The Wisconsin engineer. Volume 18, No. 7 April 1914

Madison, Wisconsin: Wisconsin Engineering Journal Association, [s.d.]

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The Wisconsin Engineer

APRIL, 1914

Vol. 18 No. 7

Volume 18 **Founded 1896** **Number 7**

The Wisconsin Engineer

$1.00 a Year **20c a Copy**

Entered as second-class matter Sept. 26, 1910, at the postoffice at Madison Wis., under the Act of March 3, 1879.

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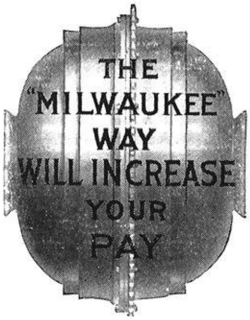
APRIL, 1914

Published monthly from October to May, inclusive, by the WISCONSIN ENGINEERING JOURNAL ASSOCIATION, Engineering Bldg., Madison, Wis.

Address all communications to The Wisconsin Engineer.

Subscription price $1.00 a year if paid before February 1; $1.25 a year after that date. Canadian subscriptions, $1.25 a year. Foreign subscriptions, $1.50 a year.



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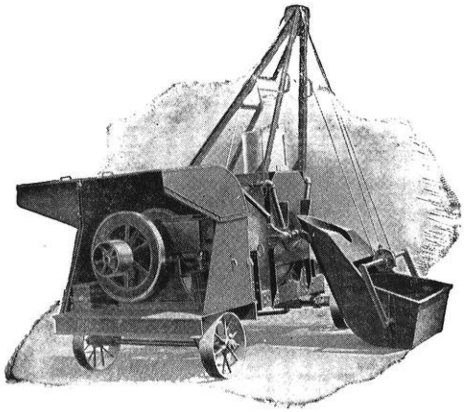

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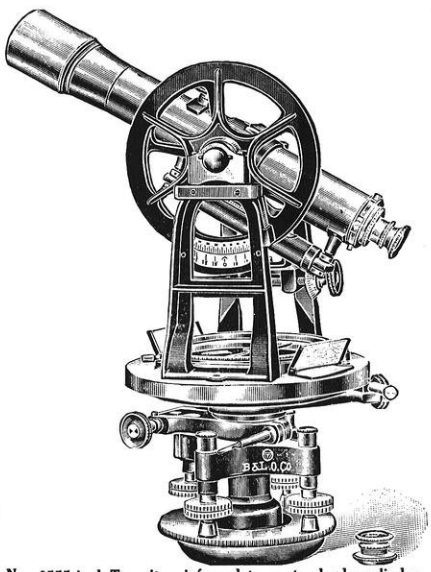

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The Wisconsin Engineer

VOL. XVIII APRIL, 1914 NO. 7

OPENING THE LINE TO CHIHUAHUA.

L. F. Van Hagan.

At the outbreak of hostilities in Mexico, three years ago, the railroads of the country found themselves in the center of the storm. The first stroke of the rebels was the capture of a passenger train at a way station in the desert south of Juarez and from that time to the present the fight has raged up and down the various lines, almost without cessation. It was imperative, from the governmental standpoint, that the lines should be kept open so that troops and supplies might be transported as needed; it was just as imperative from the rebel standpoint, that the lines should be destroyed in order to hamper the movements of the federal troops. Being well mounted themselves, the rebels could dispense with the railroads quite conveniently. Both sides were determined in their views and the roads suffered severely, at first in the matter of bridges and trains; later, as the struggle grew more bitter and the depredations of the rebel forces more wanton, water-tanks, coal-sheds and station buildings were wiped out, in most cases, it would seem, merely for the childish pleasure of causing destruction.

A large portion of the bridges in the northern part of the country were wooden trestles and these were the first to go. A small band of mounted men would ride along for miles, setting fire to one trestle after another. The timber was dry and once afire, burned rapidly. Later dynamite was used lavishly for the purpose of destroying the steel and masonry structures. An

American "soldier of fortune" was active in this dynamiting. The rapidity and thoroughness with which he did his work commanded admiration; but he earned the most cordial dislike of those of his countrymen upon whom fell the task of repairing the damage he did, and no regrets were expressed when finally he fell in battle.

Occasionally the rebels were able to capture a work train or a train of material. It was customary, upon such occasions, to run the train onto a pile bridge and set fire to both. In one instance a train was taken to the top of a steep grade and dropped,

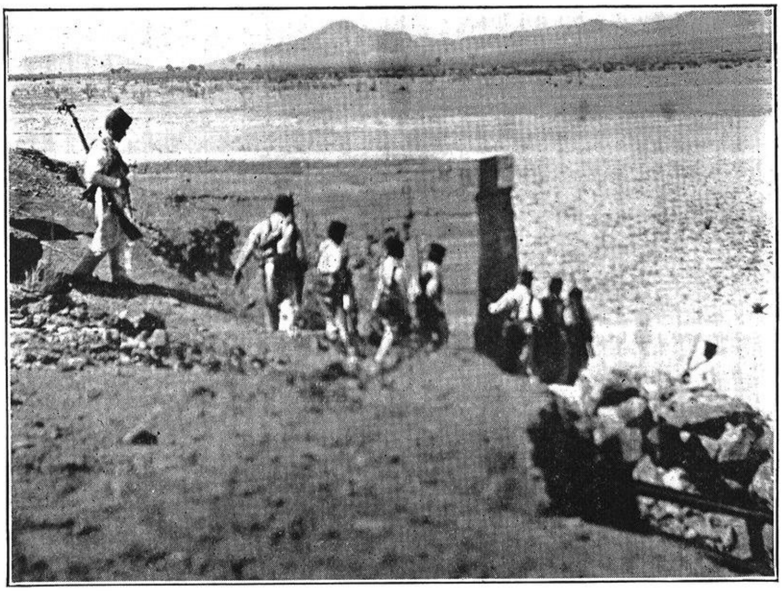


FIG. 1.—Soldier Track Layers.

car by car, down the grade and into a burning trestle at the bottom. These wanton antics reached their climax only recently when a freight train was captured, set afire and run into a long tunnel. The timber lining of the tunnel caught fire causing cave-ins. Into this horrible trap a passenger train was allowed to plunge. About fifty lives were lost, among the dead being several American railroad men.

In the beginning, the railroads made every effort to repair such damage and to keep the road open; later it became necessary to abandon operation over portions of the system. The brunt of the repair work fell upon the Mexican trackmen and those much maligned individuals distinguished themselves under the test. Their loyalty was surprising considering the scanty wages they received and the fact that their political inclinations were usually toward the rebels. The telegraph linemen had what was perhaps the most unpleasant task of all since they travelled alone, as a rule, and frequently were held up, robbed and threatened

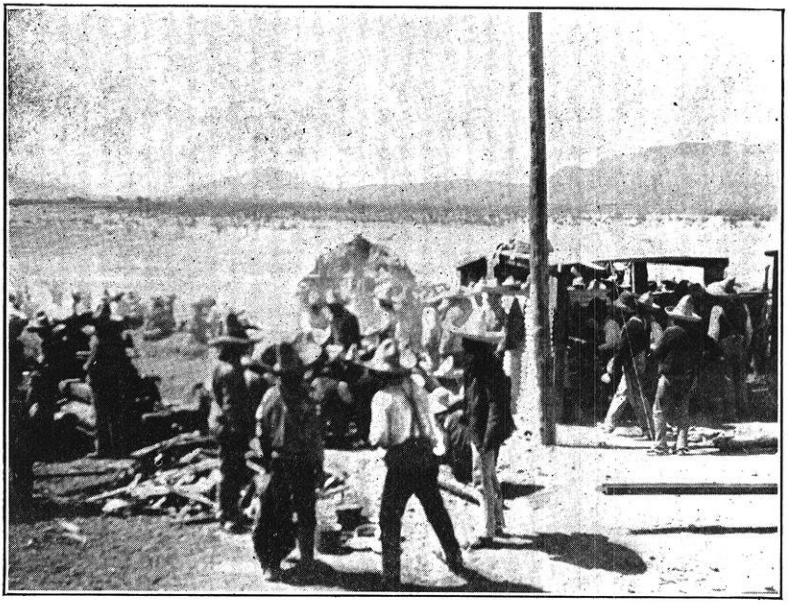


FIG. 2.—Meal-time.

by the rebels. One lineman who ignored orders to stop repairs was shot from the pole upon which he was working. Under the circumstances their persistence and success in keeping the lines in working order was remarkable.

For some time the city of Chihuahua was the center of operations. It is the capital of the state of the same name and the only city of importance between Torreon and Juarez. The rebels were anxious to take the city and establish there the headquarters of their government. Accordingly the railroad bridges and the telegraph lines in all directions were destroyed. Torreon, 294 miles to the south and Juarez 227 miles to the north, were the nearest places of importance. Chihuahua is not in a position to endure long isolation. It is really a big mining town, lacking the usual belt of truck gardens and farms that surround most cities and supply them with a considerable portion of their food stuffs. The interruption of communication caused much uneasiness in the city and the authorities went so far as to prepare a schedule of prices for food stuffs and fix the quantity that could be sold to any one person. The situation did not develope into anything serious however, as communication was restored within about two weeks.

Shut up in the town were the engineer of maintenance of way for the National Lines of Mexico and the division superintendent. They had men and rolling stock but the supply of material was limited. They decided to work toward the south until stopped either by rebels or by lack of material. The general superintendent of the system, accompanied by an escort of several hundred soldiers, started south from Juarez. This outfit was not heard from again for about three weeks. A third outfit, of which I had charge, began to work toward Chihuahua from the south. This latter outfit included about 140 trackmen and was accompanied by an escort of 200 soldiers of the 29th regiment, which afterward became rather famous as a result of the part it played in the uprising against Madero. It was commanded by Col. Blanquet, the man who later arrested Madero and who is now Minister of War under Huerta. My impressions of the Colonel are rather sketchy as I was too busy to become very chummy with him. I did entertain him at supper, in the caboose, one evening after obtaining permission from the cook to do so. The cook was the rear brakeman in disguise and naturally he was pretty independent in view of the fact that he didn't think much of the cooking job anyway. He said that, as a rebel sympathizer, he would throw up the job before he would cook for a federal soldier; but he was not proof against the wiles of diplomacy and finally consented to allow us to entertain. The Colonel, a tall, lean man, resembling the pictures of Don Quixote, came bringing a pint bottle of milk as his contribution to the feast. He impressed me as being pretty much of a soldier in spite of his appearance; but he did not seem to be at all blood thirsty. Politics were touched upon in the course of the conversation and with Mexican politeness he avoided any clash of opinion by admitting that conditions throughout the country were in need of reform. He soon got away from that topic and told us of his campaigns in Quintana Roo, boasting that he was the only commander who had not been ambushed in those campaigns. I knocked on wood for him for I didn't think he knew the charm.

In addition to the soldiers, we were protected by an armoured car mounted with gatling guns. It was an ordinary, wooden, box car, lined with sheet steel, between which lining and the sides of the car was a layer of sand about 4 inches thick. The gatling

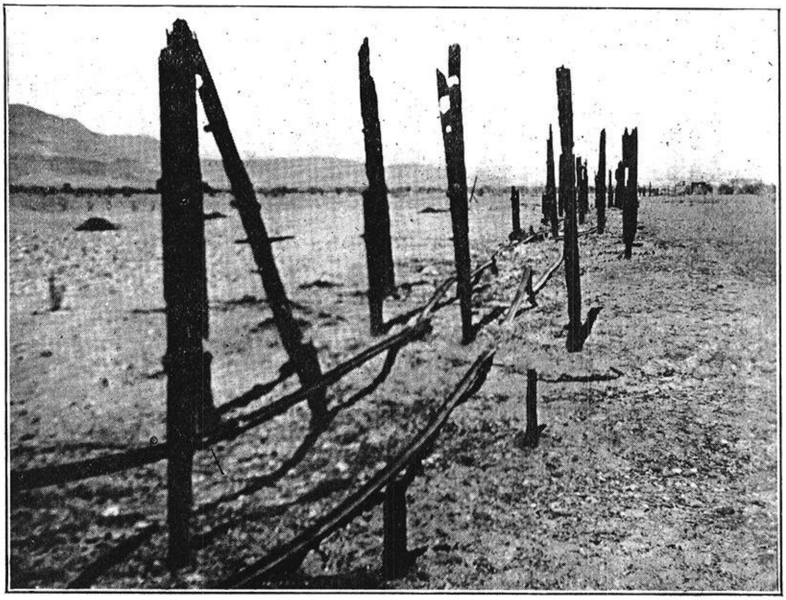


FIG. 3.—Remains of the Ortiz Bridge, 2100 feet long.

guns were to be fired through the side doors and through portholes cut in the ends. In addition numerous loop holes were provided so that rifles could be used also. The exterior of the car was painted black and white in a checker board pattern. The tout ensemble was striking. The checker board design was intended to obscure the portholes, which it did to some extent but it also rendered the car very conspicuous, especially in the country in which we were operating, where because of a lack of vegetation it is possible to see great distances. Whether the car would prove valuable in action seems questionable. The only opportunity to try it was when a couple of horsemen appeared suddenly out of a dry run. They saw the car and took a shot or two at it for luck. When the gatling cut loose in reply they fell over backwards into the gully in their hurry to escape the rain of bullets. No damage was done on either side but a few days later we received some of the Mexico City newspapers containing an account of the affair that caused much glee among the ribald train crew. According to the papers the car had received a "baptism of blood and fire" and had repulsed a fierce rebel attack with heavy loss. Perhaps the Colonel colored his official report and then again, perhaps the reporters who wrote the story used their imaginations. In either event, the story was much improved in the telling.

In most cases our task of repairing the line was a simple one, viewed from the constructional standpoint, our troubles being minor ones that were annoying chiefly because of the delay they caused when haste was so important. There was practically no difficulty from water since most of the burned structures had spanned what were dry runs most of the year. The condition of the openings as we found them is shown in the photographs. In most cases the destruction was complete, nothing remaining but the iron bolts, drift pins, etc. scattered about in the ashes. The rails sagging across the openings, were so stretched and twisted that they were of no further use. We made no attempt to rebuild the structures in the usual way; but contented ourselves with cribbing the openings. This required a great quantity of material but was more rapid than rebuilding. We were hampered at the outset by the creosoted ties that we had to use and by the lack of bridge stringers. The ties were so slippery that it was difficult to pile them into solid cribs. By sprinkling earth over them this trouble was overcome to some extent. The lack of stringers made it necessary to fill the openings with a solid mass of ties. This took material and what was worse it required extra time. Fortunately we soon began to receive a plentiful supply of untreated ties and stringers. A supply train came to us from the south every day. We never did receive any iron work. Our structures were built like the Temple of Solomon, without the sound of a hammer, until we began to lay the rail.

After reaching a burned bridge, the first task was to clear away the ashes and make sure that there were no hot embers remaining that might set fire to the crib. For the first few days we were so close behind the destroying parties that we came upon the bridges still smoking. When the ground was cleared and leveled, cribs of ties were built up to the necessary height; on top of these stringers were laid and on the stringers ties and new rails were placed. We found it convenient not to remove the old

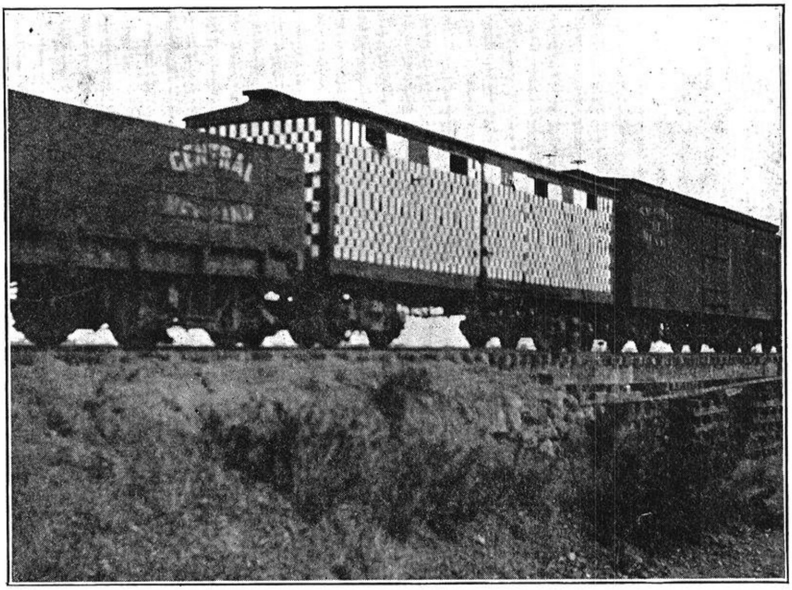


Fig. 4.—Armoured Car—painted to disguise Loop Holes.

rails until the cribs were up so that men could work on top of them in handling the rail. It was convenient also to slide the heavy stringers along the old rails.

Laying the new rail usually consumed a considerable portion of the entire time spent at any one place. The expansion and creeping of the rails that remained in the track made it impossible to fill the gap with full sized rails and at the same time secure a butt joint. We avoided the necessity of using butt joints by putting in switch points where we could; when that was not possible we were forced to cut the rail to the proper lengths. As we had no rail saw and no means of repairing track chisels properly rail cutting was a serious matter and caused much delay. There was also difficulty where our extra rails were not of the same size as the rails in the track.

Our most interesting task was at the bridge over the Conchos river at Ortiz. This bridge had been a pile trestle about 20 feet high and 2100 feet long, with a high earth fill at each end. Nothing remained of the structure but a row of blackened piles standing in smoldering ashes with two lines of warped and twisted rails woven in and out among them. At first sight it seemed that we were pretty well tied up. To redrive the trestle would be a long job; besides we had neither piles nor pile driver. To crib the opening was out of the question. The labor and time necessary would be excessive even were the material at hand. As a matter of fact there was not enough material available on the whole system to make any impression on such a hole. The rebels, as we were informed later, were satisfied that the burning of the bridge would isolate Chihuahua for two months at least. The solution of the problem proved very simple, however. Although the river at times was "bravo," as the Mexicans would express it, and had swept away a steel bridge of several spans in one of its outbursts, there was, fortunately, not a drop of water running at that time. The bed of the stream was a desert, traversed by two or three gullies where the last few trickles of water had cut depressions below the general level. As rebuilding the structure was out of the question we simply laid track across the bed of the stream. A roadbed was excavated down the side of each fill on a 2.5 % grade. No surveying instruments were available so the heights were estimated anld the distances were paced in laying out the work. Some care was necessary in laying out the grades since it would have been embarrassing to get the heavy work train down into the river and not be able to get it out again.

As there was a possibility that the track as we laid it would have to be operated for some time, three small bridges were built in the bed of the stream to take care of small amounts of water that might come down. The location of these was determined after a study of the stream bed to determine the habits of the river at low water.

On the fourth day after reaching the bridge, our track was complete to the far side of the river and we were ready to move ahead. With the engine in the center of the train, we dropped down the grade into the river. Then the rear of the train was uncoupled and the engine pushed the front part of the train up the grade on the other side. It was a breathless moment; but we finally reached the top of the fill and the engine cut off and went back for the rest of the train.

Two days after crossing the big river we met the outfit from Chihuahua and together we cribbed the last opening. It was

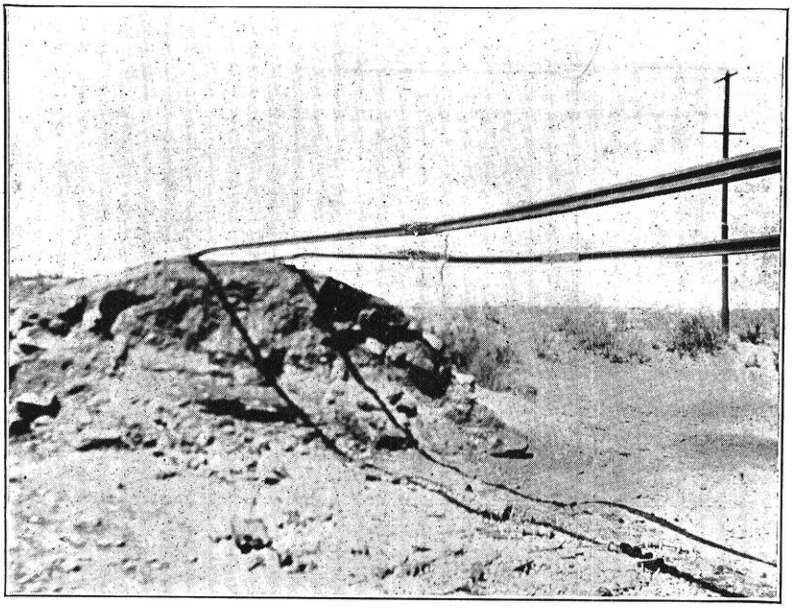


FIG. 5.—Bridge 1521 B showing complete destruction by fire.

midnight when we finished so we pulled back to the nearest station and laid up for the night. A passenger train ,the first in two weeks, was waiting at the station for the completion of the last bridge. It pulled out immediately and went on to Chihuahua where it received a hearty welcome.

During the last few days our operations were greatly facilitated by the fact that we were able to maintain telephone connection with the outfit from Chihuahua and also with a station to the south. We had a portable telephone set and wherever a stop was made, the first act was to hook the pole over the wire and find out what conditions were on either side of us.

At Chihuahua a new outfit was organized and started north in search of the general superintendent who had not been heard from for some time. Two or three days later we found him working steadily southward, but almost out of provisions and material. He had reached a condition in which he was considering the advisability of tearing up track behind him in order to secure material for repairs. After finding him we turned south, abandoning for a time, the attempt to open the line to Juarez.

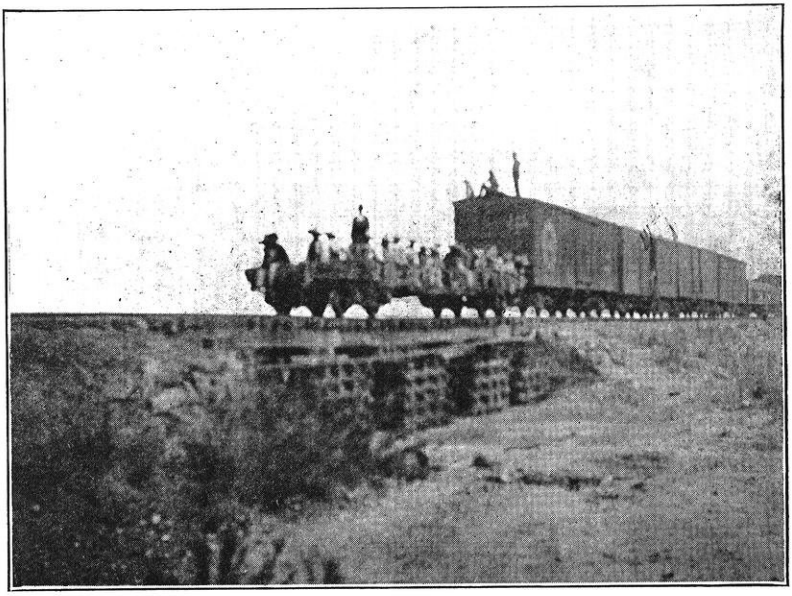
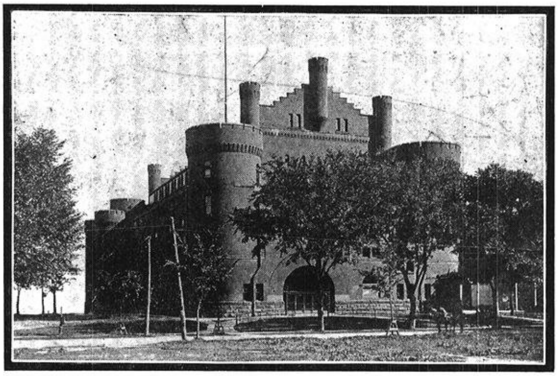


Fig. 6.—Bridge 1521 B after being repaired.

Providing food for 140 men, under the conditions outlined, was not a simple matter. At first we subsisted on lunches put up for us by a Chinaman who managed a restaurant at one of the stations to the south. These lunches consisted chiefly of egg sandwiches and were conveyed to us on a handcar under the hot sun. That diet soon caused much complaint and little work was accomplished. It was useless to try to drive the men unless their stomachs were full; accordingly we made use of the stay at Ortiz to organize a commissary department. In a town several miles away, a merchant was discovered who was willing to sell to us on credit and from him we purchased several hundred dollars worth of provisions, cooking utensils etc. Our purchases made an imposing array as they came to us by team over the desert. It was necessary to have cooks as well as provisions so I sent out scouting parties to try and round up some women but no women would come near the outfit, except the dirty "soldier women" and no one wanted them. For a time it looked as though we would have to go back to the lunches. Then some one proposed that we try to organize a squad of chefs. It was a doubtful proposition because cooking is not considered man's work by the peons. We managed however, to find half a dozen men who knew something about the business and we put an energetic foreman over the squad. A few privileges were granted them to compensate for the chaffing of the other men. A good deal of fun was made of them but they stuck to the job and provided three good meals a day. In addition to food, a plentiful supply of cigarets was purchased and doled out from time to time. These were nearly as necessary as the food.

The repairs we made did not last long. The bridges have been destroyed and repaired many times since then and even now the same grim game is still going on.



AN APPROXIMATE METHOD OF HANDLING THE DIFFERENTIAL EQUATIONS OF COMMUTATION IN DIRECT-CURRENT MACHINERY.

By V. Karapetoff.

There was a time in the history of the development of direct-current machines when a solution of the difficulties in commutation was sought in a purely mathematical way, by considering the law governing current reversals in short-circuited coils. As a result we have a large literature on the subject, with contributions from nearly every prominent electrical engineer interested in the design or operation of direct-current machinery.

The interest in the purely mathematical theory of commutation has considerably abated of late years due principally to the following causes:

(1) With the advent of commutating poles (inter-poles) it became possible to obtain satisfactory commutation without much difficulty.

(2) With large experience in building machines, empirical and semi-empirical rules have been evolved which enable one to predict commutation from a purely practical point of view with considerable certainty.

(3) The introduction of the oscillograph added a new and powerful method of attacking the features of the problem too difficult for mathematical analysis.

Nevertheless the problem still possesses a considerable interest for a theoretician, and who knows, it may pop up again at some time in a new and unexpected form of importance to the practical engineer.

The following article is *not* an elementary treatment of the known phases of the subject. The reader is assumed to be familiar with the standard treatment as found in E. Arnold's *"Die Gleichstrommaschine"*, and in the advanced text-books where it found its way from this classical work. The purpose of the following article is to show that the differential equations of commutation may be treated without much difficulty by assuming an *a priori* law according to which the current varies with the time in the coils undergoing commutation. This is an approximate method warranted by the results, and the writer believes that the mathematical method of attack by itself is of some general interest apart from the specific engineering problem to which it is applied.

Two quantities characterize the quality of commutation; (a) *the current density* between a commutator segment and the edge

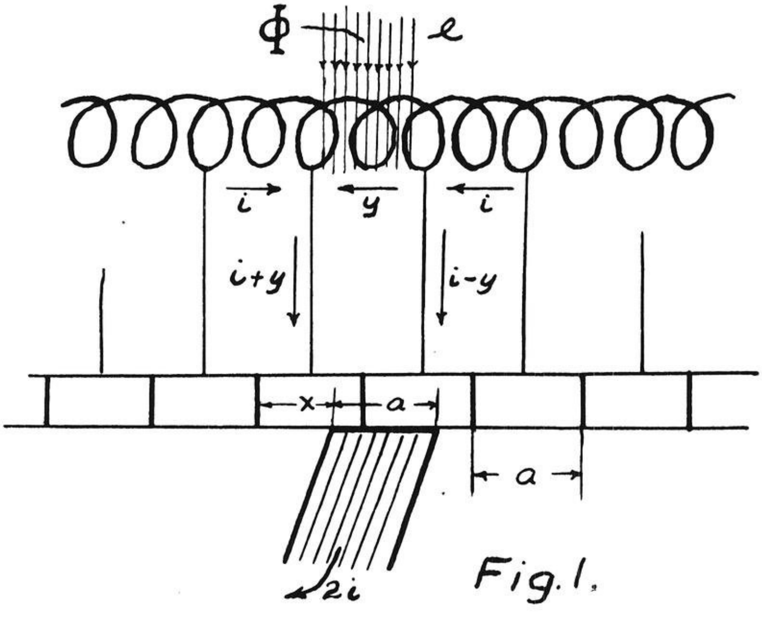


Fig. 1.

of the brush that is about to leave it; and (b) *the sparking voltage,* or the voltage between the commutator segment and the edge of the brush. This voltage depends upon the current density (a) and upon the contact resistance of the brush. It is shown below how to express these two quantities in a form suitable for practical applications.

We shall consider first the case when the width of the brush a (Fig. 1) is equal to that of a commutator segment. This is the simplest case because the mutual inductance between the coils undergoing commutation need not be taken into account. Let c be the resistance per unit area of the contact between the brush and the commutator, and let b be the length of the brush in the direction parallel to the shaft. Then, with the notation in Fig. 1, we have

$$e = (i - y) \frac{c}{x\,b} - (i + y) \frac{c}{(a - x) b} - L \frac{dy}{dt} , \qquad (1)$$

where e is the e.m.f. induced in the coil under commutation by the external field, due to the fringe of the main pole or the interpole. If there is no such field, $e = o$. L is the inductance of the short-circuited coil, and t is time. But, if T is the total time of reversal of the current, we have $\frac{x}{a} = \frac{t}{T}$, so that

$$e = (i - y) \frac{c}{x\,b} - (i + y) \frac{c}{(a - x)\,b} - \frac{L a}{T} \frac{dy}{dx} \qquad (2)$$

This is the well-known differential equation of commutation.

In order to simplify this equation let us assume the armature current per circuit to be equal to one ampere; in other words, let the variable curent y be measured in terms of the constant current i. Also, let the voltage e be understood to refer "per ampere of the current i."

The specific resistance of contact, c, is, according to experiments, a variable quantity, a function of the current density. According to Arnold's experiments

$$c = \frac{A}{d} + B \qquad (2a)$$

where d is the current density, and A and B are empirical constants which characterize a given brush. In eq. (1), $(i - y) / xb$ is the current density in the part x of the brush contact; let this density be denoted by d_1. Similarly, let $d_2 = (i + y) / (a - x) b$ be the current density in the part $(a - x)$ of the brush contact. Eq. (1) becomes

$$e = d_1 \left(\frac{A}{d_1} + B \right) - d_2 \left(\frac{A}{d_2} + B \right) - L \frac{dy}{dt} . \qquad (1a)$$

or simply

$$e = d_1 B - d_2 B - L \frac{dy}{dt} ,$$

For the sake of abbreviation we denote

$$\frac{B}{b} = R \ : \ \frac{L}{T} = h,$$

and measure x in terms of a, that is, put $a=1$. Equation (1) is thus transformed into

$$e = (1-y)\frac{R}{x} - \frac{(1+y)R}{1-x} - h\frac{dy}{dx} \ . \qquad (3)$$

In an *ideal case* of perfect commutation, that is to say, when $e=o$ and $L=o$ (or T very large) we have a *straight line law* of commutation

$$\left.\begin{array}{l} 1-y = 2x \\ 1+y = 2(1-x) \end{array}\right\} \qquad (4)$$

This solution satisfies equation (3), and also satisfies the limiting conditions, that when

$$\left.\begin{array}{l} x = 0,\ y = 1 \\ \text{and when} \\ x = 1,\ y = -1 \end{array}\right\} \qquad (5)$$

Now, instead of solving equation (3) in the general case, and obtaining an infinite series, let us assume that the curve $y=f(x)$ for an *imperfect commutation* can be represented with sufficient accuracy by adding two more terms to the solution (4), which terms modify the straight-line law sufficiently to account for the influence of e and L. Thus we put

$$\left.\begin{array}{l} (1-y) = Mx + Nx^2 + Px^3; \\ (1+y) = M(1-x) + N(1-x^2) + P(1-x^3) \end{array}\right\} \qquad (6)$$

Where M, N, and P are constants to be determined from the conditions of the problem.

The first of these equations is that of a straight-line function Mx, modified by correction terms Nx^2 and Px^3. The first condition (5) is fulfilled with any values of M, N, and P. In order that the second condition may be fulfilled, the following relation must exist:

$$M + N + P = 2 \qquad (7)$$

The second equation (6) is now obtained by simply adding together the first equation (6) and equation (7). Differentiating the first equation (6) we get

$$-\frac{dy}{dx} = M + 2\,Nx + 3\,Px^2 \qquad (8)$$

Substituting now (6) and (8) into (3) we obtain

$$(e) = R\,[M + Nx + Px^2 - M - N\,(1 + x) - P\,(1 + x + x^2)]$$
$$+ h\,(M + 2\,Nx + 3\,Px^2),$$

or, after reduction,

$$(e) = -R\,(N + P + Px) + h\,(M + 2\,Nx + 3\,Px^2) \qquad (9)$$

The symbol *(e)* in parentheses signifies that the actual e.m.f. *e* has to be modified for each value of x, in order to satisfy equation (9). An arbitrary given function *e* could not satisfy (9), because the exact solution of (3) can be represented only by an infinite series.

Now, in order to determine the coefficients *M, N,* and *P,* we make an assumption which is justified in practice, namely, that in order to satisfy (9), the given function *e* may be closely enough replaced by a parabolic function

$(e) = e + m$ (Fig. 2)

m being small in comparison with *e*. We impose two limiting conditions upon the arbitrary function *m,* namely (1) that the average value of *e* is equal to the average value of (*e*), and (2) that the total change in (*e*) between $x=0$ and $x=1$ be the same as in the actual e.m.f. *e*. These two conditions expressed analytically give

$$\left.\begin{aligned} \int_0^1 e\,dx &= \int_0^1 (e + m)\,dx \\ (e_1 - e_0) &= (e + m)_1 - (e - m)_0 \end{aligned}\right\} \qquad (10)$$

The first condition when applied to (9) gives

$$e_{ave} = -R\,(N + P + \tfrac{1}{2}\,P) + h\,(M + N + P) \qquad (11)$$

The second condition gives

$$e_1 - e_0 = -R\,P + h\,(2\,N + 3\,P) \qquad (12)$$

Solving the three equations (7), (11), and (12) together, values of *M, N,* and *P* are obtained which determine the shape of the curves given by the equations (6).

In cases where commutation is evidently good, or where the problem consists in finding conditions for a good commutation, the coefficient P in equations (6) may be assumed equal to zero and only equations (7) and (11) used. On the other hand, if even three terms in (6) should be insufficient, further terms, con-

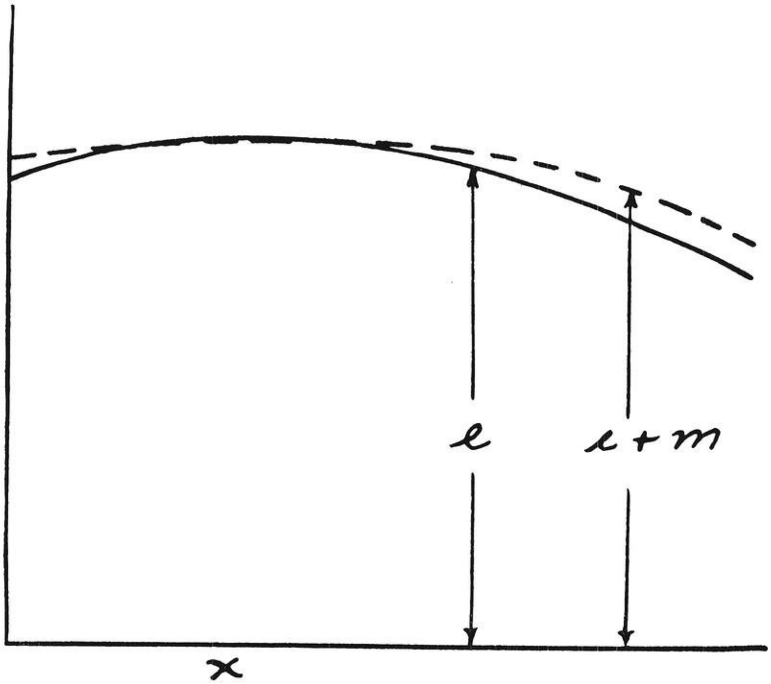


Fig. 2.

taining x may be added. In this case additional conditions concernig m may be imposed besides equations (10); for instance, that the values of de/dx are nearly equal to those of d(e+m)/dx at $x=o$ and $x=1$. Or some further limitations could be imposed concerning the curvature of e and that of $(e+m)$, etc.

Knowing $(1-y)$ and $(1+y)$, the maximum current density under the trailing tip of the brush and the sparking voltage may be readily determined and thus the criterion of commutation found.

Note. The above given method may be somewhat simplified by writing y in the form

$$y = 1 - 2x + \varphi x (1 - x) \qquad (13)$$

Here *(1—2x)* corresponds to an ideal straight-line commutation, and

$$\varphi = C + Dx + Ex^2 + \ldots$$

Where C, D, E, etc., are constants to be determined from the conditions of the problem. Substituting the value of y from equation (13) into equation (3), we obtain

$$e = [2 - \varphi (1 - x)] R - [2 + \varphi x] R + h [2 - \varphi (1 - 2x) - \frac{d\varphi}{dx} (x - x^2)] ,$$

or, after reduction,

$$e = 2h - \varphi (h + R - 2hx) - h \frac{d\varphi}{dx} (x - x^2). \qquad (14)$$

If we are satisfied with y being a curve of the second degree, in other words, $\varphi = C$ and $d\varphi / dx = 0$, the first condition (10) for e_{ave} gives

$$e_{ave} = 2h - \varphi R, \text{ or}$$

$$c = \frac{2h - e_{ave}}{R} \qquad (15)$$

If a closer approximation is desired the second condition (10) for $(e)_1 - (e)_0$ may be introduced as before, or two separate conditions, stating that the approximate curve has the same ordinaes e_0 and e_1, as the given curve. In this case φ may consist of three terms, and we have

$$\left.\begin{aligned} e_0 &= 2h - C (h + R) \\ e_1 &= 2h - (C + D + E) (R - h) \end{aligned}\right\} \qquad (16)$$

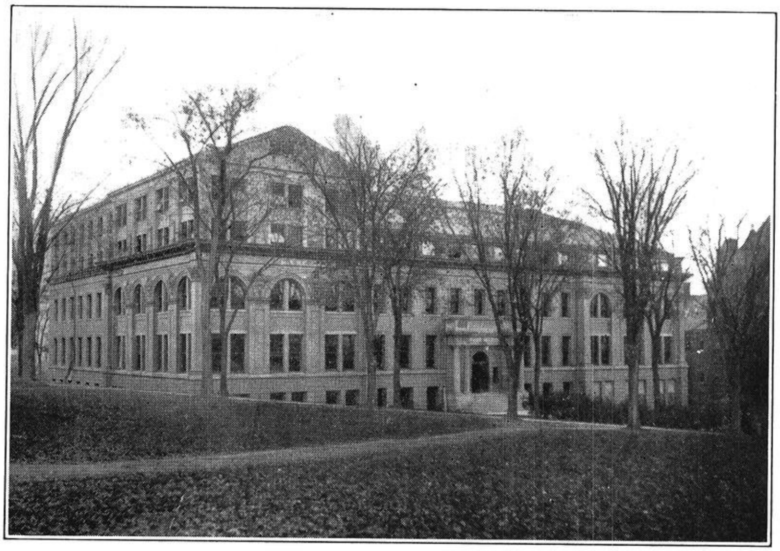
and condition (10) for e_{ave}.
Or else, the condition for e_{ave}, which is somewhat complicated, may not be used at all, and the coefficient E in equation (16) assumed $= o$. The function φ is in this case of the form $C + Dx$,

and y is a curve of the third degree. If $e = o$ throughout the commutating zone, we simply have

$$C\,(h + R) = 2\,h, \text{ and}$$
$$(C + D)\,(R - h) = 2\,h\ ,$$

from which

$$C = \frac{2\,h}{R + h}, \text{ and } D = \frac{4h^2}{R^2 - h^2}\ .$$



THE CHICAGO SERVICE AND ASSEMBLING PLANT, FORD MOTOR COMPANY.

A SIX STORY REINFORCED CONCRETE BUILDING OF FLAT SLAB CONSTRUCTION.

ALBERT M. WOLF,* '09, C. E. '13.

In order to increase the output of the popular Ford automobiles to meet the ever increasing demand, the Ford Motor Co. is erecting reinforced concrete assembling plants at various points throughout the United States and Canada. The various parts of the cars are shipped in carload lots from the Detroit plant where they are made, to the assembling stations where they are assembled and tested before selling. In this way the factory output is increased considerably and no small amount of money is saved on freight charges.

One of the largest and most interesting of these assembling and service buildings is the Chicago plant at 39th St. and Wabash Avenue.

This six story structure is 232 ft. x 164 ft. with an enclosed shipping court 30 ft. wide and 205 ft. long in the middle portion of the building from second floor to roof. In this court at the roof line are reinforced concrete girders carrying the crane rails. Below this are flat slab receiving balconies projecting out from the different floors, to receive freight picked up from shipping platform by the bridge crane. The shipping and unloading platform at second floor level is served by a depressed switch track. The court is covered by a monitor skylight of reinforced concrete construction.

GENERAL DESIGN.

One of the main factors governing the general design was that it should be such as would readily permit of future extension along the same lines.

* Principal Assistant Engineer, Condron Company, Architectural & Structural Engineers, Chicago.

The first story 20 ft. high is being used for show rooms and garage space, the second floor as the shipping floor and the others as assembly floors. The upper stories have a height of 13 ft. The floors are served by two large freight elevators with platforms 16 ft. x 9 ft., in addition to the traveling crane in the shipping court.

The floors are of the Akme System of Girderless Floor Construction with flat slabs 11 inches thick, designed for a live load of 150 lbs. per sq. ft. These slabs are carried on reinforced concrete spiral-hooped columns of octagonal section with flaring column heads of the same shape capped by a 7 ft. square plate 9 inches thick. The columns are spliced at the floor levels by lapping the bars from the column below with those above sufficiently to transmit the stress in the upper bars to the lower bars by bond. The interior columns are carried on isolated spread foundations of reinforced concrete, while the exterior columns along the street sides are carried on a continuous footing.

The typical panels are 28 ft. x 25 ft. which are unusual spans for flat slab construction. The reinforcement for the floor slabs consists of rectangular belts of square twisted bars extending in two directions only. The bars in the main belts between columns are bent so as to be in the top of slab over the column heads and the immediate vicinity thereof, and in the bottom of the slab between column capitals. The bars in the portion of the slab enclosed between the main belts are placed parallel and perpendicular to them and similarly bent, thus reinforcing the upper portion of the slab over the middle portion of the main belts in a transverse direction. The bars were bent previous to placing and held rigidly in place by supporting bars and blocks, thus insuring their proper position in the finished slab.

To provide for future extension the floor slabs at the south end of the building are carried out 4 ft. beyond column center and provided with a continuous steel angle shelf to carry the future slab. Short stub bars were placed through holes in the angles at 6 in. centers to tie the future slab to the present construction.

All stairs in the building are of reinforced concrete designed as slabs with the risers cast integral therewith. These stairs were concreted at the same time as floors and are provided with metal nosings.

TRACK STRUCTURE.

A railroad switch track enters the building at the south end at a level about 4 ft. below the second floor and extends to within one bay of the north end. The track is carried on a reinforced concrete slab 21 inches thick hung from reinforced concrete girders of 28 ft. span, 7 ft. 3 in. deep below second floor. These girders are 16 in. wide and spaced 16 ft. 6 in. centers, one being carried on brackets on the main building columns while the other line is supported on auxiliary columns.

SHIPPING AND UNLOADING PLATFORM.

The track structure being placed to one side of the court bay 35 ft. wide a considerable clear space is left along the other side. This is used as a shipping and loading platform, from which materials are picked up and transferred to the various floors by the traveling bridge crane.

RECEIVING BALCONIES.

Flat slab receiving baloncies are provided on all upper floors arranged in tiers the length of balconies decreasing one-half panel each from third floor up. These balconies project out 8 ft. 6 in. beyond the center of court-way columns. They are of the same thickness as the main floor slabs; viz. 11 inches, and are reinforced in a similar manner as cantilever slabs without deepened supporting girders as are usually used in such construction. The load carrying capacity of these balconies was very forcibly demonstrated by the application of a test load of 55 tons of cement to one of the fourth floor balconies, 42 ft. long. Under this load of 310 lbs. per sq. ft. (over twice the designed load) or 2600 lbs. per linear foot of balcony, a deflection of only 5/32 in. was recorded 24 hours after full load was applied. It should be noted that in making this test no load was applied on the interior slab beyond the column centers to care for the uplift caused by the load on the balconies: in other words, the test was made as severe as possible.

The court is enclosed along the face of columns with steel sash and sliding steel doors glazed with wire glass at the balconies.

The north end bay forms a connection between the two portions of the building separated by the craneway. This bay 35 ft. x 28 ft. consists of a panel slab 11 inches thick enclosed by deepened slabs between columns with a thickness of 20 inches. This is no doubt the largest panel ever built, employing this type of construction.

CRANE GIRDERS.

The traveling bridge crane with a capacity of 5 tons, a weight of 9 tons and a span of 34 ft. is carried on reinforced concrete girders of 28 ft. span at either side of the court. These girders are carried on and bracketed to the tops of the reinforced concrete columns and designed as fully continuous beams. The crane rails rest on $\frac{3}{4}$ in. steel plates 2 ft. centers anchored to the concrete and the rails clamped down by means of American Bridge Co. rail clamps, pattern No. A-24. The girders are designed so as to readily allow future extension at the south end of the building.

The craneway construction and arrangement just described is without doubt one of the most efficient layouts for the rapid handling of a large amount of freight and could very readily be applied to factories, machine shops, etc.

SKYLIGHT CONSTRUCTION.

The most novel and interesting feature in the building is the monitor skylight of reinforced concrete, with a span of 35 ft. 6 in. over the craneway. After considerable study and estimating on the part of the engineers and contractor it was decided that the reinforced concrete truss construction would be cheaper and more satisfactory than steel construction fireproofed with concrete or tile.

The monitor as designed and built consists of eight reinforced concrete king-post trusses, 10 ft. deep with a span of 35 ft. 6 in. spaced 28 ft. centers and carried on reinforced concrete side-walls 9 inches thick. At the peak they support a continuous longitudinal girder of T-section which in turn carries two sets of reinforced concrete T-beam rafters parallel to and between trusses At the north end a truss was omitted on account of the architectural treatment and a reinforced concrete gable wall 10 in. thick with underside arched, was used to span the court. The accompanying section of monitor shows the details of trusses.

The concrete rafters divide the roof between trusses into spaces 7 ft. 4 in. wide by about 17 ft. long which are covered with skylights. In order to obtain a water proof job around these skylights, a 3 in. x 3 in. concrete curb, cast at the same time as the trusses, etc., was placed around all openings. Continuous copper flashing was placed on the concrete from opening to opening so as to allow no joints except at the edges of glass areas.

The reinforced concrete sidewalls of the monitor are 9 in. thick and provided with window openings containing steel sash, 3 ft. 2 in. high and 7 ft. 4 in. long, directly below the glass skylights.

The trusses and other construction though heavy present an excellent appearance, obstruct very little light and are otherwise entirely satisfactory. The trusses were designed for a live load of 30 lbs. per sq. ft. of monitor surface.

WATER TANK AND TEST GROUND.

A 70,000 gallon steel water tank on a steel tower 50 ft. high above the roof, is supported directly on four of the building columns at roof level, which were designed to carry the extra load coming upon them. This tank supplies the sprinkler system which is installed throughout the building.

The main roof to the right of the monitor is sloped for drainage and covered with promenade tile and used as a testing ground for the newly assembled automobiles which are carried up to the roof in an elevator discharging at that level. This use of the roof area of a building is rather unusual and a mark of the efficiency of the plant in utilizing all available space.

MATERIALS AND UNIT STRESSES.

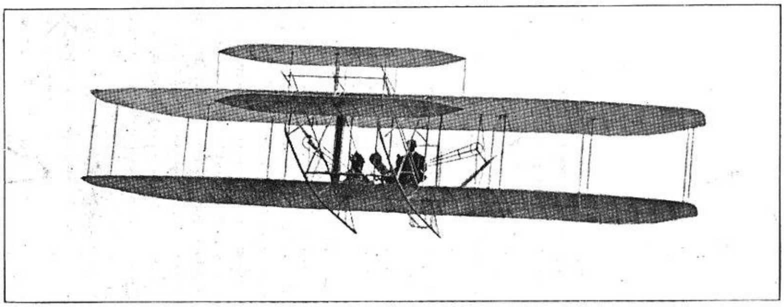
All concrete used in the building was of a 1:2:4 mixture with crushed gravel as the coarse aggregate. All reinforcing steel except that in columns consisted of cold twisted square bars. The vertical bars in the columns were plain rounds of medium steel and the spirals were of high carbon wire rods.

The allowable unit stresses for steel and concrete were in accordance with the Chicago Building code which allows 18,000 lbs. per sq. inch in tension for the grade of steel used and 700 lbs. per square inch compression in bending on extreme fibre of concrete. The flat slab floors were designed in accordance with the Akme Design Standards approved by the Building Department—no provision being made in the ordinance for flat slab construction. A test load of 147 tons of cement, or 426 lbs. per square foot, uniformly distributed over one entire panel was applied to a panel of the second floor with a resulting maximum deflection of only 0.39 inch or 1/1160 of the diagonal span. This test load was equivalent to twice the designing live load plus a load equivalent to the dead weight of the slab.

PERSONNEL.

The architectural design was made by Mr. John Graham, Supervising Architect of the Ford Motor Co., Detroit; while the structural design was executed by the Condron Company, Architectural and Structural Engineers, Chicago, who have patented the Akme System of Girderless Floor Construction. Mr. E. L. Scheidenhelm of Chicago was the General Contractor. The building was occupied by the owners in December, 1913.

The Condron Company has designed the structural features of fifteen other Service Buildings for the Ford Motor Co., in as many different cities. All of these buildings are of the Akme System of flat slab construction.



THE NEW INTAKE TUNNEL AT MILWAUKEE.

HARRY HERSH, '15.

The remarkable growth of the city of Milwaukee and the resulting demand for an additional water supply has made it necessary to undertake the construction of a new intake tunnel much larger than the present seven and one-half foot brick tunnel extending out from the shore of lake Michigan to a point 3,200 feet away. The site of the new intake has been selected along the Lake Park shore at a point one and one-half miles north of the present intake at the North Point Pumping Station, because the quality of the water off the Lake Park shore is the very best that can be found and also because the future development of the city will make this point the natural distributing center. Difficulties encountered in the construction of the former intake, which extended directly east, caused the engineers in charge to direct this intake thirty degrees north of east. The difficulty was due to the fact that the course of the old intake ran into a strata of sand, about two hundred feet wide, which had worked down through a fault in the clay and shale bed. The direction of this fault was determined as accurately as possible in order that it may not be encountered in the construction of the new intake.

The project on which construction has begun consists of a shore shaft fifteen feet in diameter; a lake tunnel twelve feet in diameter and 4,000 feet long; a lake shaft fifteen feet in diameter; and a crib sixty feet in diameter. The estimated cost of this part is $450,000. From the lake crib it is proposed to extend a number of six foot pipe lines for a distance of 2,500 feet, at which point the water supply will be drawn. The shore shaft is to be connected to the North Point pumping station by a nine foot tunnel 5,700 feet long, and another nine foot tunnel is to extend, at some future time, along Linwood Avenue to the proposed new pumping station one and one-third miles from the shaft. The total capacity of the project, when completed, will be 225,000,000 gallons per twenty-four hours, and the total cost is estimated at $2,500,000.

BORING AND EXCAVATING.

The sub-contractor started to drive sheet piling for the shore shaft on June 1st, 1913. A water-tight cylinder, twenty-two feet in diameter, and twenty-three feet deep was formed by driving interlocking sheet steel slabs which were thirty feet long and three-quarters of an inch thick. All the driving was done with a steam pile driver which was suspended from a derrick at the foot of the lake shore hill, one hundred feet below the hoisting engine. The boom was seventy-five feet long and was supported by three posts firmly anchored in the ground. About two-hundred and fifty feet of cable was used in the hoisting mechanism.

Excavating proper began about the middle of July and continued for twenty-four days. The average rate of excavation for the actual number of working days was three and three-quarter feet per day—the total depth excavated for the shore shaft being ninety feet. The material encountered consisted chiefly of red clay, hard-pan and brown shale. The hard-pan is a hard reddish clay containing about thirty per cent. of gravel and is almost impervious to water.

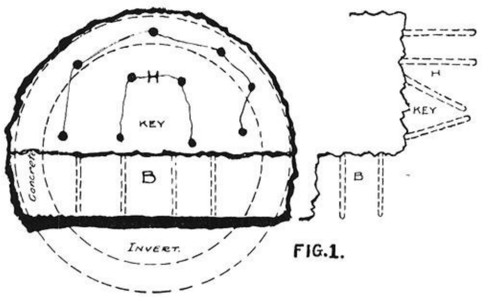


FIG. 1.

The brown shale is nothing else but a compressed clay which disintegrates as soon as it is brought to the surface or exposed to the action of the sun or air—the latter peculiarity being a source of great trouble. The excavators struck this material thirty feet below the place they started from and were forced to blast their way down through this material the remaining depth. All of the material was removed with buckets holding three-quarters of a yard—the hoisting being done with the same derrick used for the pile driver.

After the shore shaft was excavated, work was immediately begun upon the lake tunnel and is progressing now at a very satisfactory rate. The excavating is done in quite an ingenious way, since it is necessary to blast along the entire route. Figure (1) represents a section of the tunnel at the head end. Part B is called the bench and H is called the head. Two rows of holes are drilled into the head with a three and one-quarter inch rock drill, the upper row called the head row being about four feet deep and the center row called the key row being about six feet deep. All the key holes are drilled so as to converge towards the center of the segment, as the sketch shows, for a reason to be explained later. The bench extends about eight feet from the head of the tunnel, and in order to blast this part away four holes are usually drilled into it. The charge in the key is fired off first, and on account of the peculiar wedge shape of the boring, that part of the segment is driven out to the front by the force of the charge, thereby leaving an empty space in the center of the head. Consequently when the charges in the other head holes are fired off the rock will naturally break away toward the center instead of breaking in an unknown direction as might be anticipated at first thought. The bench, of course, will give way towards the front when the charges in the bench holes are fired off. The fuse for each charge is lit with an electric detonator. The amount of material taken out in that manner has varied more or less—the average being from seven to thirteen feet of tunnel length per day. Mules haul the debris in small mine cars on a double track road which leads to the shore shaft. There the cars are drawn up to the surface by a double acting elevator and then dumped on the lake shore.

A question immediately arises as to when the blasts are made and how the men are disposed of during the blasting time. It has been found most economical, as far as time is concerned, to do the blasting while the working crews are being changed because the tunnel becomes filled with gases and smoke. One crew begins work two hours after the other stops, and in that time the exhaust fan, located at the top of the shaft, sucks out all of the foul gases. This fan is connected to a twelve inch galvanized iron pipe which extends as far as the head of the tunnel.

Blasting in this kind of rock is altogether different from blasting in limestone, for the rock is comparatively soft and therefore does not offer so much resistance to the force of the exploding dynamite. The sticks used are one and one-half inches in diameter, eight and one-half inches long and contain four hundred grams of gelatine. The debris is not thrown much farther than about seventy feet and a man is safe one hundred and fifty feet from the place where the blasting is being done. However, considerable inconvenience has been caused by large slabs ten to twenty-four feet long which fell from the roof or walls, and as a result it has been necessary to brace the walls about every five feet with 12x12 new long-leaf yellow pine timbers, and to brace the roof with 6x8 stringers.

CONCRETE LINING.

Before excavation on the lake tunnel was carried very far, the shore shaft was lined with 1:2:4 concrete, eighteen inches thick and reinforced with three-quarter inch open-hearth steel rods. About ten tests of neat cement gave an average tensile test of 690 pounds for a seven day briquet and 800 pounds for a twenty-eight day briquet. The mixture of cement, sand and stone was loaded into small cars at the top of the hill and sent down the incline to the mixing machine at the bottom. This machine then dumped its prepared mixture into other cars which were drawn to the shaft by mules. The concrete was held in place until it set by forms or casings which came in five foot sections.

During the time that the shaft was being concreted the air locks were installed into the entrance of the lake tunnel. The locks were needed to enclose the compressed air within the tunnel in order that the water might not come through the fissures in the rocks overhead. The pressure required is about thirty pounds per square inch, hence three air pumps are installed in the machine room to supply the amount of air required. The air lock is a long cylindrical steel shell which is divided into two compartments—the lower one for the use of the mine cars and the upper one for the use of the workmen. The part between the shell and the earthen walls of the tunnel was filled in with concrete to make the opening as air tight as possible. The compartments have doors at each end, one of which remains closed while the compartment is entered, then, when the opened door is closed, the other door may be opened and the person may enter or leave the tunnel without disturbing the air pressure.

Figure 2 shows the divisions of the forms used for holding the concrete in place within the tunnel. There are five sections in all; the slider, the lower side plate, the upper side plate and the top plate being about twenty-three feet long. The frame work for holding the sections moves along a track near the sides of the tunnel, so that after one section has become set, the frame is

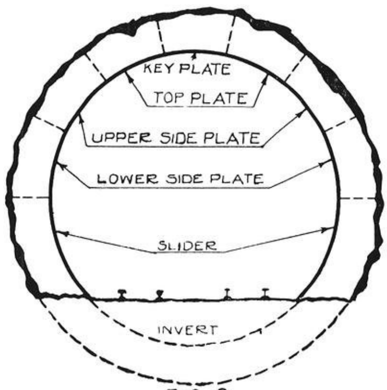


FIG. 2.

moved ahead to start another section. The concrete is delivered in small mine cars which are hauled by mules, and all the filling must be done by shoveling the concrete into the molds. After the first four plates have been filled in, the sections of the key plate are taken next. These sections come in five foot lengths so that the concrete may be shoveled into the key and rammed hard for each length, after which the other sections are added until the entire length of the key has been filled in. The general rule followed is to do the concreting within two hundred feet of the head of the tunnel. The lower part of the section, known as the invert, will not be excavated or concreted until the whole tunnel is finished, after which all this part will be removed and concreted from the end of the tunnel to the shaft.

All of this work will not be carried on from the shore end of the tunnel alone. A shaft is to be sunk into the lake at the point where the tunnel is to end, the opening to this shaft being protected by the crib mentioned at the beginning of this article. The work of excavating and lining will then also be carried on from the lake shaft as well, in order to hasten the time of completion. At this rate the contractors expect to do the entire 4,000 feet of tunnel in about sixteen or eighteen months.

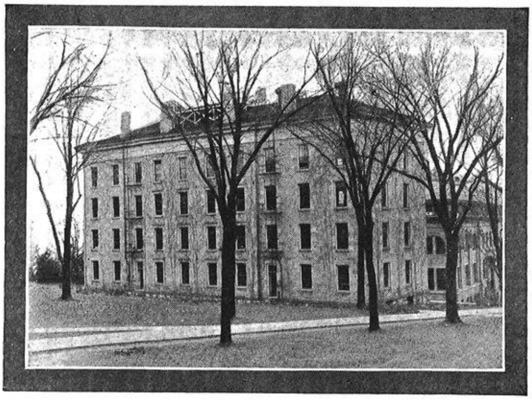
EQUIPMENT, MEN, AND RECORDS.

The main equipment for carrying on the work consists of a hoisting engine, dumping cars, and concrete mixers. However, the key-note to the successful completion of the entire project is the air compress or plant. This plant is housed in a separate building and is composed of three Ingersoll Rand air compressors—one two stage and two single stage. Each pump is driven by an electric motor which is controlled by a pressure system of governing. Normally the two single pumps are used to supply the air for the tunnel and the drills, but the third one is automatically started by the pressure regulator whenever the pressure in the tunnel falls below the required intensity. The pumps and motors are supported on concrete foundations, but the bed plates are not grouted in as is the custom with permanent installations. Nevertheless the installation is so good that there is hardly a vibration in the bases of the pumps or motors.

The air plant is not the only part which is provided with safety appliances. The office of the city supervisor of the work contains a stretcher, a complete set of bandages and all the medicines needed in emergency cases. Arrangements have also been made with St. Mary's Hospital and with a physician to immediately take charge of all accidents. Although the hospital is one and one-half miles from the intake, a man can be taken out of the tunnel and brought to the hospital in twenty minutes.

As a rule, the men who have had mine experience are preferred for this kind of work. The character of the work requires men who are perfectly well and who know how to take care of themselves. If a man neglects the latter requirement he is very liable to get the caisson fever which is somewhat of a rheumatic effect produced by the compressed air lodging in the man's joints. The fever is not dangerous, but it is very painful during the time it lasts.

The city supervision of the work is done by inspectors who are on the job both day and night. These men, who are under the city civil service juisdiction, have been selected for certain qualifications—experience, honesty and reliability—because the job is one where the public is practically excluded from the grounds on account of the danger involved. Since the city officials do not have an opportunity to make inspections often enough, the entire work is entrusted to these men who make thorough and complete reports every day about everything that is being done and about all of the material that is received and used.



BAZIN'S INVESTIGATIONS OF THE FLOW OF WATER OVER SUBMERGED, SHARP-CRESTED WEIRS.

CLIFFORD A. BETTS.

Scholar in Hydraulics, University of Wisconsin.

The information available at the present time concerning the flow of water over submerged weirs is far from adequate for the practical solution of problems relating to this form of flow. This is a result not only of the predominating importance of the free-fall weir, which has led to its development before that of the submerged weir, but also to a lack of usable experimental coefficients and of a suitable means of measuring the elevation of the surface of the water below the weir.

Transition from free-fall to submerged flow introduces new discharge-governing factors. As soon as the downstream water level rises to the height of the top, or crest, of the weir, the condition of submergence occurs and begins to affect the discharge. The submergence of the weir may be best expressed as a percentage by the ratio of the observed upstream head, h, to the downstream head, h_1; whence it is evident that an accurate determination of the factor h_1 is essential. Investigations covering these difficulties are now being carried on at the Hydraulic Laboratory of the University of Wisconsin.

The valuable pioneer work of Francis*, Fteley and Stearns**, Bazin and others, besides serving as a basis of more extended experiments, are studyworthy from the standpoint of research. Results of experiments on submerged weirs of irregular section as made by Bazin, in France, and by the United States Deep Waterways Board at Cornell University hydraulic laboratory, in 1899, have been collected and discussed in *Transactions Am. Soc. C. E.*, Vol. 44, pp. 220 to 398, and in Horton's "*Weir Experiments, Coefficients and Formulas*", U. S. Geological Survey Water Supply Paper No. 200.

* Transactions, Am. Soc. C. E., Vols. 12, 13, 14. Lowell Hydraulic Experiments.

** Trans. Am. Soc. C. E., Vol. 12, pp. 101–108.

Inasmuch as Bazin's studies of submerged flow are duplications, with various degrees of submergence, of his earlier free-fall experiments over thin-edged weirs, a preliminary résumé of these investigations, which have been published in *Annales des Ponts et Chaussées,* 1888, 1890 and 1891, will lead to a clearer understanding of his fourth article treating of submergence. The first two articles relating to sharp-crested weirs and velocity of approach have been translated by Arthur Marichal and J. C. Trautwine, Jr.* Article No. 4, *Annales des Ponts et Chaussées,* 1894, has been translated in connection with investigations now being made at the Hydraulic Laboratory of the University of Wisconsin where it will be on file.

Bazin's fourth article contains a careful study of the various forms of flow over suppressed weirs of different heights; beginning, where the third article left off, with the case where the nappe, or sheet of water falling over the weir, is wetted underneath and flows away without being affected by the water level below. Following this come the successive stages where the falling sheet is influenced first by the backing up of the water downstream while the level is below the crest of the weir and, finally, by the rising of this downstream surface level above the crest, thus causing submergence.

In his analysis of the conditions governing the discharge over a submerged weir, Bazin uses the ratio, $\frac{m}{m'}$ between a coefficient of discharge, m, for submerged flow and a coefficient, m′, corresponding to a nappe falling free in the air, having the same head and upon a weir of the same height. The influence of velocity of approach is thereby reduced and discussion facilitated. In absolute value m, and therefore the discharge, was found to be greater, for cases of submergence, than for free fall conditions. The ratio $\frac{m}{m'}$ was affected by the height, p, of the experimental weir above the bottom of the channel, m′, increasing slowly with h so long as the downstream water-level did not fall below $h_1 = -_{005p}$ Accordingly $\frac{m}{m'}$ was compared with the ratio $\frac{h}{p}$ rather than with

* Proceedings Engineers' Club of Philadelphia: 1888 in Vol. 7, Jan., 1890, pp. 259–310; 1890 in Vol. 9, July, 1892, pp. 231–244, Oct., 1892, pp. 287–319; and in Vol. 10, Apr., 1893, pp. 121–164.

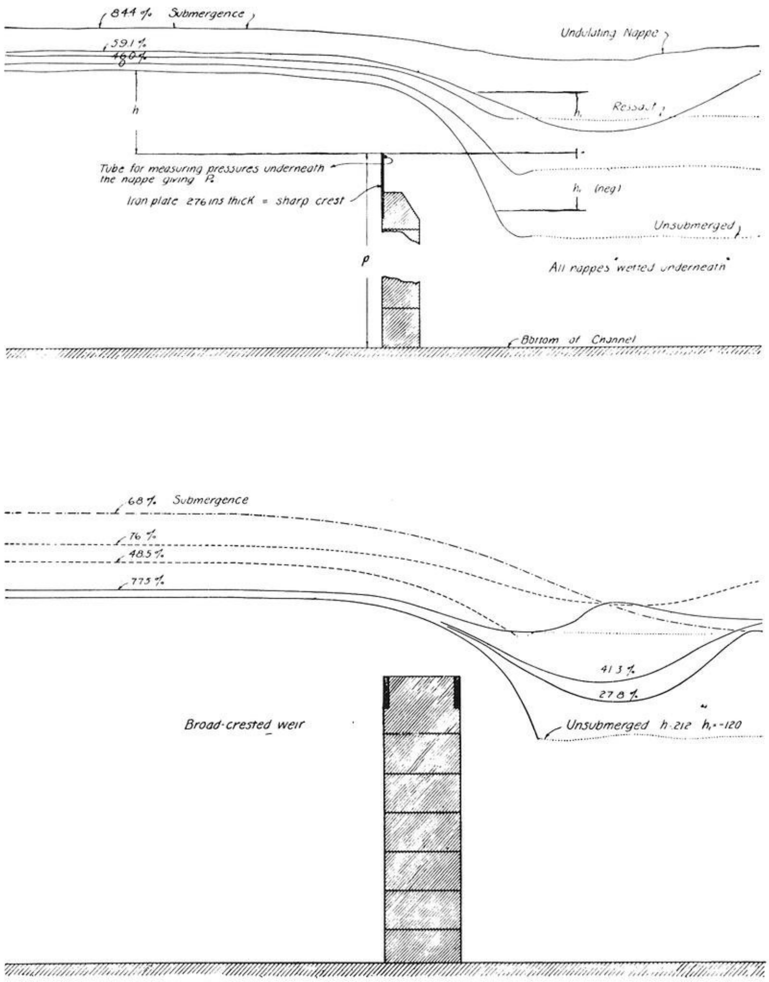

84.4 % Submergence
59.1 %
46.0 %
Undulating Nappe
h
h1
Ressaut
Tube for measuring pressures underneath the nappe giving P.
Iron plate .276 ins thick = sharp crest
h1 (neg)
Unsubmerged
p
All nappes "wetted underneath"
Bottom of Channel
68 % Submergence
76 %
48.5 %
77.5 %
41.3 %
27.8 %
Broad-crested weir
Unsubmerged h = .212 h1 = -.120

FIG. 1.

absolute values of h. As in the earlier experiments it was found that the pressures, P_0, beneath the nappe bore a definite and close relation to h and that the ratio $\frac{P_0}{h}$ in turn, was so related to $\frac{m}{m'}$ and $\frac{P}{h}$ that, by substitution, $\frac{m}{m'}$ could be obtained in terms of $\frac{p}{h}$. In addition to the influence on m of the height of the weir above the floor of the channel of approach, it was found, as the downstream water level was raised and the ressaut (or rapid below the weir) driven back against the foot of the over-falling sheet, that, for a given upstream head, m decreased with the rise of the downstream water level thus varying inversely with the submergence. Within given limits the rate of these variations increased with the upstream head showing that both heads must be considered in selecting a satisfactory coefficient of discharge. Before m could be expressed as a function of both upstream and downstream water levels by the above procedure it was necessary to express $\frac{P_0}{h}$ as a function of h and h_1.

For this purpose experimental weirs 0.75 m. (2.46 ft.), 0.50 m. (1.64 ft.), 0.35 m. (1.15 ft.) and 0.24 m. (0.79 ft.) in height were placed 33 meters (108.2 ft.) from the lower end of a 6.56 ft. wide channel where a system of gates controlled the submergence upon the weirs. The upstream head was measured in a still basin at one side of the channel, connection being made thru a 4-inch piezometer pipe opening flush with the side at a point 16.4 ft. above the weir. Similarly the downstream head was measured 36.2 ft. below the weir, a dial float gage serving to show the respective water levels. The pressures beneath the nappe, obtained by placing a small horizontal tube part way along the crest of the weir, were transmitted thru tubes to air and water gages conveniently placed in a pit at the side of the weir near gages registering the two water levels.

Analysis of the results obtained from fifteen series for submerged flow led to determinations of $\frac{m}{m'}$ as a direct function of $\frac{h}{p}$ and $\frac{h_1}{p}$ as well as by an intermediate calculation of $\frac{P_0}{h}$. Only the former are given below.

For values of $\frac{p}{h}$ less than $0.4\left(1 + 0.3\ \frac{p}{h_1}\right)^2$,

$$(1) \qquad m = m'\left[1.06 + 0.16\left(\frac{h_1}{p} - 0.05\right)\frac{p}{h}\right]$$

and for greater values of $\frac{p}{h}$, where the weir is more deeply drowned,

$$(2) \qquad m = m'\left[1.08\ \left(1 + \frac{h_1}{6p}\right)\ \sqrt[3]{\frac{h - h_1}{h}}\right]$$

$$= m'\left[\left(1.08 + 0.18\,\frac{h_1}{p}\right)\ \sqrt[3]{\frac{z}{h}}\right].$$

By slight alterations in the coefficients of (2)

$$(3) \qquad m = 1.05\,m'\left[1 + \tfrac{1}{5}\left(\frac{h_1}{p}\right)\right]\ \sqrt[3]{\frac{z}{h}}\ ,$$

which may be used for all cases where variations of from 1 to 5% are permissible.

These coefficients are applied to Bazin's formula for free discharge into air:

$$Q = m\ L\ h\ \sqrt{2gh}$$

where L=the length of the weir crest
and g=the acceleration by gravity. Value used, 32.16.

For detailed information the data and diagrams accompanying the original articles in *Annales des Ponts et Chaussées* should be used in conjunction with the translations.

The utilization of the ratio $\frac{h}{p}$ enabled Bazin to eliminate repeated approximations in computing the discharge over weirs of different heights when conditions approaching those of his own experiments were maintained. Under these same restricted conditions Bazin's formula has the peculiar advantage of including the effects of velocity of approach in the coefficient. The value of these formulas is vitiated for practical purposes by their narrow limits of application.

Admittedly, whenever the given data does not warrant great precision, the formula used for finding discharge should be as simple as possible. The results of Bazin's experiments have been re-computed and applied to the somewhat simple submergence formula $Q = 3.33\ L\ (Nh)^{\frac{3}{2}}$ in which N depends on the proportional submergence; making the discharge over a submerged weir N $\frac{3}{2}$ that over an unsubmerged weir under the same head. Curves representing fifteen individual series, in each of which the submergence varied under an approximately constant value of $\frac{h_1}{p}$ are collected in Fig. 2. A curve obtained from experiments on a submerged, suppressed weir at the University of Wisconsin

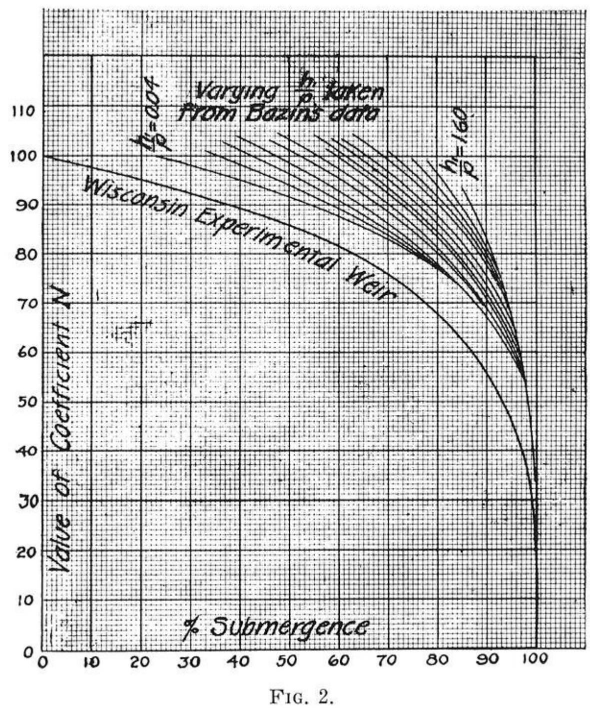


FIG. 2.

hydraulic laboratory has also been plotted. Bazin's use of different heights of weirs combined with the fact that an average value 3.33 has been used in computing N for varying values of Bazin's m undoubtedly accounts in a large measure for the discrepancies that appear.

For cases of submergence, as for free fall, Bazin has made a systematic collection of data relative to the profile of the nappe for various up-stream and down-stream levels and also for the study of velocities and pressures within the nappe. Characteristic profiles for a sharp-crested weir ("déversoir en mince paroi") together with corresponding profiles for a broad-crested weir ("déversoir à poutrelles") are shown in Fig. 1.

Not until extensive data covering widely varying conditions of submergence has been collected and correlated will it be practicable to apply formulas for submerged flow to slack-water improvements of rivers, for navigation of flood flow purposes where head can not be sacrificed; or to canals for determining the required height of lock walls, or for the distribution of water for power or irrigation uses. There is reason to believe, however, that Bazin's "classic" investigations of flow over submerged weirs, like his earlier work on free-fall weirs, may be of invaluable service as a guide for more extended experiments which may eventually lead to the development of a more workable submergence formula or, at least, to a more complete understanding of the subject.

A CHART OF HEAT CONTENTS OF STEAM.

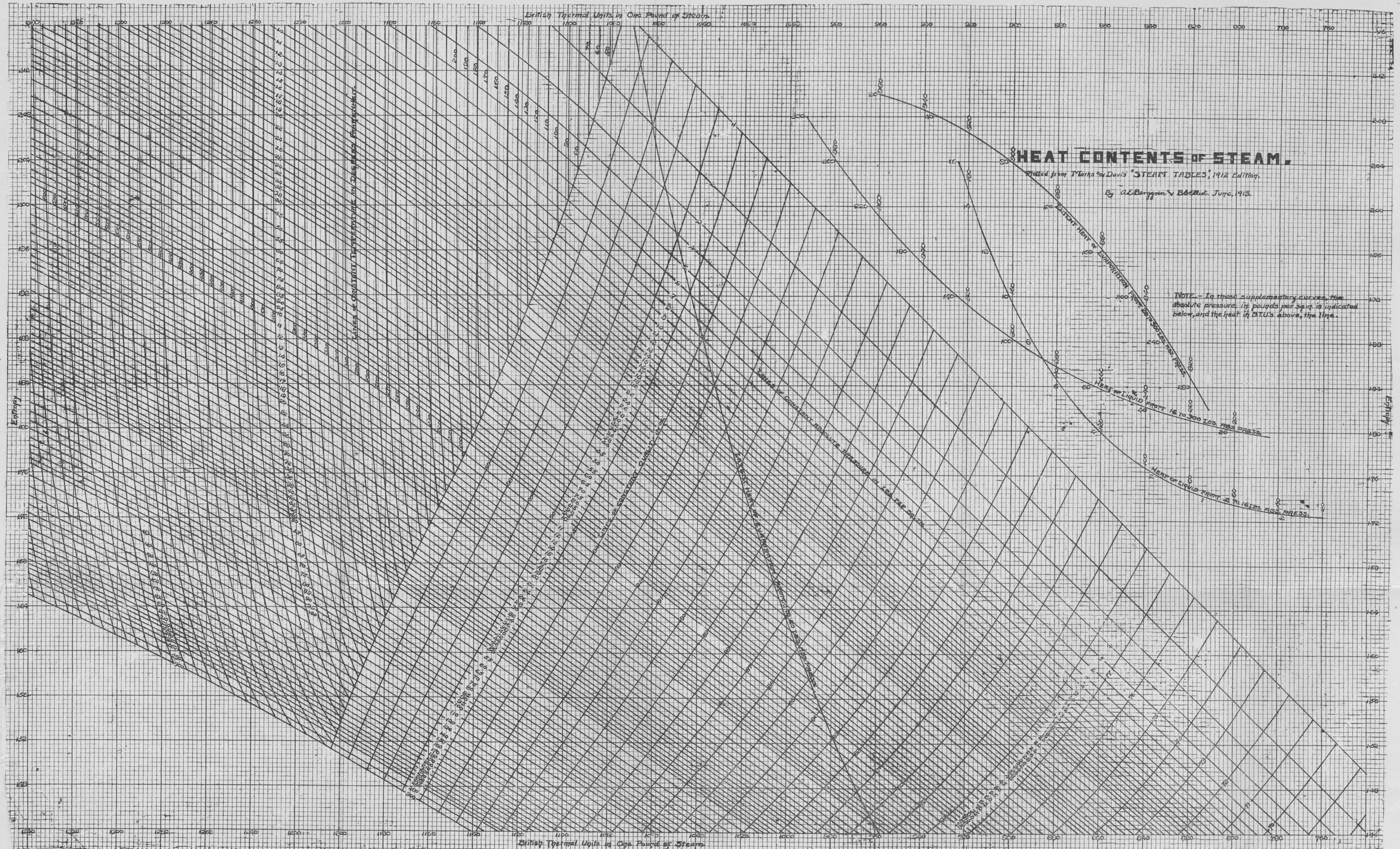
A E. BERGGREN.

Instructor in Steam and Gas Engineering.

A graphical presentation of any set of changing values which are dependent upon each other is often a much more convenient reference than a tabulation of those values. This is true because the user can find at a glance the particular value he desires, can see in actual proportion its relation to similar values through different ranges of the other variable, can choose values between plotted points without the laborious interpolation that would be necessary with the use of tables and is less liable to make gross numerical error than when working from a tabulation.

The scale of units on the axes of the chart determines the limit of accurate reading and the slope of the lines and the convenience of cross reading fix the ease and rapidity with which the chart can be used. In the chart on the opposite page are plotted the heat values of a pound of steam as given by Marks and Davis' "Steam Tables" 1912 edition, which values have been very generally accepted by the engineering profession. The horizontal scale of twenty British Thermal Units to the inch allows accurate reading to a fractional part of a unit, while the entropy of the vertical scale gives to most of the lines an angle of about 45° with the horizontal, making intersections of plotted lines come nearly at right angles and thus allowing definite reading of values at such intersections.

The chart differs from most such diagrams in the superheat region, in that lines of constant temperature are shown rather than lines of constant superheat. This seems more rational in describing the condition of steam at some designated pressure and is certainly more convenient in the solution of problems. Then, too, the chart gives information down to one tenth of a pound pressure, which seems advisable on account of the low vacuums being attained in practice and research. Another feature which, so far as the writer knows, is new is the addition of lines of "latent heat" and "heat of the liquid". These preclude the necessity of reference to the original steam table should these values enter into a problem.



Supplement to The Wisconsin Engineer, April, 1914.

By far the largest percentage of problems with which the steam engineer has to deal are concerned with the total heat of steam, or with the changes in total heat that takes place in a given process, such as expansion in the cylinder of an engine or in the nozzles and blades of a turbine, or in a throttling calorimeter. Any condition of steam as to pressure and quality (or temperature) within the limits of the chart can be designated by a point on that chart and the total heat found by projecting that point to the horizontal scale. The ideal expansion to do work, as in the cylinder of the reciprocating engine or in the nozzle of a turbine or injector, is adiabatic, i. e., without the addition or loss of heat as heat, therefore isentropic, and any change of heat content between the initial and final state points can be found by noting the total heat at the initial condition, following he horizontal ordinate though this point until it intersects the lower pressure, noting the total heat at that point, and subtracting. In the throttling calorimeter there is no heat change, and the problem of determining the initial quality of the sample of steam becomes merely the tracing of the vertical ordinate from the point indicated by the calorimeter data to the intersection with the initial pressure.

For any pressure below twenty pounds absolute, the latent heat is found from the intersection of the line of "latent heat of evaporation" with that pressure line, and projecting that point to the horizontal scale. For latent heat at any pressure above twenty pounds and for "heat of the liquid at any pressure, the supplementary curves must be used, locating the desired pressure on the scale on the lower side of the line and reading the desired value on the upper side.

REVIEW OF "ENGLISH PATENT SYSTEM" BY WILLIAM MARTIN, 1904.

C. M. OSTERHELD.

The first monopolies in England were given by the Crown to favorites, or else were given by this same source to foreign or native craftsmen that introduced new industries. The first patent on an invention was given in 1561 to an inventor of a scented soap. The law held that no monopoly should be given to anything that would "be inconvenient or mischievous to the State" and on this ground the famous Matthews patent for making of knives was annulled; because it upset an existing industry. This idea of interference with existing trades is still a fundamental back-ground for the thought of English Courts.

In the early patents no specifications were necessary but a bounty was often given by the Crown to allow the discovery to be published. Thus the inventor of gunpowder was given a bounty of £300 beside the monopoly afforded by the patent.

In the year 1700, novelty of invention was a requisite, and specifications also accompanied the request for patent.

The granting of patents was looked upon with great disfavor by the ordinary member of British society until 1852 when the former laws were changed and the whole arrangement placed upon a purely business basis. The granting of a patent has become a purely ministerial act, the holder of the patent having a right to sue for infringement but because he held a patent this was not substantial proof of his being a prior inventor though it was often an aid in proving this. The *holder* of the *patent has no right* to threaten an infringer beyond the statement that he will bring suit for infringement. To the ordinary man who considered patents as documentary evidence of priority this is an important surprise. Should a patentee so threaten he will have a harder time with his case because of so doing.

The patent as it is now granted according to the act of 1902 is given for a period of 14 years with a chance of renewal by act of the Privy Council to a period of usually 7 and never more than 14 years. The fees for a patent are £100 and a renewal fee of £5 must be paid annually or the patent expires before the natural time of expiration. A patent that expires from this cause can only be renewed by an Act of Parliament. The patent thus granted applies only to the United Kingdom and the Isle of Man, though arrangements are made so that patents are readily obtained throughout the British colonies by the payment of the proper fees.

The inventor who does not desire to take out immediate application because of incomplete specifications can get a six months protection on his invention according to "Form O" wherein he is allowed to exhibit his article at fairs, etc., and receives protection. To obtain this protection he must set forth some general specifications and apply for this protection and apply for a patent at the end of 6 months. This application must be accompanied by the usual specifications. The specifications for letters patent are quite important and the following are certain fundamental rules for their construction by courts:

1. Complete specification shall be construed before its accompanying provisional specification.
2. Construction shall be largely based on reports of experts.
3. Construction is to be literal.

These above rules governing court procedure are worthy of note since they give a glimpse of the possible impartial method of also examining the claims of a patent. Another thing worthy of mention is the "disclaimer." It is defined as a "negation of a claim" and may protect the patentee from being wholly construed by a court.

If patents are assigned, the assignee has full possession of the patent for the district assigned him. Patents can be mortgaged and sold for debt or bankruptcy the same as any other personal or private property.

Conflicting information is often at hand concerning "patent medicines". They are usually made from a secret formula and are not patented but are sold under the protection of a revenue stamp.

In conclusion, let us review the fundamentals of the British Patent System. Patents are easily obtained in Great Britain but at a fairly high fee. Patentees must pay a yearly renewal fee. Injunctions for infringement will not be given until the status of the patent has been determined in court.

The Wisconsin Engineer.

EDITORIALS.

At present we have the boosting craze. We feel that criticisms are not called for; that suggestions pointing out a fault and remedy are only carping statements of ill will; and that the proper way to remedy evils or correct faults is to "talk up" the good points, and the poor ones will automatically be ameliorated. This attitude has grown out of the kindly desire of people who wanted to prevent unnecessary, unconstructive and objectionable analyses. The spirit was good, but the application has been carried beyond its limit and sphere. This method is perfectly legitimate in boosting "Silver Gulch," Canadian land, or in selling automobiles; but for an aid in the solution of real problems, it is about as effective as putting a coat of fresh paint on the girders of a defective bridge and telling the public to resume traffic because everything looks fine.

Nobody likes a "knocker" and nobody should like him; but we must distinguish between the cynic who maliciously magnifies mistakes without making any attempt to help prevent such mistakes, and the man who sees the fly that is spoiling the amber and forthwith goes to take the fly out. Unfortunately, we do not make this distinction; and the man who makes a suggestion that strikes a blow at some evil is stamped as a sorehead, a knocker, and a fool.

There are many who see small things that could well be dispersed with in certain courses. They also see things that could well be added to other courses. Where do these suggestions get a hearing? Nowhere. We leave it to the "prof" to find out the mistake and eventually it may be corrected; but what a waste of precious time could be avoided by a spirit of co-operation!

In many of the large manufacturing plants the employees are requested to make suggestions that either show a fault or means for improvement. The companies have greatly benefited by such systems. In our own University the student sees chances for improvement that might be of real value; but who cares for such suggestions? Our present code of ethics requires that these suggestions be stifled, even though the student may have a sincere and earnest desire to help give Wisconsin a better name than that of any other school. We are proud of our college, its past and present; but the future holds in store a period of further success due to loyal co-operation, and of that we will be more proud.

NEW ADDITIONS TO THE S. & G. LABORATORY IN 1913–1914.

The equipment of the steam and gas engineering laboratories has received some valuable additions during the year 1913–14. Some of this equipment has been purchased for permanent use, while other machines have been loaned by the manufacturers temporarily. Still other outfits have been donated to the department.

Among the most important permanent equipment is a small contractor's boiler and engine outfit complete, which is being erected in the producer room. This unit was obtained from the Universal Machinery Co., Milwaukee, through the courtesy of W. F. Teschan, '07. It is the intention of the department to give all students taking laboratory work, an exercise on this combined unit early in their course and thereby get a clearer conception of the fundamentals and machinery involved in the generation of power. The lack of such an elementary power plant has been felt for some years.

Messrs. Epstein and Stephany of the class of '13 chose as their thesis, Comparative Tests of Carbon Dioxide Recorders. They experimented with several different instruments at the capitol heating plant. Of the various types tested the Simmance-Abady instrument manufactured by the Precision Instrument Co., of Detroit, Mich., gave very satisfactory results. As a result of these tests the department purchased this CO_2 recorder, and it is now being used by Messrs. Cowin and Hinckley at the plant of the Madison Gas & Electric Co. in connection with their thesis investigation on methods of improving the efficiency of boiler operation. The use and importance of CO_2 recorders in central station operation are now universally recognized by all leading engineers. This new equipment will be available for all future power plant investigations.

WITH THE ALUMNI.

Henry H. Force, '10; has resigned his position with the General Electric Company and has accepted the position of Chief Electrician with the Stanley Works.

Herbert J. Newman, '10, is now with the real estate firm of Maynard and Picken, Milwaukee.

John J. Hogan, '99, designing and consulting engineer has changed his office from Chicago to Chippewa Falls, Wis.

Albert M. Wolf, '09, C. E., '13, is Principal Assistant Engineer with Condron Co., Structural Engineers, Chicago; and contributing Editor on "Concrete Work" for "Railway Engineering and Maintenance of Way", of which K. L. Van Auken, '09, C. E., '13, is editor.

E. K. Morgan, '13, is in charge of the drafting department for the Rockford Drilling Machine Co., Rockford, Ill., under John Langwill, '11, who is the superintendent.

H. H. Rogers, '12, is assistant superintendent and chemist for the Hess and Hopkins Leather Company, Rockford, Ill.

O. J. Schieber, '12, is a draftsman in the Hydraulic Department of the Pacific Light and Power corporation, Los Angeles, Cal.

C. E. Carter, '04, is with the Henry L. Doherty & Co., New York City.

J. C. Beebe, '10, is a "Power and Pumping Engineer" with the Idaho Irrigation Co., Richfield, Idaho.

C. L. Van Auken, '10, is a draftsman and designer for the Condron Co., Structural Engineers, Chicago.

W. A. Rowe, '04, is with the Midland Engineering Co., Edmonton, Alberta, Canada.

F. Meinicke, '12, is with the Michigan-Utah Mining Co., Alta, Utah.

E. A. Kalsched, '11, is in the plumbing business at Marshfield, Wis.

C. M. Kehr, '08, is now auditor or the Wooland Company, Chicago, Ill.

M. M. Brenan, '94, is superintendent of the Walsh Construction Co., Davenport, Iowa. He was formerly Division Engineer of the C. & N. Ry.

R. C. Youngren, '09, is with the Allegheny Steel Co., Brackenridge, Pa.

A. T. Sjoblom, '10, who was formerly in the Engineering Department of the Commonwealth Edison Co., Chicago, is now General Electrical Foreman at the Miroflores Locks, Panama.

J. E. Smith, '02, is now assistant professor of Civil Engineering at Illinois.

M. O. Krahn, '09, is a Construction Engineer at the International Harvester Corporation, Milwaukee, Wis.

A. C. Kelm, '13, is in charge of the Municipal Power plant at Idaho Falls, Idaho.

C. N. Johnson, '08, is an Electrical Contractor at Chicago.

G. G. Ryder, '07, is at Minneapolis, Minn., with the Twin City Electric Co., which does electrical contracting.

E. B. Nelson, '13, is a draftsman for the Isthmian Canal Commission.

Thos. W. Reilly, '12, is with the Wisconsin Highway Commission.

W. S. Russel, '06, is Manager of the Law Auto Co., La Crosse, Wis.

Albert H. Heyroth, '07, is doing "Development" Engineering work at Hawarden, Montana.

W. D. Bliss, '13, is an instructor in Mechanics at Marquette University.

Adolph D. Bullerjahn, '13, is with the Pawling & Harnishfeger Co., Milwaukee.

N. R. Harvey, '05, is with the Wernicke-Hatcher Pump Co., Grand Rapids, Mich.

H. E. Holbrook, '12, is a chemist for the Goldsmith Smelting & Refining Co., Chicago.

Ernst Jacobson, '06, is at Oak Park, Ill. He is employed as a Gas Production Engineer for the Public Service Company of Northern Illinois.

S. L. Clark, '07, is an Iron Bridge Inspector for the C. M. & St. P. Ry., with headquarters at Chicago.

Ray S. Hoyt, '05, is with the American Telephone & Telegraph Co., New York City.