar, ammonia, and cyanogen produced while manufacturing coke, at the same time not reducing the quality of the coke produced from that obtained from bee-hive ovens. They were first in evidence in steel plants, and the industry was represented in the United States, until very recently, by the United Coke & Gas Co., and the Semet–Solvay Co. The two large firms being now under one financial control, we thus find the Semet–Solvay Co. prepared to contract for the erection and operation of plants of either the Semet–Solvay or Otto–Hoffmann systems.

By-product coke ovens not only affect the gas industry by producing gas, but they contribute immense quantities of coke, tar and ammonia to the market. These ovens are nothing more or less than sets of large built-up retorts. Approximately the first 40 per cent. of the coal gas given off is sold as illuminating gas, as it is the richer portion, the remainder, or about 60 per cent., being used to heat the retorts, and this 60 per cent. is of a low photometrical and calorific value. The operation of such ovens is not very much different from a large modern gas plant, except the much larger scale upon which it is carried out. This very magnitude renders mechanical devices for handling everything absolutely necessary. I do not wish to dwell long upon any of the gas manufacturing processes except coal and water gas, and will therefore confine my description to illustrating the size of a by-product coke oven plant with whose designing I am associated.

This plant consists of 400 Semet-Solvay ovens, erected in eight stacks of 50 retorts, or ovens, each. It will use per day of 24 hours, 3,000 tons of coal. The products will be:

1,700 tons of coke per day.
40,000 gallons of coal tar per day.
15,000 pounds of anhydrous ammonia or
60,000 pounds of ammonium sulphate per day.

I will leave it to you to construct in your minds the machinery necessary to perform all this.

PRODUCER GAS.

This gas is usually made by o ne or both processes already explained under coal gas and water gas manufacture. It sometimes consists of CO and N produced by air being blown through a bed of incandescent fuel, and is then possessed of a heat value of about 140 B. T. U. per cubic foot. If in addition to the blasting process we add steam under the fire, the resultant gas will contain H, Co, and N as previously explained. Of course, there are always some impurities like CO_2, H_2S, etc., associated, but I am naming only the principal constituents. Producer gas is coming into prominence of late owing to great advances in the design of gas engines, and those interested can secure much pleasure and benefit from studying up such processes as the Mond, Dowson, Duff, Wood, etc.

OIL AND PINTSCH GAS.

Since Pintsch gas is a pure oil gas I will describe it. Such a gas is usually used where a high candle power is necessary, and in the Pintsch gas system it must withstand comparatively high compression without liquefaction of too large a part of it. The average coal gas made is probably 16 candle power in this country, but in England and Europe, the poor grades of coal obtainable will produce gas of only from 8 to 14 candles. It was formerly the practice to enrich coal gas by the addition of oil gas, but the water gas process is doing away with that.

In the Pintsch system we have probably the largest application of a pure oil gas there is in vogue today. The process is to distill and gasify the oil in iron or clay retorts very much as coal gas is produced, but with this difference; the oil is run into the retorts constantly in a small stream, and they are opened only for cleaning out, and decarbonizing.

Under coal gas manufacture, I should have added that retorts periodically "carbon up," that is, the heat of the retorts breaks up some of the hydrocarbons formed during distillation and carbon deposits on the sides and bottom of them. This carbon deposit is very dense and hard, and is removed by burning it off the walls of the retorts. You have all seen this substance, for it is used largely to manufacture electric arc light carbons.

Now, in oil gas, the same thing occurs, and were it not for carbon and tar deposits, an oil retort might be used indefinitely. Pintsch gas is of about 60 candle power, and after purification is compressed to from 10 to 20 atmospheres, and is thus stored in strong tanks under railroad cars, where it is used for lighting. We are just completing a Pintsch plant of 400,000 cubic feet daily capacity in St. Louis, and can gas 1200 to 1400 cars daily. This plant is one of the largest of its kind in the world, and will probably be taxed to its capacity during the World's Fair.

LOWE OIL GAS.

There is one other noteworthy application of oil for gas making purposes, and that is the Lowe oil process. This consists of an apparatus similar to a water gas set. To heat it, oil is burned with air directly in the generator and superheater. These vessels are filled with a checker-work of firebrick, which heat up to a bright red under the hot oil fire. When the heat is up, the air is cut off, and the oil is admitted alone. This vaporizes and gasifies the oil, which gas is afterwards mixed with air to reduce the candle power to a reasonable commercial basis, to say 20 candles.

You can readily see that such a process is only applicable where oil is plenty and cheap. Both it and the Pintsch system require about 15 gallons of oil per thousand feet of gas made. If oil were four or five cents per gallon, the common eastern price, the Lowe gas would thus cost 60 cents to 75 cents per M for oil alone. In fact, the Lowe oil gas process is used only in or about California, where immense deposits of oil are found, and where it is worth possibly one or two cents per gallon.

BLAST FURNACE GAS.

This subject is not really in the realm of gas manufacture, and I will only touch upon it. It is a very low calorific gas, of only about 90 B. T. U. per cubic foot, but is being largely used to drive gas engines, some engineering experts being of the opinion that it is the best available gas for such use, on account of its readily withstanding high compression. This brings us to a short consideration of the final classes of gas I will touch upon, viz:

ACETYLENE, WOOD GAS, GARBAGE GAS, ETC.

Acetylene. or C_2H_2, is produced by the action of water on calcium carbide. It is a very heavy gas, of high candle power, and its flame is said to most nearly resemble sunlight in its spectrum; that is, more so than any known artificial light. Even though such water power devolopments as Niagara and the Sioux have rendered the production of calcium carbide reasonably cheap, acetylene is still too dear for general use. For lighting country residences, etc., it finds a limited application, and can be adapted to fuel use if desired.

Wood gas can be made by distilling wood either in horizontal or vertical retorts. A fair grade of coke is produced therefrom, and the process is applied in France and other foreign countries where coal is scarce. This, and garbage gas, made by distilling garbage, with many other minor processes, finds a limited application.

PURIFICATION OF GASES.

Coal Gas—In this gas we extract first the tar, then the ammonia, and finally sulphur. In some more modern works cyanogen is also removed. The tar is largely taken out in the hydraulic main, which is situated on top of the stack of retorts. Here the gas bubbles through a seal of tar and weak ammoniacal liquor. The gas next passes to the exhauster, which is usually of the positive rotary blower type, and is the heart of the works, driving the gas forward through all vessels and finally into the holder. Then the gas passes through various mechanical tar extractors, and finally washers or scrubbers, through which water is pumped, and here the last traces of tar and ammonia are removed. Rotary scrubbers are usually employed to remove the cyanogen in the gas in the form of ferrocyanide of potash, sodium, or ammonia.

The sulphur is the most difficult impurity to remove. In this country, we employ mostly iron oxide mixed with shavings. The $H_2 S$ in the gas combines with the iron oxide to form iron sulphide. When all the oxide has been "fouled," or is in the form of iron sulphide, the material is taken out of the purifying boxes and exposed to the air. The oxygen of the air causes the iron sulphide to return to the form of iron oxide, leaving the sulphur in the free state among the material. This can then be used over again, and the process repeated until there is approximately 50 per cent by weight of free sulphur in the mass, when it becomes too sluggish to act. In England, lime or rather the hydrated form of quick lime, $CaO, H_2 O$ is used. This is done because lime removes CS_2 as well as H_2S. The process, however, is too expensive. After purification, the gas is ready for commercial use. Water gas is treated only for tar and sulphur, coke oven gas for the same products as coal gas.

Producer and blast furnace gases are treated for tar, amonia and cyanogen, while oil gas needs only the removal of the tar and sulphur. Therefore, since the coal gas by-products cover those obtained from any other gas, we can sum up the commercially valuable substances produced from gas manufacture, as

1. Gas, about 10,000 cubic feet per ton of coal.
2. Coke, about 1350 lb. per ton of coal.

3. Tar, about 13 gals. per ton of coal.
4. Ammonia, about 5 lb. pure NH_3 gas per ton of coal.
5. Cyanogen, about 2 lb. ferrocyanide of potash per ton of coal.
6. Sulphur, varies with coal.
7. Retort carbon, varies with heats, etc.

The gas, coke, tar and ammonia are all very valuable, and constitute the main source of revenue. It is useless to recount the applications of each, except to remind you that modern organic chemistry was begun largely by studying the properties and constitution of coal tar. I will, therefore, omit a more detailed description and pass on to the

STATION METER.

The gas after passing the purifiers is ready to sell, except that the amount made must be determined in order to keep the several parts of the works under control. This measuring is usually done by means of a large four-compartment drum, which revolves in a cast iron case filled about two-thirds full of water.

The inlet and outlets of the drum compartments are so arranged that when the outlet is below water, the inlet is above, and the compartment fills with gas. The drum revolves something like a squirrel cage and shortly after the inlet dips below water, the outlet comes above, and the compartment discharges its contained gas. The cubical contents of the compartments being accurately known, the motion of the drum is communicated by gearing to the dial, and thus we have an apparatus which accurately measures the gas made. It is customary to make proper corrections for temperature, and barometric pressure, and we reduce the gas manufactured to 60° F. and 30 inches barometer height.

On account of the large size of Station meters, various forms of proportional meters have been tried. These measure only a small fraction, usually 1 per cent of the make, and are arranged to register the total, but so far there is no absolutely reliable proportional meter on the market.

Leaving the station meter, the gas passes into the

GAS HOLDERS.

These are the storage reservoirs for gas, and allow us to manufacture uniformly during the 24 hours of the day. The rate of send-out is constantly varying; but the holder takes care of that. Gas holders are now usually censtructed of steel throughout, and can be brought up to 20,000,000 cubic feet capacity. In St. Louis, we have two four-million foot holders and I will give you a few of the principal points of such a construction.

Diameter of tank,	210 feet
Depth of tank,	34 feet
Height of holder,	160 feet
Steel work required,	2200 tons.

Cost—about $250,000, complete.

These holders are designed to safely withstand a wind load of 25 lb. per sq. foot on the full exposed diametrical section at full height, and a snow load of 5 lb per sq. foot of the upper area, considered as being entirely massed on one edge of the crown.

For a more complete discussion of these immense structural steel holders, I will refer any one interested to an article I wrote for the WISCONSIN ENGINEER in 1901. There is now only one more subject I wish to touch upon before leaving the manufacturing end, and that is

CHEMISTRY AND PHOTOMETRY.

The gas business is essentially the business for a chemist. Where do we find richer fields for investigation, or better scope for that research for economy than in this industry? Take ordinary coal gas. It is composed largely of some eight or ten substances, but there are traces of numberless organic changes, decompositions, and formations during its evolution in the retort. Ammonia, cyanogen, and tar afford unlimited possibilities to say nothing of the analysis of the crude substances, coals and oils.

Then in a works there are flue gas analysis, and numberless thermo-chemical reactions to be investigated. I have been in this business for years and have devoted a great deal of study to it, and yet to-day I feel as if I were at the threshold of an unknown world, timidly seeking light. For instance, we must find a cheap way to manufacture natural gas artifically, that is CH_4, and yet no one has so far found it.

Photometry is likewise in a rather unsatisfactory state. We read of mean spherical candle power, of the Harcourt pentane lamp, the Hefner amyl-acetate standard, or a standardized electric incandescent unit, and yet these ultimately refer to a sperm candle of certain physical characteristics, and burning at a certain rate, as the basis of comparison. Let us question a little deeper, and ask what is the real nature of that standard light, and how can we satisfactorily compare it to, say Peter Cooper Hewitt's mercury vapor lamp? I leave it to you to ask if there is work ahead in this line.

Leaving now the first great division of the gas business, viz: manufacture, I will take up

DISTRIBUTION.

This subject will be treated in a very short manner. The gas mains mostly used to-day are of cast iron, but clay, wood and steel pipes have all been tried. An ordinary system consists of large mains even up to 48″ and 60″, leaving the works and acting as feeders. The secondary mains may be 6″, 4″ or even less, but in large cities the practice is rapidly tending to a minimum size of 6″ cast pipe. In these cases, the gas pressure is only from one to two or three ounces per square inch, and the natural result is that with a rapidly growing business the sizes of pipes soon prove insufficient. The remedy in former times was to build district holders and thus help out the pressure, but nowadays more economy is necessary.

I can best illustrate the case by telling how we are handling this problem in St. Louis. We first ran a 24″ belt line around the city, passing all the gas works and near all present district holders. This is so arranged that the gas made at the works is pumped into this belt line at five-pound pressure per square inch. During the night, after 10 P. M., and at periods in the daytime, the district holders are filled by merely opening valves and allowing the five-pound pressure to force the gas into them.

Then at meal times, and especially in the evening about six o'clock, when the peak load occurs, all holders are full to keep the pressure up in the low pressure system. At various points in the city, where formerly district holders would have been placed to keep up the pressure in the neighborhood, we now use pressure reducing governors from the 24″ five-pound belt line. These governors are placed in manholes in the street, and serve the purpose of district holders, as far as pressure is concerned, remarkably well, besides being so cheap to install.

For serving the belt line we use positive rotary blowers, in some cases direct connected to gas engines, since such blowers have their limit of reasonable efficiency near five-pound pressure. If we had desired to use ten-pound, we should either have been obliged to use two rotary blowers in series or blowing engines. For city use, where electrolysis is so frequently met, we did not feel safe in going over five-pound.

For reaching suburban communities, however, we compress the gas up to anywhere from 20 to 100 lb. pressure per square inch. Large quantities of it can then be transmitted a long distance through comparatively small pipe, and for this work screw pipe is usually employed. The reduction to working pressure is accomplished either by district governors, or a governor at each house.

The whole system resembles nothing so much as electric alternating current distribution. The high pressure lines take the place of the high tension primaries, the governors of the transformers, and the low pressure pipes of the low tension secondaries.

For supplying the individual consumer, small service pipes are run, and generally $1\frac{1}{4}''$ to $2''$ steel or wrought screw pipe. One of the great bugbears of underground piping today is the electrolytic action resulting from the return currents of the street railway systems. At places in St. Louis it is so severe that our men ofttimes wear rubber gloves in setting meters. The remedies suggested have been better rail bonding, connecting the pipes and rails by wires at certain points, insulating pipe joints, covering the pipes by pitch or other non-conductors, and others, but these are not remedies, they merely postpone the fatal day of trouble.

My own opinion of the real way to accomplish the result permanently is for the street railway system to adopt alternating current traction, and it is to be hoped that Mr. Lamme, of the Westinghouse Electric Company, and others who are working on the same problem, will succeed in demonstrating the practicability and desirability of this system.

Consumers' meters are next in order. These little machines, so often maligned, and which are said to work while the gas man sleeps, are really very ingenious and accurate instruments. They are usually of the dry type, having a partition in the center, and on each side tin discs vibrate back and forth. These discs are connected to the center plate by leather diaphrams, and the gas passes in and out through little slide valves like those on simple steam engines. The cubical contents between these discs and the meter plates are accurately known, and the vibration back and forth moves the index on the dials by means of gearing. I will now consider the appliances by which gas is consumed.

APPLIANCES.

The Welsbach light has been an important factor in maintaining gas for illuminating purposes in face of the electric light. Its spectrum is nearer to sunlight than any electric device yet produced, except, of course, the Nernst lamp, which is practically the same. Gas will probably be used for lighting purposes for a long time to come, but its most rapid advance of late is in the fuel field. Gas stoves, gas water heaters, metal melters, industrial fuel devices, and even house heating, preferably by hot water systems with gas fires in the furnace, together with innumerable other appliances, are all so well known that it is useless to describe them.

A recent and rapidly increasing development in gas engines is very noteworthy. Already the steam engine and steam turbine are left far behind in the race for thermal efficiency, and that with the gas engine hardly started. We can reasonably hope for a thermal efficiency of 50 per cent. before long. Then the possibilities of the gas turbines are hardly dreamt of to-day.

Gas engines of 3000 H. P. are in use to-day. Their operation is very satisfactory, and their regulation is so close that alternators driven by separate engines are readily kept in step.

The World's Fair at St. Louis this year will afford a good display of gas producers, gas engines, and other appliances. The grounds and buildings are beautiful, the fair will be ready on time, barring unforseen great disasters, and the gas exhibit should be extremely interesting. When you visit St. Louis in behalf of the Laclede Gas Light Company, I extend a cordial invitation to all interested to visit our works. You will find some of your college mates working with us, and they will, of course, be only too glad to show you around.

In conclusion, I wish to add that I hope the University of Wisconsin will before long establish a course of Chemical Technology. It is sadly needed. Good positions are open in the gas business, as from my own personal acquaintance among those occupying responsible positions, too many are not college men. This should be changed. The field is there; it only remains to be conquered.

Finally, boys, do your own individual share towards upbuilding our grand old college. You need not be ashamed of her; on the contrary, your standing as graduates of the University of Wisconsin will be as high as from any university in the world, and her engineers, as I do to-day, will look back upon her with the deep consciousness of pride in her professors, her graduates, and her accomplishments.

THE STORAGE BATTERY IN SMALL CENTRAL STATIONS.*

Owing to the impossibility of drawing any distinct line separating storage battery practice in small central stations from that in the larger stations, and to the fact that many or most of the economies and advantages effected are common to all direct current stations, irrespective of their output, I have decided to deal with this subject in the following way:

First, to cite a battery application peculiar to small stations, and then to dwell briefly on the features common to all central stations.

In the first case the consideration will be that of a lighting station in a small village. In such cases it usually proves unprofitable to furnish continuous service throughout a 24-hour day, as the demand for current during the early morning hours and throughout the greater portion of the day would be so small that the additional shift of men required and the increased fuel consumption on the plant would prohibit the commercial success of the venture.

It is, however, true that the manager of a central station operating only a night schedule is greatly handicapped. In order to secure any great amount of residential lighting business, continuous current must be supplied, as the owner of a residence would naturally demand light during all hours of the night, and would further probably demand fan service throughout the day during the summer months. If these facilities cannot be offered to the public the amount of business of the small central station is necessarily limited.

As an illustration of what has been accomplished along this line I might cite a case in actual practice where the conditions were as follows:

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*Paper read by J. M. S. Waring at the twelfth annual convention of the Northwestern Electrical Association, held at Milwaukee, Wis., Jan. 20-22, 1894.

The plant I have in mind consisted of one 60 and one 120 H. P. non-condensing engine, which in addition to driving certain machinery, operated two 125-volt generators, one having a capacity of 20 and the other of 25 kilowatts, the two being operated in combination on a three-wire Edison system, with 220 volts across the outside mains. This plant has been operating and supplying a load concentrated within a very small radius. The maximum peak load of 150 amperes was on the station for about an hour and a half in the evening—that is from 6:30 until 8; it then gradually decreased to about 10 amperes at 11 o'clock at night, and at 12 the plant was shut down.

An opportunity arose for this plant to obtain the contract for city lighting, but the cost of the necessary transmission line, including poles, copper, etc., amounted to so much that the returns from the city lighting alone would not warrant the investment; however, it was obvious upon investigation that if a sufficient amount of residential lighting could be assured the investment would become a decidedly paying one, and with this in view a storage battery was installed. This installation made, the station continued to operate for the same number of hours daily. On account of the new business the load was materially increased. From 12 o'clock (midnight) until dusk in the afternoon the entire load was taken care of by the battery.

While this was a three-wire system with 220 volts across the outside mains, only a 110-volt battery was installed, for, during the hours that the battery was operating, the load was so light that by connecting the two outside mains together at the station the system could be operated by a two-wire 110-volt system, and even under these conditions, owing to the light load, the drop was considerably less than when operated as a three-wire system with the maximum load. In this case there was an increase in load after lhe installation of the battery of about 66⅔ per cent., and an increase in fuel consumption of only about 25 per cent., showing that the cost of fuel per kilowatt hour was decreased about 37½ per cent., this decreased fuel consumption being due to the fact that the generator set, while operating with the battery, was run at a considerably higher percentage of full load than was the case before, the efficiency being correspondingly increased.

Another instance which occurs to me is similar to the above, with the exception that the plant supplied the adjacent district from a three-wire direct current system, while in the outlying districts the load was on an alternating system. While this alternating load was extremely heavy during the peak, it was very light during the day, consisting only of a small amount of fan service in the summer months. A battery was installed in this plant which furnished current directly to the direct current mains and at the same time operated a direct current motor running a small alternator so that the fans on the alternating current system could be operated.

These, and cases of a similar nature, are, of course, confined to very small plants.

Another application of the storage battery, which is irrespective of the size of the plant, is that of a battery operating in conjunction with a water power plant. A number of cases have come before the attention of the writer where there was sufficient water power to supply considerably more than the load existing during the greater portion of the 24-hour day, the peak load during the evening hours, however, being in excess of the capacity of the turbines. In this case the value of the battery is apparent, as the generators while carrying the day load are charging the battery at the same time, the battery assisting to the extent of its capacity during the peak, thus giving an increased station capacity which would otherwise be only obtainable by the addition of an auxiliary steam plant, with a correspondingly increased cost of operation, which would probably make the investment prohibitive.

There are a number of features which may now be briefly mentioned as being of interest to the central station manager, regardless of the size of the plant he is operating.

To the central station manager a minimum cost of production and transmission, allied with reliability of service, are essential. The consumer, however, demands that the latter item be not sacrificed in the pursuit of economy. Intermittent service results in a loss of business to the central station, and, while it may be difficult to compute the expense to which a lighting station is subjected by a ten or fifteen minute interruption, the official who receives the complaints of his customers fully realizes that a loss of revenue does result from frequent recurrences of this complaint. The storage battery insures increased economies of production and transmission, at the same time almost entirely preventing interruptions to service. A battery at the source of the direct current transmission—that is to say, in either a direct current power house or a rotary sub-station—will offset, in the first place, the installation of a corresponding capacity of poilers, engines and generators.

In the second case—that of a rotary sub-station—in addition to this apparatus it will also offset a certain proportion of the static transformers and rotary equipment, with the cost of which apparatus that of the battery will compare favorably. It is of the greatest value as a reserve in either case, tiding over shut-downs occasioned by trouble on any of the apparatus just mentioned, or in the high tension line in the latter case. The battery, being ever present on the system, is readily available as a reserve.

It further obviates the necessity of carrying boilers under steam in anticipation of a peak load, thus insuring a decreased fuel consumption.

Another familiar application of the storage battery is that of placing it at the center of load on a direct current system of distribution. When the volume of business in a congested locality covered by a low tension system of transmission reaches a certain volume (and the more remote this locality from the central station the sooner this point is reached), the amount of copper required to care for the power from the central station necessitates an outlay tending to render this system of transmission prohibitive. By the installation of a battery of a capacity sufficient to care for a certain portion of the peak, the amount of copper between the central station and the center of load is decreased to such an extent that the battery investment is decidedly the preferable one from a commercial standpoint.

One of the more recent adaptations of the storage battery, and one whose importance will readily be recognized by central station managers, is its use in connection with the direct current exciters in alternating current power and lighting plants. With an installation of storage batteries floating at all times on the exciter bus, interruptions of current in the exciter circuit are practically obviated. Reduced fluctuations of the exciter voltage are assured, together with corresponding reductions in the alternating current voltage fluctuations. Where alternating current motors are used to drive the exciters, the battery also serves to supply field current when starting up the plant after a shut-down.. An attractive feature in any battery installation is its adaptability to changes of conditions over a very wide range. Its capacity or voltage may be increased or decreased by varying the number of plates per cell or the number of cells in series without affecting in any way the original installation, thus obviating the necessity of anticipating any future increase in business.

It may be said in general that there are few direct current systems on which the service may not be improved, the liabilities of interruption decreased and the operating expenses minimized by the use of a storage battery auxiliary.

OUR PREHISTORIC EARTHWORKS—A SUGGESTION TO THE REGENTS.

BY REUBEN G. THWAITES.

The Indian mounds which are so familiar to those loving to ramble around the shores of our beautiful lakes, speak eloquently to us of the prehistoric past. Time was when antiquarians believed them to be the product of a race of barbarians superior to the red Indians, and perhaps in a stage of culture not far behind the Mexicans and Peruvians, when discovered by the Spanish *conquistadores*. But long and faithful study of the mounds of the Mississippi basin has convinced ethnologists that they were erected by the ancestors of tribesmen who are still with us—Winnebago, Potawatomi, Miami, and the like. While no doubt some of the works are thousands of years old, there is evidence which inclines scientists to believe that many others were reared not long before the coming of Jean Nicolet in 1634; indeed, possibly a few originated quite within the French régime.

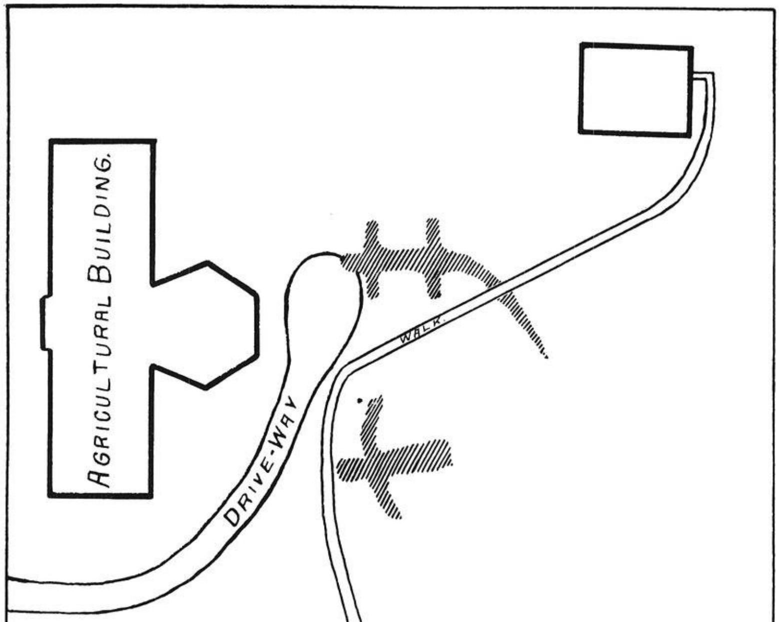
As not infrequently is the case with prehistoric monuments, the doctors occasionally disagree regarding the uses to which the mounds were put by the builders. It is, however, generally agreed that the long lines of embankments which may sometimes be found in the outskirts of groups of mounds are the remains of rude fortifications—possibly the earth thrown against the bases of now rotted palisades, in the manner of the Iroquois forts which were imitated by our early white backwoodsmen. Interesting remains of such embankments may be found at Morris Park and the Insane Hospital grounds on Lake Mendota, at W. T. McConnell's farm on Lake Waubesa, and at various points on the shores of Lake Koshkonong, to mention a few only of well-accentuated specimens. The topography of the neighborhood shows that the embankments were skilfully placed to protect the village from water-side attacks.

In each Indian village many clans (or families) were represented—such as the clan of the Turtle, that of the Lizard, the Eagle, the Bear, the Wolf, etc. As in Scotland and Ireland, in modern times, the head of the clan was accorded especial honors. We often find, in the Indian village sites of this region, mounds erected in the shapes of birds, serpents, and animals, all nestling side by side—the "effigy mounds" of the ethnologist. It is thought that on top of the effigies were erected the wigwams of the heads of the clans whose armorial bearings were set forth by these rude monuments. As for the round mounds, which the ethnologist calls "tumuli," they were undoubtedly burial places. Near village clusters of these tumuli and effigies, there are often still to be seen the remains of planting grounds, evidenced by the little hillocks which were hoed up around the stands of corn and pumpkins. Old planting grounds, well preserved, are to be found at Morris Park, Winnequah, Fox's Bluff, and on a farm near the outlet of Lake Monona; although possibly all of these, save at Morris Park, are of much later date than the neighboring mounds.

Not only are Indian mounds met with in large village groups, but they are to be found planted singly or in small clusters, generally at vantage points, overlooking lakes or rivers. Such isolated mounds we often find in elevated woods, as at Wingra Park, or on hilltops, such as the well-defined lizard and bird on our own Observatory Hill.

We are fortunate in living in a district so rich in these historical legacies, which in our new land are quite as interesting and suggestive in their way, as the engineering works of the Druid, the Saxon, or the Roman in England, or the archæological remains of Ireland and France. Our Indian mounds are not only of general popular concern, but of great practical value to the student of American ethnology, a branch of research which is still in its infancy, although with a promising future. But vandalism and agricultural development are fast obliterating many of the best specimens within the Four Lake country.

It is perhaps too early in the development of the historical spirit among us as a people, to hope for public protection of such monuments of the past as exist upon private grounds; but fortunately there are interesting groups upon state property—the grounds of the University and of the Insane Hospital, both of them overlooking Lake Mendota. It should require no great effort to induce the custodians of these remains to save them from further mutilation, for the benefit of scientific students in this and future generations. The mere suggestion should, and doubtless will, be sufficient with the gentlemen having these trusts in their keeping. In nearly every European country, heavily-endowed corporations, aided by government, are at last protecting historical monuments. A bill for preserving ethnological and archæological remains on federal lands, is now pending in Congress. In the face of these movements, the mere hint that the beautiful specimens crowning Observatory Hill are fast being ruined by the thoughtlessness of the University's own servants, should suffice to bestir the regents to prompt and creditable action. An institution which stands for the advancement of knowledge among men, can ill afford to allow its own historical memorials to become the prey of an unappreciative spirit, which has already worked irremediable damage.



Effigy Mounds on Observatory Hill.

The Wisconsin Engineer.

Published Quarterly by the Students of the College of Engineering,
University of Wisconsin.

Vol. 8. Madison, Wis., April, 1904. No. 3.

TERMS:

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The attention of many students, and in particular those whose duties take them to the Observatory hill, has been called of late to the mutilation, by careless or ignorant employes of the University, of the two fine examples of the work of the ancient mound building tribes of Wisconsin, viz.: the effigy mounds, located to the rear of the new Agricultural building on the northwest slope of Observatory Hill. There are doubtless many students who are ignorant even of the existence of these interesting relics of the past upon the University grounds, and yet until very recently these mounds have been preserved in a very perfect form. During the past year, however, they have suffered much as a result of certain improvements to the agricultural department, much to the regret of those who appreciate the educational importance of preserving these relics which we have at our very doors.

At the request of THE ENGINEER, Mr. Reuben G. Thwaites, secretary of the Wisconsin Historical Association, has given us an interesting article concerning these remarkable earth structures, and embodying a very reasonable protest against the carelessness which permits of their destruction by thoughtless workmen.

While there are many hundreds of animal mounds in this portion of the state, the majority are located on private property where their destruction is only a matter of a few years at most. It would naturally seem that the location of the two fine specimens we have on Observatory hill, being upon state grounds, should make them ideally situated as regards preservation, but this assumption is apparently a mistaken one, as any one who will take the trouble to visit them, may learn.

The mounds consist of representations of a bird and of a lizard, the latter, which lies upon the slope back of the Agricultural building, being over a hundred feet in length, and the former, somewhat smaller, being located about one hundred feet nearer the Observatory. The accompanying map shows the location of the mounds with respect to the buildings, sidewalks and driveway, showing where mutilation has occurred. The sidewalk extending from the Observatory to the Agricultural and Dairy buildings cuts off a portion of the head of the bird and cuts through the ridge forming the tail of the lizard. A recently excavated ditch for the University water supply system was made to pass directly through the body of the bird, leaving a depression where the earth has settled. But more serious still, the driveway leading to the rear of the Agricultural building has been made to end in a loop which mutilates the upper portion of the lizard.

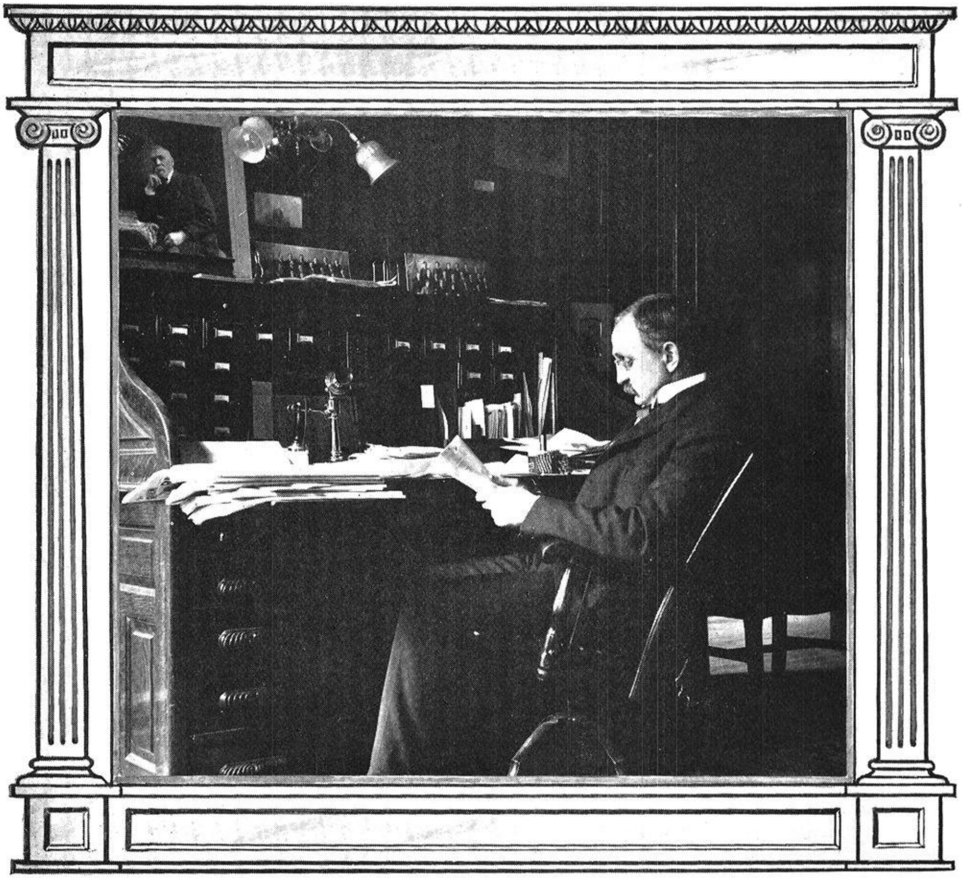
If these mounds are to be preserved for future generations, and there seems no good reason why they should not be, the proper authorities should interest themselves in the matter at once before the destruction, but recently begun, progresses so far as to be beyond repair. The mutilated portions should be restored with durable material and the stripped parts resodded, and positive instructions be given all University employes, teamsters. etc., against further mutilation.

The location of the sidewalks is perhaps the best that can be found, and these do not seriously interfere with the general outlines of the figures, but further excavation into or leveling of these valuable relics, the ENGINEER believes, should not be tolerated, even upon the excellent pretext of convenience or utility.

NAMING THE BUILDING.

A year ago this spring, with the memory of the late Dean Johnson and his services to the College of Engineering still fresh in our minds, a general meeting of engineering students was called to consider the matter of presenting the college with a fitting memorial of the life and services of this revered teacher, the influence and inspiration of whose character had touched so many of our lives. There was a warm response from the student body and the auditorium was filled. A memorial fund was started which was eventually increased to nearly four hundred dollars, with which the handsome oil painting of Dean Johnson and the brass memorial tablet, which are now in the college reading room, was purchased.

The movement originated in the student body and was carried through with a spontaneity which betokened the deep respect and affection entertained for the late dean by that body. No suggestions were needed from the faculty and no assistance was accepted from its members, even though offered, as it was deemed fitting that the memorial should be a simple expression of student loyalty to a loved teacher, who had also been a guide and friend on many occasions.



Dean Johnson.

At this general mass meeting of engineering students it was also suggested that our engineering building be given a name and that it be called Johnson Hall, in recognition of the substantial services of Dean Johnson in building up the school from a department to a college, and in the actual erection of the building, a project of which he was the animus from its inception to its completion. The suggestion was embodied in a resolution designed to be laid before the Board of Regents, and the resolution, in effect that the building be named Johnson Hall, after the late John Butler Johnson, was unanimously adopted. The resolution was duly presented to the Board of Regents, but no action was taken by the Board at that time, the resolution being "laid on the table" indefinitely and without discussion.

The fate of this resolution was known to but few and has been the subject of frequent inquiry among upper classmen during the present school year. A general sentiment seemed to exist, and has constantly gained strength, that some effort should be made to bring this matter once more to the notice of the Regents in a substantial way, the upper classmen realizing that whatever student action is taken must come necessarily from those whose privilege it was to come into personal contact with Dean Johnson in his classes.

Members of the senior class recently conferred with Dean Turneaure and Secretary Riley with regard to the matter, and as a result a definite plan has been organized once more to determine the student sentiment and to present the wishes of the students again before the governing body of the University, in a way that shall demand some expression either for or against the proposition. Carrying out this idea, a committee was elected, consisting of a representative from each course as follows: Mechanicals, Edgar J. McEachron; Electricals, W. A. Rowe; Civils, G. E. Kahn. This committee has called upon President Van Hise, to learn if there exists any sentiment of opposition to the plan, and finding none whatever, a petition is now being circulated which will be presented at the next meeting of the Board of Regents. Following is the text of the petition:

MADISON, WIS., April, 1904.

To the Board of Regents of the University of Wisconsin:

We, the undersigned students of the College of Engineering of the University of Wisconsin, do hereby respectfully petition that the building for the College of Engineering be named, by your official consent, "Johnson Hall," such action to be in recognition of the substantial services of the late Dean John Butler Johnson, in building up the college, and also in the actual erection and equipment of the building.

Quoting Dr. E. A. Birge, former acting president of the University, "The building for the College of Engineering stands as perhaps the best material memorial of Professor Johnson's work with us. While his presence and work were in the highest degree helpful, and were indispensable to this material advancement and improvement of the college, yet these results do not at all adequately represent the real measure of his services to the institution. That service is best found in the spirit and temper of the college, in the development of higher ideals in its faculty and students, in the presence of a stronger and purer *esprit de corps* among all the members of the college, and in the broadening and liberalizing of the spirit of engineering education as represented in the college."

In recognition of this rich legacy left us by our late dean, THE ENGINEER believes that it reflects the sentiment of the student body as represented in the College of Engineering, in most heartily endorsing the proposed naming of the engineering building, after its first dean,—Johnson Hall.

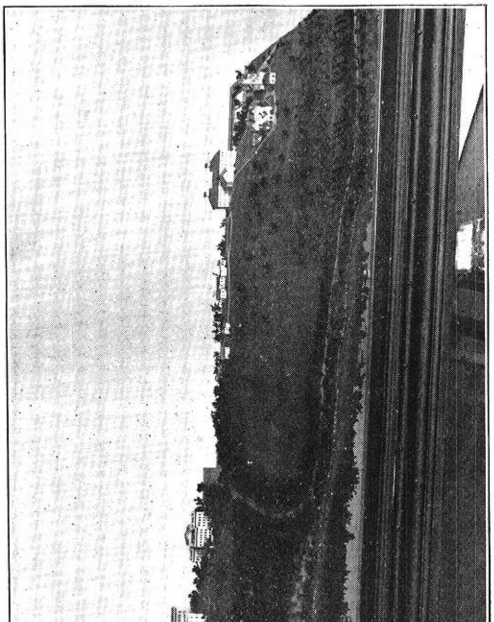
MODELS FOR THE ST. LOUIS EXPOSITION.

The large model of the University Campus and buildings and the model of the Steam Engineering laboratory, both of which have been in process of preparation for several months past under the direction of E. H. J. Lorenz, University mechanician, were placed on exhibition in the reading room of the Engineering building, March 29th and were allowed to remain there for several days before being shipped to St. Louis. Several thousand people viewed the exhibit during these few days, and unstinted admiration was lavished upon the work and also upon the clever workmen who executed the plans.

Each of the models in its particular sphere, is indeed a work of art. The campus model is enclosed within a beautiful plate glass and Ventian iron case, which sets off its beauty rarely. It is the entire University in minature, with the exception of the University barns and the farm property west of them. The case is eight by four and a half feet by three feet deep, and the model is constructed to a horizontal scale of one to five hundred, while the vertical scale is one to two hundred and fifty. Not a detail of topography or culture is lacking. Every tree and shrub is shown, the hills are carpeted with grass which looks as if it might be growing, and even old South Hall has its dense covering of ivy.

The buildings are scrupulously exact as to detail. They were carved by hand from solid blocks of wood and painted to correspond with the originals. The new Chemistry building which is not yet erected, but which will be completed during the summer is shown as it will appear on the site selected, adjoining the tennis courts.

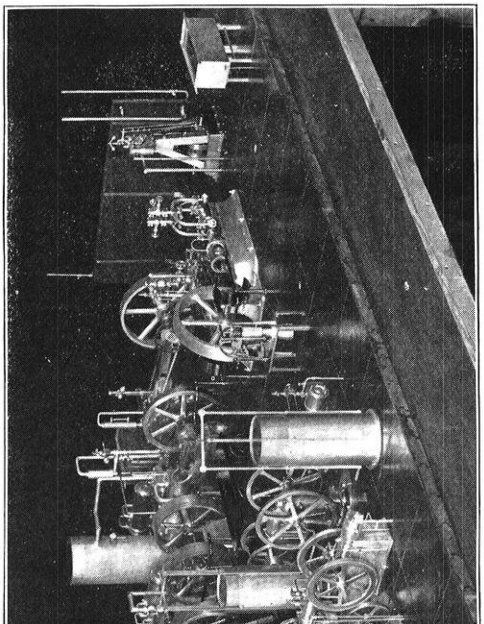
Mr. Lorenz gave the editor of THE ENGINEER an interesting account of the method of reproducing the campus topography. It was not "modeled," but rather built up of suc-



Model of University Campus.

cessive sheets of one-sixteenth inch wood pulp board, cut according to pattern supplied by a ten-foot contour map. Each sheet was firmly nailed to that below it with fine brads, of which thirteen pounds were used. This process left all the slopes "terraced" in steps a sixteenth of an inch in height, but by means of a compound consisting of ground up "currency," plaster of Paris and glue, the irregularities were filled and the slopes made smooth and flowing. The surface was then varnished, and, wherever grass was to be represented, green "flock," a material often used on Dumpy levels, was sprinkled. Where cultivated ground was to be represented, brown flock was used. The trees and shrubbery were made of copper wire and natural moss. Lake Mendota is cleverly represented with a sand beach showing through the transparent waters at the the shoreline, but shading to an obscure blue toward the deeper portions.

The most attractive part of the exhibit to an engineer is, of course, the model of the steam laboratory, in which every piece of machinery and every detail of this large and well-filled laboratory is represented by a model, in size one-fiftieth of the original. The perfection of these diminutive engines, compressers, condensers, etc., seems truly marvelous, and particularly so when it is considered that most of the work on them was done outside of regular hours by Mr. Lorenz and his assistants during the past few months. The spectator views this exhibit from the visitor's gallery which surrounds the laboratory on four sides, a plate glass cover resting upon the railing of this gallery, through which the machinery can be examined. While not working models in the sense of being real steam engines, yet all wheels, valves, etc., are movable, the bearings are perfect and proportions correct. The machinary will not be put in motion at the exposition as at first planned, as it is thought that it would give the effect of a toy shop rather than of a dignified college exhibit. All parts of the machines are turned out of brass or steel, the brass being either polished or nickeled to correspond with the original.



Model of Steam Laboratory.

The various pipe systems, the wall gauges, tanks and brine-coolers for the refrigerating plant, are all represented exactly as we see them in the laboratory. Even the long wooden table, around which the students figure out their various tests, together with the tiny wooden chairs, are there, the chairs being the work of Mr. Small, janitor in charge of the laboratories. All the machine work was done by Mr. Lorenz, assisted by L. M. Post and Fred. Horstman, machinists employed by the University. In the construction of the Campus model Mr. Lorenz was assisted by Mr. Westcott, of this city.

The genius of Mechanician Lorenz consists in the rapidity, accuracy and economy with which his work is executed. As an example of the cost of making the models, the Vilter Manufacturing Company of Milwaukee volunteered to furnish a model of their refrigerating plant, recently installed in the laboratory; but, after expending $120 on the engine alone, their expert machinists were compelled to abandon the attempt. Wisconsin's expert mechanician built perfect models of both engine and compressor at a total cost of $35. Mr. Lorenz is an instrument maker, having learned his trade in Germany. He has been at the University in the capacity of mechanician for the past three years, and during that time has been called upon to construct at different times various kinds of special apparatus, more or less delicate, all of which he has handled with marked ability.

Besides the models above described, the St. Louis exhibit will include a large showing of the work of students in the machine and wood shops and in the forge room.

THE PRE-JUBILEE BANQUET.

Plans for Wisconsin's Jubilee celebration are already materializing among the students, and the first public demonstration from the student body will find expression at the Pre-Jubilee Banquet to be held at the Gymnasium on Saturday evening, April 23. Just at present the large committee consisting of fifty-five students representing every debartment of activity in the University, is straining every fiber to make this event what it deserves to be—a land-mark in the undergraduate history of "Wisconsin." The successful issue of this student dinner should furnish an opportunity for the truest Wisconsin spirit, as never before in our history has there been a great gathering of students for the single purpose of doing honor to Alma Mater.

It is to be an all-university gathering, at which first of all the inner man is to be coaxed into good humor by substantial viands, and, once in a receptive mood, the "flow of soul," good fellowship and inspiration, befitting such an occasion, will follow spontaneously and irresistably. The committee is planning for not less than a thousand students, while nearly fifteen-hundred can be easily accommodated in the Gymnasium.

President Van Hise will act as toastmaster, and responses will be given by a number of student speakers as well as speakers from outside the University. Ex. Gov. Geo. W. Peck will make a short speech among others, and Prof. Howare L. Smith of the law school, who is well known as an entertaining after-dinner speaker, will respond to a toast, and Dean Turneaure will speak. The official announcement of the part the students are expected to take in the program of Jubilee week will be made at this time.

Every University society and Fraternity is taking an active interest in the preparations, and many of them have already pledged the attendance of their entire membership. The engineers who are acting on the Pre-Jubilee Dinner committee are as follows, E. A. Moritz, G. F. Ungrodt, Edward Zaremba, B. F. Anger, O. L. Kowalkie, William S. Wheeler, F. Downey, and H. L. McDonald.

ILLINOIS UNIVERSITY COLLEGE OF ENGINEERING.

The President of the University of Illinois and the board of trustees have reached a decision concerning the disposition of the appropriation of $150,000 lately made by the state for the equipment of the Engineering department. The sum of $30,000 is to be reserved to extend the present equipment for the use of the undergraduate classes. The remainder, after full consideration of the best means of providing opportunities for advanced research and for furthering the interests of the engineering profession, and other public affairs, largely managed by engineers, and particularly to elevate engineering education, will be used to establish an engineering experiment station, which will be the first ever instituted in connection with a state university in this country.

Two buildings of simple construction will probably be built, a foundry costing $10,000, to permit the present forge and machine shops to be enlarged to accommodate future students, and a steam engineering laboratory, costing $20,000 to contain machinery and apparatus for advanced experiments on steam engines, gas engines, gasoline motors, compressed air, etc.

CIVIL SERVICE EXAMINATIONS.

An important examination was held, April 1, by the United States Civil Service Commission to secure constructing engineers on the Reclamation Service of the United States Geological Survey, at salaries of $3,600 to $4,800 a year. The subjects for examination were the applicant's education and training, counting ten points; his professional experience in general engineering, counting twenty points; his professional experience in construction counting fifty points, and a technical description in detail of the most important piece of engineering work done under the applicant's supervision, counting twenty points. Personal attendance for this examination was not required, the papers being forwarded to Washington.

As this was a special examination, the Civil Service Commission will be given the assistance of a board of eminent engineers in rating the papers.

An examination for engineering aid on the Reclamation Service, also for Assistant Topographer on the United States Geological Survey will be held in Madison April 19 and 20. A large number of engineering students have made application for privilege of taking these examinations. Of the University of Wisconsin students in engineering who took the examinations a year ago, five received appointments.

NOTES.

Arthur Anderson, '03, of Janesville, has taken a position with the General Electric Company at Schenectady, N. Y.

H. W. Young, E. E. '02, formerly with the Western Electric Company, was recently made an associate editor of The Western Electrician, with offices at 510 Marquette Building, Chicago.

H. P. Boardman, C. E., '94, has left the employ of the C., M. & St. P. Road to enter that of the Savage Construction Company, of Chicago, contractors for bridge substructures. Mr. Boardman was formerly located at Merrill Park depot, Milwaukee.

John Cadby E. E., '03, has accepted a position with the Milwaukee Electric Railway Company. Mr. F. C. Stieler, E. E., '02, formerly connected with the Milwaukee Electric Railway Company is now engaged in engineering work in St. Louis.

A copy of Bulletin thirty-five of the Northern Electrical Manufacturing Company of this city, has been received by THE ENGINEER. The booklet is gotten up in the usual artistic style and is devoted entirely to the various motors manufactured by this company.

The date for the minstrel show to be given by the senior engineers has been set for Thursday evening, April 14. Library hall has been secured for that evening, and admission will be by complimentary ticket admitting bearer "and lady." Tickets will be issued free of charge to all engineers who have paid their dues to the social committee, and no one will be admitted without a ticket.

The chorus has been in training for several weeks under the direction of stage manager Huels, and Allan Lee pianist, and good results are anticipated. A number of special "stunts" which will be worth seeing are also promised.

THE ENGINEER acknowledges the receipt of the Niles-Bement-Pond Company's mammoth book on "Machine Tools." It is a magnificent volume from a typographical standpoint. It contains 943 pages, quarto, and weighs nine and a half pounds. It is printed on beautiful heavy calendered paper, with remarkably good half-tone engravings, showing all the machines and machine tools manufactured by the half dozen different works controlled by this company. The printing throughout shows a character and distinction which gives the book a dignity above that of the average manufacturer's catalogue. It is bound in a plain red cloth over heavy boards, altogether too modestly for so fine a piece of printing.

THE ENGINEER is in receipt of a copy of Howe's Handbook of Parliamentary Usage, a neat little booklet containing the essential rules of parliamentary practice in a condensed and handy form.

It is at once the index and the contents, having an ingenious arrangement such that when opened at the center all the subjects to be referred to, are before one. By placing the thumb on the letter opposite any subject the book is immediately opened to all the rules, exceptions and quotations bearing on the particular motion referred to.

It will aid the presiding officer as well as the man on the floor and would be a valuable aid in the hands of all who desire to conduct themselves "decently and in order" in all meetings of a business character.

We are in receipt of a letter under date of March 30, announcing that Messrs. Murray C. Beebe E. E., '97 and Edward Bennet have established general engineering and contracting offices in the Farmer's Bank Building, Pittsburg, Pa.

Mr. Beebe was for several years an instructor in Electrical Engineering at the University of Wisconsin, which position he left to engage with Mr. Westinghouse during the development period of the Nernst lamp and later with the Nernst lamp Company as Chemist and Technical Superintendent.

Mr. Bennet, as one of the Westinghouse engineers, became associated with the development of the Nernst lamp shortly after the inception of the work in America, and for the past fifteen months, has served as Chief Electrician of the Nernst Lamp Company.

The firm is prepared to act as consulting and supervising engineers for the construction of railway, light, and power plants or to contract for the complete erection of such installations.

PATENTS.

749,210. FASTENING FOR TUBES OR STAY-BOLTS FOR STEAM-BOILERS. Madison M. Massfy and George Spooner, Cloudcroft, N. Mex., assignors of one-third to J. J. Wiles, Cloudcroft, N. Mex. Filed Feb. 12, 1903. Serial No. 143,067. (No model.)

The crown sheet, instead of having the material punched out for the holes, has the material formed into a nipple, to which the flue is attached by a coupling-sleeve and gasket.

752,028. APPARATUS FOR PREVENTING ENGINE-DRIVERS RUNNING PAST HOME OR DISTANT SIGNALS. Thomas Cairns, Auckland, New Zealand. Filed July 14, 1903. Serial No. 165,538. (No model.)

To the signal mechanism is attached an arm which, when the signal is out, engages a lever on the engine and sets the brakes.

752,619. COMBINED STEAM AND EXPLOSION ENGINE. William D. Gardner, Washington, Pa. Filed April 8, 1903. Serial No. 151,596. (No model.)

An ordinary slide valve admits steam to the cylinder. There is a valve which simultaneously closes all steam connections with the cylinder when the engine is to run as an explosion engine.

750,316. STEAM OR GAS TURBINE. Johann Stumpf, Charlottenburg, Germany. Filed Sept. 8, 1903. Serial No. 172,241. (No model.)

In a steam or gas turbine, the combination of two turbine-wheels rotating in opposite directions, with two concentric vane-rims for each turbine-wheel, and means for leading steam to the inner rim of one turbine-wheel and means for leading steam to the outer rim of the second one, substantially as described and for the purpose set forth.

754,439. STEAM-TURBINE. Ernst E. F. Fagerstrom, Sundbyberg, Sweden. Filed Feb. 12, 1903. Serial No. 143,116. (No model.)

749,885. STEAM-TURBINE. Sommers N. Smith, Philadelphia, Pa. Filed April 9, 1903. Serial No. 151,884. (No model.)

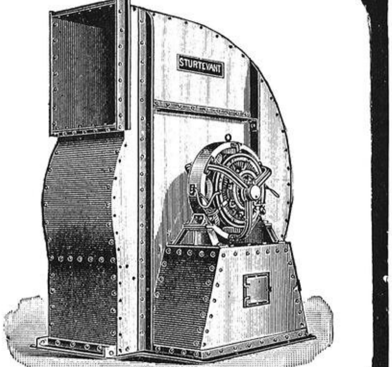
754.411. ROTARY ENGINE. Henrik Berglund, Stockholm, Sweden. Filed Feb. 25, 1902. Serial No. 95,514. (No model.)

753,390. MACHINE HAVING ROTATING PISTONS. Carl H. O. Hamann, Bergedorf, near Hamburg, Germany. Filed Dec. 13, 1902. Serial No. 135,125. (No model.)

753,388. ROTARY ENGINE. Arthur Groves, Sr., Ladue, Mo. Filed Dec. 26, 1903. Serial No. 186,653. (No model.)

748,832. ROTARY ENGINE. Peter A. Anderson, Grandin, N. D. Filed March 14, 1900. Serial No. 8,669. (No model.)

749,712. ROTARY ENGINE. Charles W. Allen, Merriman, Neb. Filed May 6, 1903. Serial No. 155,914. (No model.)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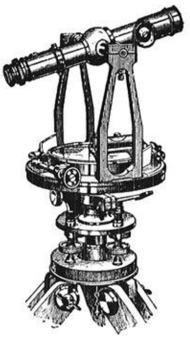

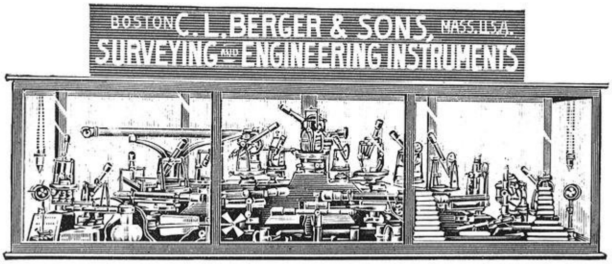
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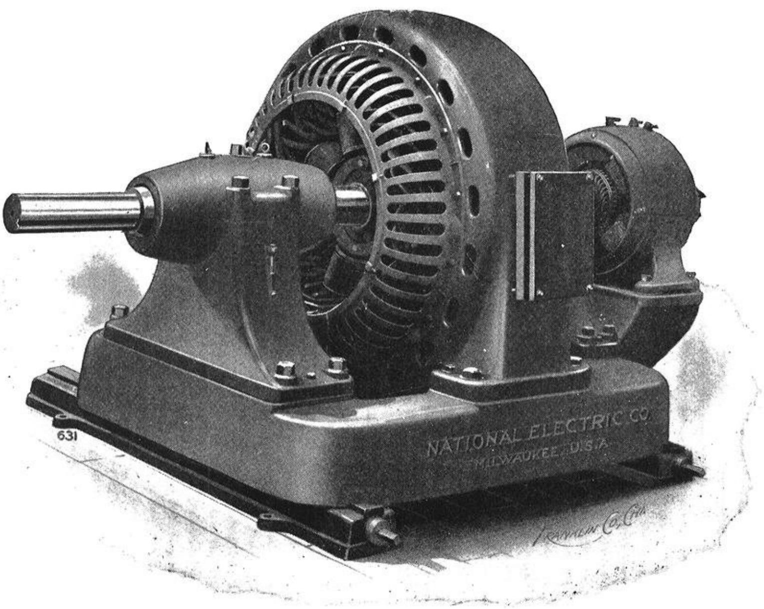
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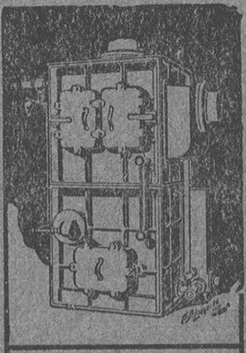

COCHRANE HEATER

Utilizing Exhaust Steam

After your engines have converted into work the very small per cent. of the heat in the steam that can be utilized in this way, what do you do with the exhaust steam that leaves these engines? This exhaust steam (in the case of non-condensing engines) contains from 90 to 95 per cent. of all the heat that the live steam had when it left the boilers. Certainly something ought to be done with this exhaust to prevent losing what it cost in the way of coal and labor to make it. There is one way in which a large part of the exhaust steam can be utilized—send it into a

Cochrane Heater

and immediately you will use as much of it as is required for heating the boiler feed supply right up to the temperature of the steam. This also means taking part of the load off the boilers, for with the exhaust steam (a waste product) you will then be heating water that otherwise the boilers would have to heat, and for which you would have to supply coal. The boilers also gain other advantages by having a hot feed supply delivered to them. The resulting economy runs all the way to 20 per cent of the entire fuel bill, according to the conditions.

Having made provision for heating the boiler feed supply, the remaining exhaust steam can be utilized in the Cochrane Heater for heating any water that may be required for other purposes or it can be used in an exhaust steam heating system, and the returns from the heating system can be brought back to the heater and utilized as part of the feed supply, thus saving even the heat in the returns.

If you will tell us what your conditions and requirements are, we shall be glad to tell you what a Cochrane Heater can do for you, at the same time submitting detailed specifications and prices, recommendations and guarantees. Send for our **Catalogue 44-H.**

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