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Erection of the Hell Gate Bridge

Fitting Equations to Plotted Points

Concrete Warehouse Construction

Eastern Trip

Civil's Trip

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The Wisconsin Engineer

VOL. XX DECEMBER, 1915 NO. 3.

ERECTION OF THE HELL GATE BRIDGE

Walter J. Parsons, '00

The connection of the two outstanding halves of the Hell Gate arch span on September 30 and October 1 marked the culmination of one of the boldest bridge erection schemes on record.

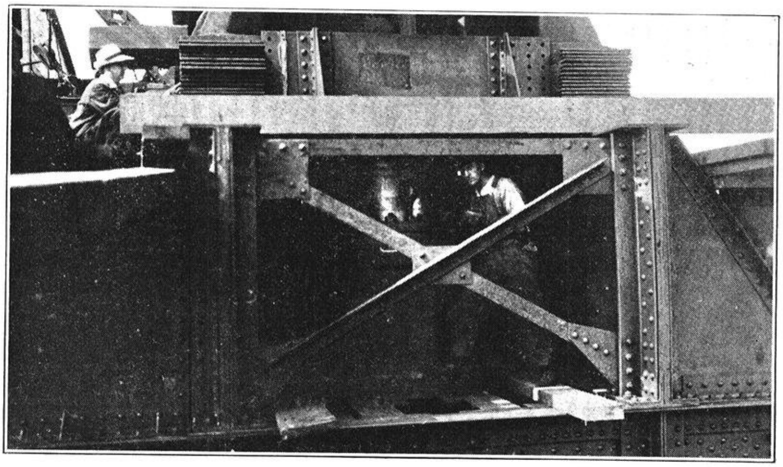
This arch span, when completed, will be the crossing of the New York connecting railroad over the east channel of the East River in New York City and is a part of the 2½ miles of bridge work which extends from 138th Street in the Bronx to Lawrence Street in Astoria, Long Island. This bridge work crosses from the Bronx over the Bronx Kills to Randall's Island, then over the Little Hell Gate to Ward's Island, and from there over Hell Gate to Astoria.

This arch span will have four railroad tracks between its trusses, and two highway tracks on brackets outside. The span distance between centers of skewbacks is 977 ft. 6 in. The distance between near sides of the tower piers at the coping is 1015 ft. The distance between centers of trusses is 60 ft., and the distance between outside railings is 93 ft. The bottom of the floor system will clear the river at high tide by 135 ft. The center of the bottom chord will clear the water by 265 ft., and the center of the top chord by 307 ft. 6 in. The span is divided into 23 panels of 42 ft. 6 in. each, and the arch is of the two hinged type.

The first great controlling feature of the erection of this arch span was that it could not be erected on falsework, the river being 140 ft. deep in places, and the boat traffic not only very dense, but very unwieldy in the swift flood tides and swirling waters of Hell Gate. This meant that the span would have to be erected by the cantilever method.

The second big controlling feature was the tremendous weight and size of the members, the bottom chord sections weighing from 180 tons at the skewbacks to 85 tons at the center. These sections are 10 ft. 6 in. high and 6 ft. 6 in. wide in section. The handling of such heavy pieces passed all precedent, as 125 tons had been the maximum weight on any previous work.

With these two controlling features before them, the American Bridge Co. developed an erection scheme which is briefly as follows: A huge triangular structure was designed for each side of the river to hold up its half of the arch span until the two halves could be connected at the center, and the whole span



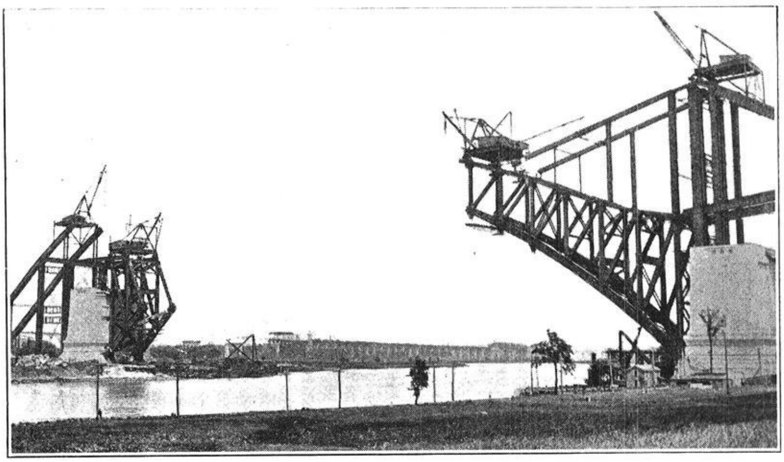
The Hydraulic Jacks.

be made self-supporting. The bottom of this structure rested partly on the tower pier and partly on the ground, and the rear end was held down by a large counterweight.

From a point about half way up on this structure, a tension member connected it with the end of the top chord of the span. This held up the outstanding panels of the span until six of them were erected. Then a tension connection was made from the top of the structure to the top chords at the end of the fifth panel and this connection, which was called the fore stay, held up the half spans out to the center.

The other part of the structure was called the back stay. At the top of this back stay two 2,500 ton capacity hydraulic jacks were placed, one at each truss line. A saddle casting was placed on top of the plungers of the jacks and the eyebar connection between the back and fore stay was made by means of a 16 in. pin on top of this saddle casting. A movement of these jacks would thus raise or lower the saddle casting, and in turn raise or lower the fore stay and arch span half attached. The back stay was held down with counterweight making it immovable.

These back and fore stays being only temporary structures, were designed with the chief object of using the permanent steelwork wherever it was possible, and thus saving the expense



The Stays and Travelers.

of special material. So the floor beam hangers, track stringers, and railings of the arch span were used, as they would not be erected until the span was self supporting. The girder spans of the approach viaducts were also used, as the approaches were not to be erected until after the arch span was completed.

Extra ends were built on these pieces so that they could be spliced and joined together and later cut or burned off without changing the permanent member. In this way 15,425 tons of steel work were used in the back and fore stays and counterweights and only 2,296 tons of it were special. Three thousand one hundred ten tons of it will go in the arch span, and 10,019 tons in the viaduct approaches.

This use of the permanent steel for the back and fore stays is considered by the Bridge Company as a masterpiece of erection scheming, and the economic value of it can easily be seen.

The erection of the Long Island back stay was started September 1, 1914, and was completed for the first connection to the arch span by January 1, 1915. The Ward's Island back stay was started February and was completed for the first connection to the arch span by June 1, 1915. The start of the Ward's Island back stay was delayed on account of the masonry tower pier not being completed on time.

Both back stays were erected in like manner. First a locomotive crane was landed on the dock from a lighter. The locomotive crane erected an unloading derrick on the dock and, after erecting the bottom chord of the back stay, erected a derrick at the counterweight end. This last derrick in turn erected the counterweight bases and a tier of counterweight girders. It then erected the back stay traveler on top of this tier of girders. The back stay traveler erected the back stay ahead of it, climbing upon what it had erected. When it had erected the first connection for the arch span, it erected the arch traveler on top of this connection. This arch traveler rolled out to the end of the connection and erected the arch members, rolling ahead on the top chord.

Thus one outfit erected another without extra moves and with ease and economy. The locomotive crane assisted with the erection of the back stay after it had erected its derricks; the rear derrick erected the balance of the counterweight; and the back stay traveler erected the upper part of the back stay and the fore stay as soon as the arch traveler had moved out of the way. In this way each outfit amply paid for its cost of installation.

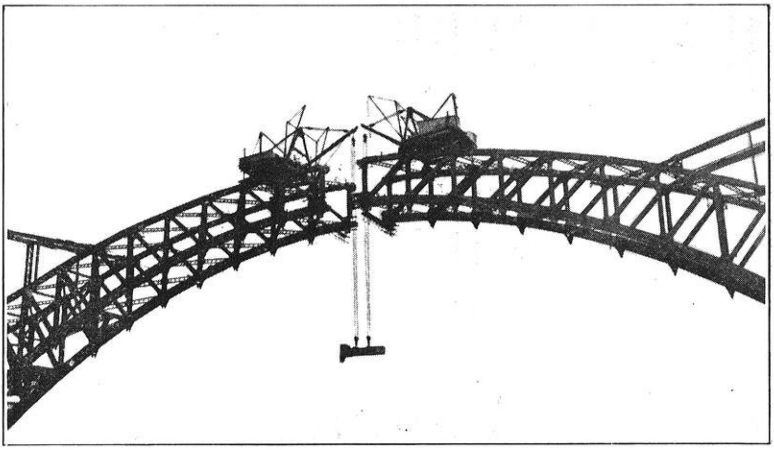
The erection of the Long Island half of arch was started January 22 and continued until seven panels stood out over the river. Work was then stopped on this half and the men were transferred to the Ward's Island side to hasten its erection. The Ward's Island half of arch was started May 28, 1915, and on August 30, when six panels were in place, the erection of the Long Island half was resumed and both halves were erected simultaneously until September 30, when they touched at the center.

All panels were erected in like manner. First the bottom chords were erected and the many drift pins and bolts placed in their lower connections gave sufficient strength so that these huge masses could stand out alone without sagging more than one-half inch. Next the diagonals were erected and connected first at the top end and then to the outer end of the bottom chords. The sag of the bottom chord was brought up at this last connection by the use of drift pins. The posts were then erected and held up alone securely by the drift pins and bolts in their bottom connection. The top chords were then erected and the bottom laterals, top laterals, and sway system followed.

Bottom Chord of Center Panel.

The travelers which erected these arch members are "A" frame structures with telescoping rear legs to keep them level on the different grades of the top chord of the arch span. Their booms are 65 ft. long and are rigged with a double topping lift tackle of 36 parts of ⅞ in. diameter wire rope, reaved on tandem blocks, and a main fall tackle of 26 parts of ⅞ in. diameter wire rope reaved on a one piece top block and a five part bottom block. This bottom block could have its center three sheaves, or its center nine sheaves bolted to the top block so as to make the tackle one of 20 parts or of 8 parts of line. This tackle was changed to less parts in this way as the loads became lighter toward the center of the arch span so as to gain speed in lifting and also to save length in the wire rope. The wire rope on this main fall tackle is 7,000 ft. long. Both the topping lift and the main fall tackles are reaved from the center out and both ends of the wire rope are attached to drums on the hoist, thus making two lead lines for the main fall and four for the double topping lift.

The hoists that operate these tackles are all electrically driven, using a direct current of 550 volts. The hoists on the arch travelers are especially large and have 240 H. P. motors. Each traveler has one two drum and one four drum hoist with one drum of each having a center partition so that it can take two lead lines.



Completing the Center Panel.

On the morning of September 30 eleven panels of the arch stood out over the river from each side, and all was ready to erect the center closing panel. The remaining distance between the ends of the bottom chords was measured and an excess of 3½ in. on the north truss and 3⅛ in. on the south truss, was found with the temperature at about 62° F. The alignment taken showed the Long Island half leaning to the north 2⅝ in. and the Ward's Island half $\frac{5}{16}$ in. in the same direction. The elevations showed the Ward's Island half to be lower than the Lond Island half by 6¾ in. on the north truss and 4¼ in. on the south truss. This difference of alignment and elevation was within connecting limits, consequently the center panel pieces were started up. The temperature had increased from

62° F. to 80° F. at noon time and the opening had closed up nearly 1½ in., but there was sufficient room to work the members up through the dovetailing splice plates bolted on the ends of the chords of the eleventh panels. These center panel members were bolted to the Long Island half and the opening between the Ward's Island half was left loose for the night.

The next day, October 1, was a day of rain and a temperature of about 62° F. The big jacks on top of the back stays were operated both up and down in order to bring the bottom chords ends in connection and contact. One truss being lower than the other caused considerable jacking in order to correct the difference and connect both of them. Finally the connection was made and drift pins and bolts were in place at the center of the bottom chord points. These points were to act as a hinge for the time being and so the pins and bolts were kept within 8 in. radius of the panel point center.

A zero point was then marked on the plunger of each jack opposite the zero on a scale at its side. The scales on the Long Island jacks had units of one inch and the Ward's Island scales had units of ⅞ in. This was because the Long Island half had the center panel attached to it and was thus the longer.

Then came the order to lower all jacks and to lower them evenly according to scale. A man watched each scale and reported the readings to the engineer in charge, who in turn reported the readings over the phone to the foreman at the center of the bridge. The foreman was thus able to hold up one side or increase the speed of the other so as to lower the center together and not throw a load from one half to the other. The plungers of the jacks were lowered a total of 16⅜ in. on the Ward's Island side and 19¼ in. on the Long Island side until the pressure gauges registered zero and the fore stay connections to the arch were loose. The hydraulic pressure on the Ward's Island plungers at the start was 3,900 pounds per sq. in. on their 39 in. diameter surface, and 4,100 pounds on the Long Island side. The total time of lowering was about an hour and a quarter, and at all times the four jacks were within one quarter of an inch of each other.

Levels were observed continually during the lowering at the counterweights to see that their released weight did not cause too much settlement of the foundations and thus canal the lowering at the center. The 5,091 tons of counterweight had not acted on the grillage foundations before and so the action was in question. The Long Island counterweight settled 2½ in. and the Ward's Island ⅞ in. These levels were also reported over the telephone to the foreman at the center.

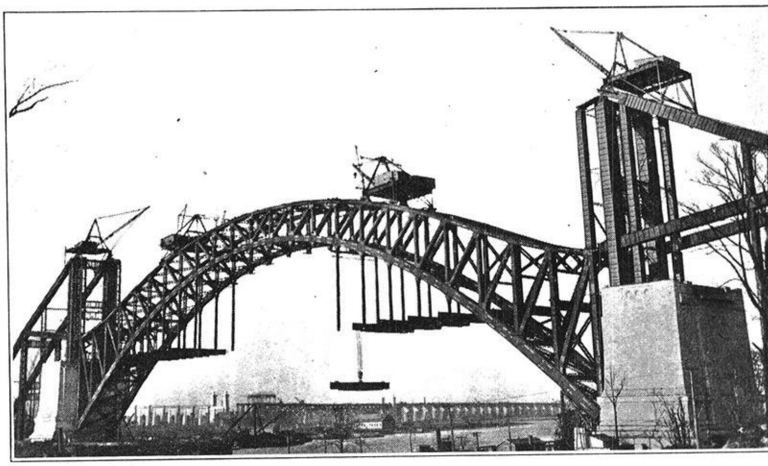
An open line telephone system was maintained between the center of the arch, the two jack platforms on top of the back stays, the two counterweights of the back stays, and the field office. At each place a man held the receiver to his ear continually and heard all the reports and the orders given. Each one knew all that was happening at every moment. The head officials of the company sat in the field office and heard it all, too. They had the plans and figured schedule before them and if the lowering had started to deviate from this schedule they could have stopped it all in a moment. This open line phone system placed the lowering in absolute control of the officials.

The arch span was now self supporting and every man on the job heaved a long breath of relief. The men knew that the danger of their going down to their deaths on the top of a falling bridge was over and the officials felt that the bridge was not held up by mere calculations any more. They knew these calculations had been checked and rechecked many times and that there was a good factor of safety, but still they felt the nervous strain so much during the last few days that none of them could settle down to their regular work. The Quebec bridge disaster was in their minds, and the lives of the 150 men up on this bridge was a thought not to be pushed aside. And so every one felt relieved of a tremendous strain and congratulations were exchanged all around in the happy crowd.

The center top chords were not put in place until October 4 as rainy days intervened. The top chord pieces had been made two inches too short so as to provide for any miscalculation as to exact length when the stress was in the bottom chord. The two inches or whatever distance it proved to be was to be filled up with a filler block after the full dead load was acting. When the top chords were placed the openings were found to be 2⅝ in. at the north truss and 2½ in. at the south. The calculated distance was 2½ in. for this condition and temperature.

The top chord pieces were connected at their Long Island ends only and left loose at the other end, for the arch span is to remain as a three hinged arch until the dead load is all acting. Then rivet holes will be drilled in the blank Ward's Island ends of these top chords to match those in the splice plates, and rivets will be driven. The bottom chords will be fully riveted at this third hinge point and from then on there will be but two hinges, one at each skewback.

Since this closing performance, the floor beam hangers have been taken down from the fore stays and hung with their floor beams in their permanent places. The back stays are now being taken down and as soon as the arch span stringers and railings are released, they will be erected to place and the span will be all erected and ready for riveting. The girder viaduct ap-



Hoisting a Floor Beam.

proaches will then be erected from the far ends toward the arch span, and as soon as the six concrete piers on each side are built where the back stays stand and the girder spans placed on top of them, the bridge company's work will be completed and railroad traffic will soon follow.

This Hell Gate bridge work has all been designed by Gustave Lindenthal, consulting engineer for the New York Connecting Railroad. The steel work was fabricated and is being erected by the American Bridge Co. The entire scheme of erection including the use of these back stays was developed by the Bridge Company under the direction of Mr. Emil Larsson, assistant chief engineer.

FITTING EQUATIONS TO PLOTTED POINTS

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The beginner will probably find that there is very little information to be obtained as to the actual detailed work which much be done in determining the equations which will fit curves obtained from experimental data. Evidently if he could refer to curves of somewhat similar form for which the detailed work were given, he would be better able to determine what to do to obtain a correct solution to his own particular problem.

In this article I will attempt to supply some information which will be of assistance in the manner indicated, but I will limit myself to the discussion of the equations of the parabolic, hyperbolic, logarithmic and the power series types.

When the first three of the above types have no constant terms, they take the following form:

$$y = ax^b \text{ (Parabolic)} \quad (1)$$
$$yx^b = a \text{ (Hyperbolic)} \quad (2)$$
$$y = ae^{bx} \text{ (Logarithmic)} \quad (3)$$

Taking the logarithms in each case, we have

$$\log y = \log a + b \log x \quad (4)$$
$$\log y + b \log x = \log a \quad (5)$$
$$\log y = \log a + bx \log e \quad (6)$$

These equations show that if in the first two cases the logarithms of the co-ordinates are plotted, a straight line will result. In the third case, if x and the logarithm of y are plotted, a straight line will result. This can be most easily done by plotting on logarithmic paper in the first two cases and on semi-logarithmic paper in the third case. The latter paper has only one of the co-ordinates plotted logarithmically.

If the equation, therefore, is of this simple type the constants a and b can be quickly determined. In equations (4) and (5) a is the intercept on the y axis and b is the slope; while in (6) a is the intercept and the slope is b log e, which equals 0.434 b when the base 10 is used.

It is in the cases of equations having one or more constant terms that the difficulties arise which require more detailed explanation. The more general types of the parabolic, hyperbolic and logarithmic equations are as follows:

$$y + y_1 = a\ (x + x_1)^b \qquad \text{(Parabolic)} \qquad (7)$$
$$(y + y_1)\ (x + x_1)^b = a \qquad \text{(Hyperbolic)} \qquad (8)$$
$$y + y_1 = ae^{bx} \qquad \text{(Logarithmic)} \qquad (9)$$

The signs in the above equation may of course be plus or minus.

None of these equations when plotted on logarithmic or semi-logarithmic paper will result in straight lines. The method of procedure in these cases can be best explained by working out the equations to fit given sets of data. Most of the curves which will be discussed are experimental curves, gathered from various publications, and therefore typical of the kind that are met with in practical work. It is taken for granted, of course, that every advantage should be taken of any theoretical considerations which would help to determine the probable form of the equation.

Fig. 1 shows a curve which was plotted from the following points:

x	.2	.3	.5	.8	1.2	1.9	2.5	3.3	5.0	6.0	7.0	8.	9.	10
y	17	15	13	11	9	7	6	5	4	3.7	3.5	3.25	3.25	3.2

Here y = leakage loss in watts for an insulator.
x = time in minutes.

Plotted on logarithmic and semi-logarithmic paper the curves are not straight lines, showing that the equation is not of the simple parabolic, hyperbolic or logarithmic type.

The curve looks like a hyperbola, so the general equation of that type will be tried first. The advice sometimes given to evaluate the constants x_1 and y_1, is to try various values for these constants until the curve becomes a straight line when plotted on logarithmic paper. In practice I have found this method tedious, and I much prefer the method of selected points. The desire in any case is to determine whether the chosen type of equation will fit the curve, and a method which answers this question definitely and fairly quickly will recommend itself.

The method of selected points makes use of as many sets of co-ordinate points on the curve as there are constants in the equation. Solving the simultaneous equations obtained by substituting these values, gives the complete trial equation; and

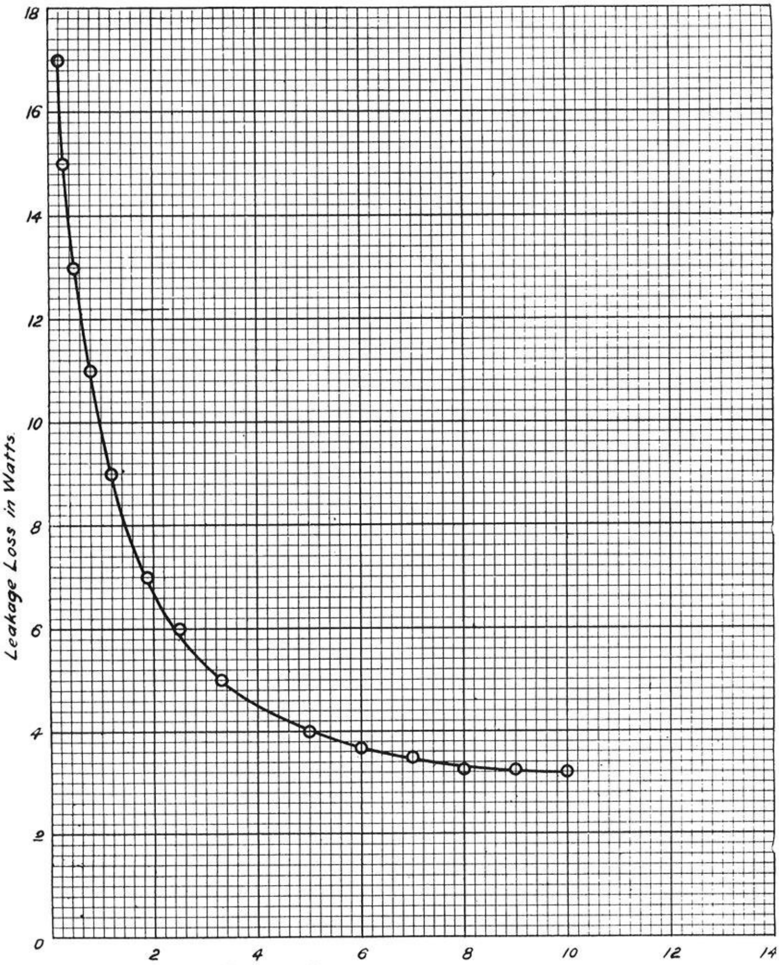


FIGURE 1

this should then be tried for various values of x to see if it fits the other points on the curve. If, say, three sets of points are chosen, they should be taken from the beginning, middle and end of the curve, so as to cover the whole range fairly well.

In the present case evidently it would not be easy to handle the simultaneous equations if the exponent b were left merely expressed. It is best, therefore, to choose $b = 1$ for a first trial and solve for the other constants. If the equation doesn't fit, try b = 2 and b = 3. This would generally show whether the type of equation chosen is likely to fit at all. Experience will suggest what to do in particular cases.

In this case, therefore, make b = 1 and take the following selected points on the curve:

$x = 0.2 \quad y = 17, \quad x = 3.3 \quad y = 5, \quad x = 10 \quad y = 3.2$

Substituting in the equation we have

$$(17 + y_1)\ (.2 + x_1) = a \qquad (10)$$
$$(5 + y_1)\ (3.3 + x_1) = a \qquad (11)$$
$$(3.2 + y_1)\ (10 + x_1) = a \qquad (12)$$

Combining (10) and (11)

$$(17 + y_1)\ (.2 + x_1) = (5 + y_1)\ (3.3 + x_1)$$

Combining (10) and (12)

$$(17 + y_1)\ (.2 + x_1) = (3.2 + y_1)\ (10 + x_1)$$

Eliminating y_1

$$x_1^2 + 2.78 \quad x_1 = 1.75 \quad x_1 = .52 \text{ or } —3.3 \quad a = 10.8 \quad y_1 = —2.18$$

It will be found that when $x_1 = —3.3$ the equation cannot be used.

Then the trial equation is $(y — 2.8)\ (x + .52) = 10.8$

This gives

x	.2	.3	.5	.8	1.2	1.9	2.5	3.3	5	6	7	8	9	10
y	17.18	15.38	12.78	10.36	8.46	6.65	5.76	5.01	4.14	3.84	3.62	3.45	3.32	3.2
Plotted values of y	17	15	13	11	9	7	6	5	4	3.7	3.5	3.25	3.25	3.2

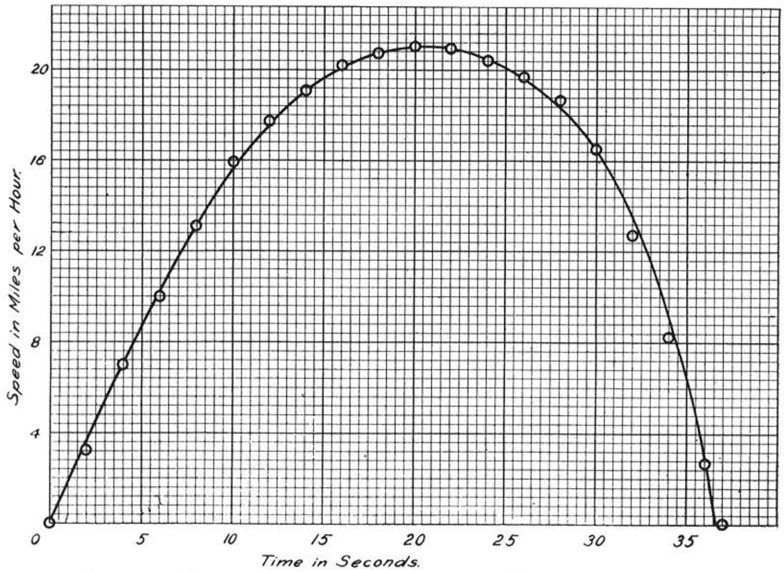
This agreement is quite satisfactory and the equation may be considered sufficiently correct.

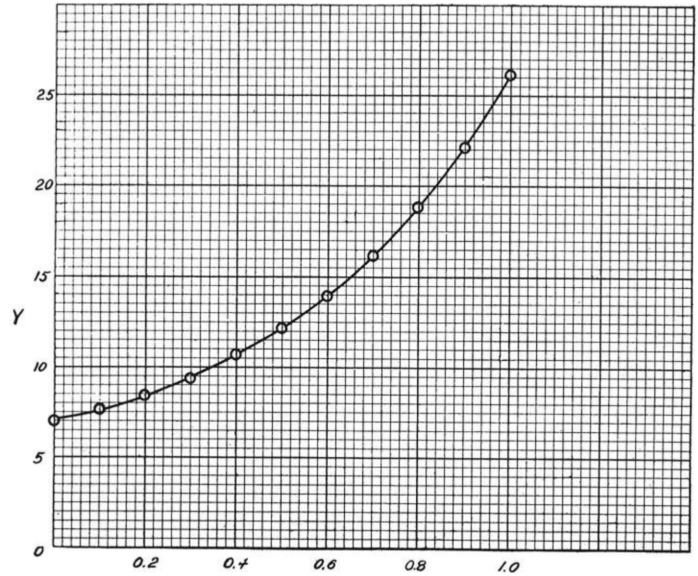
The next curve, shown in Fig. 2, is not an experimental curve, but has been chosen because it illustrates the logarithmic type of equation containing a constant term.

The curve was plotted from the following data:

x	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
y	7	7.66	8.47	9.46	10.69	12.15	13.96	16.15	18.85	22.15	26.17

These values plotted on logarithmic and semi-logarithmic paper do not result in straight lines. Since the curve looks like a logarithmic curve the general equation of this type will be





FIGURES 2 AND 3

tried first. Using the selected points x = 0 y = 7, x = 0.5, y = 12.15, and x = 1 y = 26.17, the following equations result:

$$7 + y_1 = a \qquad (13)$$
$$12.15 + y_1 = ae^{.5b} \qquad (14)$$
$$26.17 + y_1 = ae^{b} \qquad (15)$$

Combining (13) and (14)

$$\frac{12.15 + y_1}{7 + y_1} = e^{.5b} \qquad (16)$$

Combining (13) and (15)

$$\frac{26.17 + y_1}{7 + y_1} = e^{b} \qquad (17)$$

Squaring (16)

$$\left(\frac{12.15 + y_1}{7 + y_1}\right)^2 = e^{b} = \frac{26.17 + y_1}{7 + y_1}$$

Solving: $y_1 = -4$, a = 3 and b = 2.

The trial equation is $(y - 4) = 3\,e^{2x}$, which when solved for the values of x will be found to fit the curve.

It may be remarked in passing that if care is taken with this type of equation in choosing the values of x, the exponents of e will be such that the equation is quite easily solved.

The curve shown in Fig. 3 brings up for discussion both the parabolic and logarithmic types of education. The curve was plotted from the following data:

x	0	2	4	6	8	10	12	14	16	18	20	22	24
y	0	3.25	6.5	10	13.1	15.9	17.7	19.1	20.2	20.7	21	20.9	20.4

x	26	28	30	32	34	36	37
y	19.7	18.7	16.5	12.7	8.2	2.7	0

Here y = speed of an electric locomotive in miles per hour.
x = time in seconds.

The curve is not symmetrical, and since the law of speed and time will be different after the maximum speed is reached, the attempt to fit one equation to the whole range of x values will probably prove useless. It will be better to attempt to get one equation for values of x from 0 to 20 and another equation from x = 20 to x = 37.

Plotting on logarithmic and semi-logarithmic paper up to x = 20 does not result in a straight line in any case. Since this part of the curve looks like a parabola with its vertex at x = 20, the following general equation will be tried:

$$a\,(y + y_1) = (x + x_1)^b$$

Make b = 2 and use the selected points x = 0, y = 0; x = 10, y = 15.9 and x = 20 y = 21. Substituting in the equation the following simultaneous equations result:

$$a y_1 = x_1^2 \qquad (18)$$

$$a\,(15.19 + y_1) = (10 + x_1)^2 \qquad (19)$$

$$a\,(21 + y_1) = (20 + x_1)^2 \qquad (20)$$

Combining (18) and (19)

$$\frac{x_1^2}{y_1} = \frac{(10 + x_1)^2}{15.9 + y_1} \qquad \frac{15.9 + y_1}{y_1} = \frac{100 + 20\ x_1 + x_1^2}{x_1^2}$$

$$\frac{15.9}{y_1} = \frac{100 + 20\,x_1}{x_1^2} \qquad (21)$$

Combining (18) and (20)

$$\frac{x_1^2}{y_1} = \frac{(20 + x_1)^2}{21 + y_1} \qquad \frac{21 + y_1}{y_1} = \frac{400 + 40\ x_1 + x_1^2}{x_1^2}$$

$$\frac{21}{y_1} = \frac{400 + 40\,x_1}{x_1^2} \qquad (22)$$

Eliminating y_1 between (21) and (22) x_1^2 also drops out and $x_1 = -19.7$, $y_1 = -21$ and a = —18.47. The trial equation is $-18.5\,(y - 21) = (x - 19.7)^2$
This gives:

x	0	2	4	6	8	10	12	14	16	18	20
y	0	4.08	7.68	10.85	13.6	15.93	17.79	19.24	20.26	20.74	21
Plotted values of											
y	0	3.25	6.5	10	13.1	15.9	17.7	19.1	20.2	20.7	21

The agreement is not exact for the lower values but is still fairly good.

The second part of the curve from x = 20 to x = 37 plotted on logarithmic and semi-logarithmic paper does not give a straight line in any case. Since this part of the curve also looks like a parabola the same type of equation that was used in the first part may be tried. Using the selected points x = 20, y = 21; x = 30, y = 16.5; x = 37, y = 0; and solving the equation gives $y_1 = -22$, $x_1 = -22.9$, and a = —9.03.

The trial equation is $-9.03\,(y-22)=(x-22.9)^2$. When $x=22.9$ in this equation, $y=22$. This is not satisfactory, and instead of trying other exponents for the x term, an entirely different equation will be tried.

From the appearance of the curve it would seem that a logarithmic equation may be made to fit; and therefore the following type will be tried:

$$y - y_1 = ae^{bx}$$

Using the selected points $x=20$, $y=21$; $x=30$, $y=16.5$; and $x=37$, $y=0$, the following equations are obtained:

$$21 + y_1 = ae^{20b} \qquad (23)$$

$$16.5 + y_1 = ae^{30b} \qquad (24)$$

$$y_1 = ae^{37b} \qquad (25)$$

Combining (23) and (25)

$$21 + y_1 = y_1e^{-17b} \qquad (26)$$

Combining (24) and (25)

$$16.5 + y_1 = y_1e^{-7b} \qquad (27)$$

Raising (27) to the 2.4 power

$$\left(\frac{16.5 + y_1}{y_1}\right)^{2.4} = e^{-17b} = \frac{21 + y_1}{y_1} \qquad \frac{16.5}{y_1} + 1 = \frac{21}{y_1} + 1$$

By cut and try methods it can be shown that $y_1 = -21.7$. Then $b = 0.204$ and $a = -0.01328$.

Use as a trial equation $(y - 21.7) = -0.0133\,e^5$

This gives:

x	20	22	24	26	28	30	32	34	36	37
y	20.98	20.6	20.1	19.3	18.1	16.3	13.7	9.8	3.9	0
Plotted values of y	21	20.9	20.4	19.7	18.7	16.5	12.7	8.2	2.7	0

This is a fairly good fit except for some of the large values of x.

It may be worth while to point out that in curves of the parabola type with constant terms, the constant terms may be evaluated by knowing the position of the vertex of the parabola. For instance, the curve just discussed seems to have the vertex at $x=20$, $y=21$; therefore the equation may be written:

$$(y - 21) = a\,(x - 20)^b$$

If the corresponding values of $(y-21)$ and $(x-20)$ are plotted on logarithmic paper, a straight line will result if the equation fits the points. The intercept a and the slope b may then be determined.

The curve shown in Fig. 4 is different from any discussed hitherto. It will serve to illustrate the power series type of

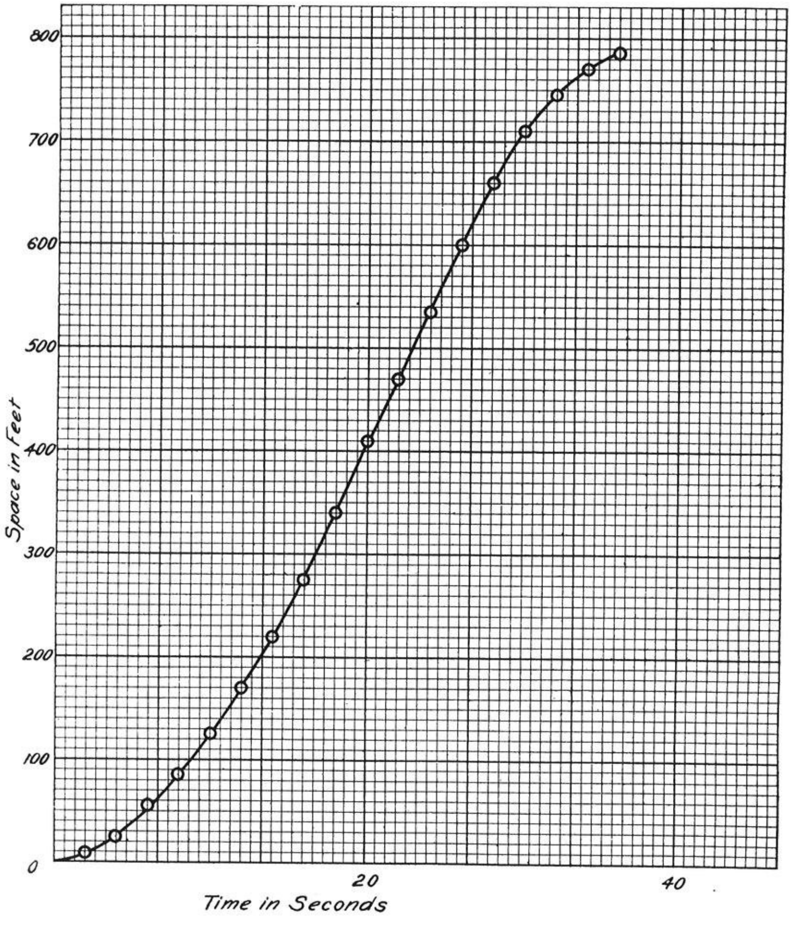


FIGURE 4

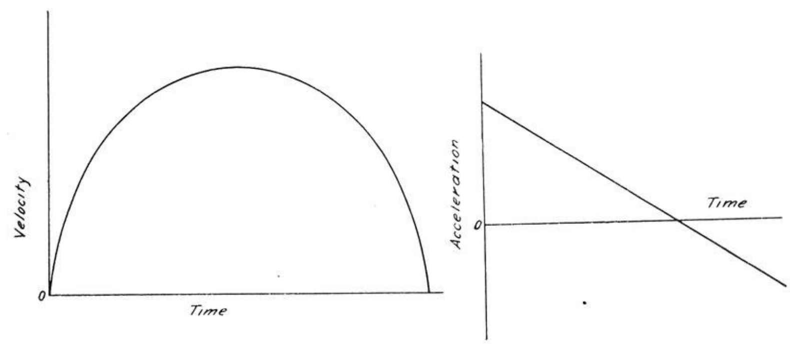
equation and at the same time show the value of theoretical considerations in arriving at the form of equation which will fit a given curve.

The curve is plotted from the following data:

x	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
y	0	8	25	55	85	125	170	220	275	340	410	470	535	600	660	710	745	770	785

Here x = time in seconds.
y = space covered by an electric locomotive.

In this curve it is seen that the curvature changes at about x = 20. One might attack the problem by assuming that a parabola equation with its vertex at x = 0 would hold from x = 0 to x = 20; and another type of parabola with its vertex at x = 36 would hold from x = 20 to x = 36. However, if a little theory is made use of, a much easier way is found and single equation may be made to fit the entire range of the curve.



FIGURES 5 AND 6

A study of the curve will show that it is almost symmetrical about a line going through the origin of co-ordinates and cutting the curve at x = 20. Furthermore, since this is a space-time curve, the change of slope occurring at x = 20 suggests a maximum point on the velocity-time curve, the zero slope at the beginning and end of the curve suggests zero velocity at those points, and therefore the velocity-time curve is probably of the form shown in Fig. 5. This figure suggests that the acceleration-time curve is probably of the form shown in Fig. 6, having the equation $y = a - bx$.

Integrating this twice gives us as the probable expression for the space-time curve $y = Ax^2 - Bx^3$.

Substituting in this equation the selected points x = 22,

$y = 470$ and $x = 37$, $y = 785$, and solving: $A = 1.55$ and $B = 0.0262$.

The trial equation is therefore $y = 1.55\,x^2 - 0.0262\,x^3$.

This gives:

x	0	2	4	6	8	10	12	14	16	18	20	22	24	26
y	0	6	23.1	50	85.8	128.8	180	232	289	349	411	471	530	588

x	28	30	32	34	36
y	641	688	730	763	784

Plotted values of y:

x	0	2	4	6	8	10	12	14	16	18	20	22	24	26
y	0	8	25	55	85	125	170	220	275	340	410	470	535	600

x	28	30	32	34	36
y	660	710	745	770	785

The values from the equation when plotted are seen to be in fairly good agreement with the original curve.

THE BINGHAM WAREHOUSE, CLEVELAND, OHIO.

R. B. BUETTELL, c., '13

The new hardware warehouse for the W. Bingham Co., just completed in Cleveland, Ohio, at a cost of $1,000,000, is representative of the heaviest type of modern reinforced concrete building construction. The building, consisting of eight stories and three basements, was designed for a live load, on the typical floors, of 300 lb. per sq. ft.; on and below the second floor, however, this was increased to 500 lb. per sq. ft., and part of the second basement floor slab was designed for 700 lb. per sq. ft. on a span of 24 ft. 8 in., due to an overhead monorail system in the third basement which will be used to handle comparatively heavy loads of steel bars.

The Akme system of flat slab construction was used throughout. This system is designed with two-way reinforcement, and without spandrel beams. On account of the offices on the third floor, however, spandrels were used in conjunction with the fourth floor slab to eliminate the wall column caps in the third story (see Fig. 1), and thus allow an unobstructed entrance of light through the windows adjoining these columns. The typical span is 20 ft. 6 in., and the maximum span 24 ft. 8 in. It will be noted that in the southwest corner of the building the floor slabs were cantilevered for a distance of almost seven feet. These cantilevers carried a solid 13 in. brick wall in each story for seven stories, and thereby avoided an additional row of columns along this wall. The slabs varied in thickness from 7½ in. for the roof to 15½ in. for part of the second basement slab. The thickness of the typical floor slab was 9½ in.

The maximum column diameter adopted was 38 in.; and all interior columns below the second floor line, including four exterior columns which supported the girders at the rear, were, therefore, built with heavy structural steel cores, each composed of a 14 in.-148 lb. special Bethlehem H, four angles 4 in. by 3 in. by $\frac{13}{16}$ in., and plates, as shown in Fig. 2. At each column cap these columns were provided with shelf angles on webs and flanges to assist in taking the stresses from the concrete, and at the tops octagonal plates with stiffeners transmitted the loads

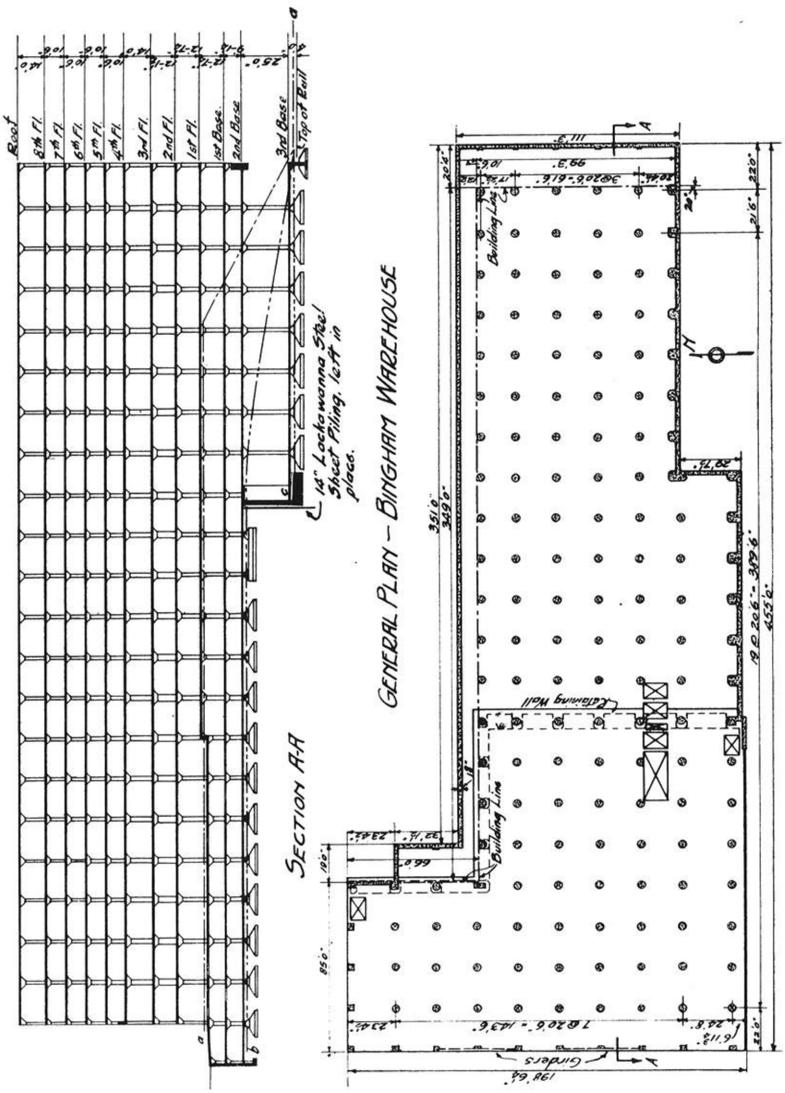

Section A-A
General Plan – Bingham Warehouse
14" Lackawanna Steel Sheet Piling, left in place.
Roof
8th Fl.
7th Fl.
6th Fl.
5th Fl.
4th Fl.
3rd Fl.
2nd Fl.
1st Fl.
1st Base.
2nd Base.
3rd Base.
Top of Rail
Building Line
Retaining Wall
Girders

FIGURE 1

from the concrete columns above. These details can be seen in Fig. 3. As a nadded refinement, the webs and flanges of the columns were drilled to permit the reinforcing bars in the slabs to pass directly through instead of around the steel cores.

It is interesting to note that the gross column load, that is, the maximum load supported by the earth directly beneath the footing, was 2,850,000 lb., which is approximately the equivalent of the gross column load of an interior column of a thirty-five story office building, with typical office building construction and

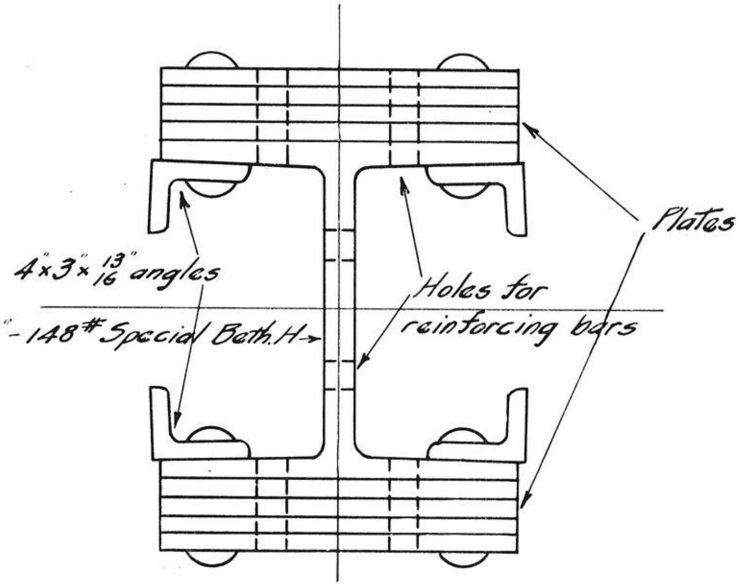


FIGURE 2

loading. If spirally reinforced concrete columns had been used below the second floor, the maximum column diameter in the third basement, using the above load, would have been about 50 in.

At the rear of the building two large steel shipping doors were installed, each 37 ft. 2 in. wide by 21 ft. 2 in. high. This necessitated the omission of two columns in the third basement, and the use of two large structural steel girders to carry these columns above the second basement floor line. The girders are shown in Fig. 2. Each of them weighed thirty tons, and the distance back to back of angles was 7 ft. 2 in½ in. The figure of a man at the left end of the nearest girder, in Fig. 2, will give an idea of their size.

The building is carried, for the greater part, on ordinary spread footings, reinforced two ways. The soil bearing value was determined by making a series of borings and soil tests, which revealed a hard blue clay capable of supporting 14,000 lb. per sq. ft. without serious settlement. The bearing value adopted was 7,500 lb. per sq. ft. After the excavation was completed, pockets of quicksand were found to underlie the established elevations of practically all of the footings at the east end of the building. A test pit was therefore dug, and the level of

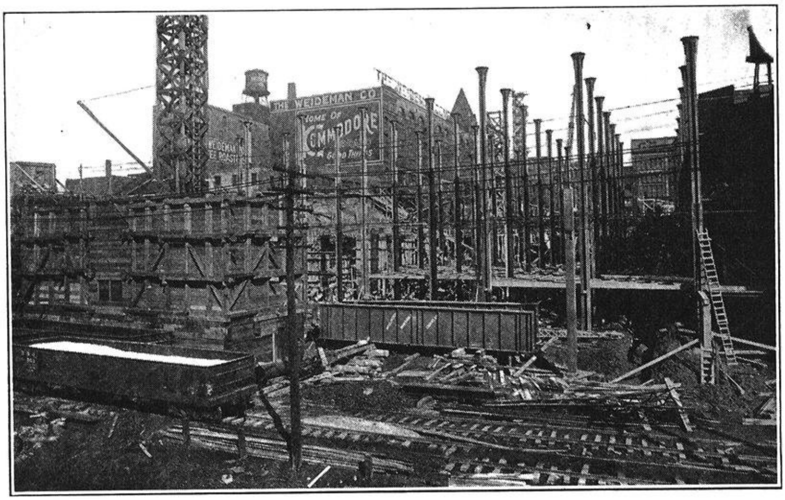


FIGURE 3

solid clay was determined. The footings were then carried down below the previously established elevation to this new level, light steel sheet piling being necessary in some cases to insure good working conditions.

In the design of the exterior and interior retaining walls, however, the method of excavating the site was the determining factor. This method is indicated in Fig 1. Line a–a shows the original grade on the center line of the building. The excavation, which was done with a Bucyrus steam shovel, was started along the line a–b from the west or rear end of the site. At the same time the exterior retaining walls shown in plan in Fig. 1

were trenched and poured; so that when the shovel reached the level of the second basement, it excavated up to and between these walls. It was then withdrawn to the point a, and started along the line a–c. While this was being done, the 14 in. Lackawanna sheet piling shown in Fig. 1 was driven. The shovel then ate its way up to the piling, which was heavily braced as the excavation proceeded, owing to the height of over 25 ft. of earth which had to be supported. The cross retaining wall was poured directly against this sheet piling.

It is evident that the retaining walls had to be designed, therefore, as free-standing walls. The buttresses, besides taking the column loads from above, acted as cantilever buttresses, and the wall between them was designed for slab action. On the south side of the building, in addition to the pressure of about 18 or 20 ft. of earth, the weight of an adjoining six-story warehouse was taken into consideration. The two rows of columns just east of the cross retaining wall were supported on combined footings as shown in Fig. 1, in order to insure added stability against any slight movement of the earth behind the 25-ft. retaining wall, and also because there was insufficient space for typical footings under the columns nearest the wall.

The main concreting plant was situated at the rear of the building. The sand and stone bins, on account of the rapidity of concreting and the limited switching service obtainable, were each designed for a heaped capacity of 470 yds., or about 635 tons. The cement was handled by means of gravity rollers from storage sheds in the third basement. In the construction of the tower there was a counterweight on the exterior to take part of the load from the electric motor which hoisted the bucket. The weight of this counterweight was about 500 lb. less than the weight of the empty bucket; and the speed obtained is sufficient evidence of the practicability of such an arrangement. During the average day's run, deducting time consumed for stops of whatever nature, a ¾ yd. batch was mixed and hoisted in 45 seconds. At times this was increased to two batches a minute. The materials for the secondary concreting plant were hoisted from the cars to storage bins at the top of a trestle. From these bins they were taken to the materal bins by means of industrial tracks and side-dump cars. After the foundation work was completed, mixing was discontinued at the secondary plant, all concrete was mixed at the main plant, and a third tower was built between this plant and the secondary plant, as shown in Fig. 4. The concrete was chuted from the main plant over the projecting wing of the building past this third tower to the bottom of the secondary tower, and was distributed as needed between all three towers. Each tower was provided with a 50-ft. Wylie truss chute, as shown in Fig. 4, which greatly increased the range and the speed of concreting.

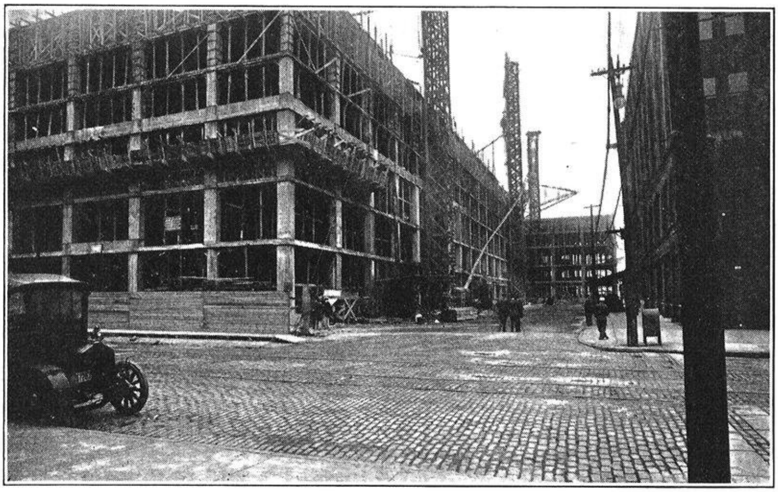


FIGURE 4

For concrete in the footings and retaining walls, limestone and gravel were used. For the concrete in the superstructure a considerable amount of blast furnace slag was used, the amount of porous slag being limited to 25%.

The speed with which the superstructure was built deserves special note. The basement slabs were not concreted so rapidly, partly because of numerous hangers, etc., which had to be poured with the concrete, and which had to be placed very accurately in the forms. The upper floors, however, were poured at the rate of three floors in thirteen working days. When it is considered that this included the raising of forms and the placing of steel, and that one floor slab, with the columns in the story below, contained about 1,900 yds. of concrete, this speed is little short of remarkable. The exterior brick walls around the entire building above the second floor were carried up at the rate of one story in two days.

After the completion of the building, a four-panel floor test was conducted according to the requirements of the Cleveland Building Department. Each of the four panels was loaded with sand to the equivalent of twice the figured live load, i. e., 600 lb. per sq. ft. Around the column in the center a small space was kept clear, and the slab was covered with cement finish for the purpose of detecting cracks at this point. When the full load had been applied, the following deflections were noted at the centers of the four panels: 0.225 in., 0.240 in., 0.249 in., 0.255 in. Hair cracks were observed in the cement finish around the center column, indicating that the steel over the column head was stressed to at least 18,000 lb. per sq. in., at which point the concrete should be stressed beyond its resistance. However, the average deflection of about 1/4 in. would seem to indicate that even this stress had not been reached; for using the formulas by which the slab was designed, a deflection of 7/8 in. would correspond to a tress in the steel of only 30,500 lb. per sq. in. In view of the fact that the slab was designed for a steel stress of 18,000 lb. per sq. in. under a load of only 300 lb. per sq. ft., we are therefore, led to believe that deflections and the use of deflection formulas are not a true indication of the stresses in this type of construction.

The new building will furnish about 16 acres of floor space. About 38,000 yds. of concrete were involved in its construction, 1,200 tons of structural steel, and 2,300 tons of reinforcing steel.

Walker and Weeks, of Cleveland, were the architects for the building; Christian, Schwarzenberg, and Gaede, of Cleveland, representatives of the Akme system, were the engineers. The Crowell-Lundoff-Little Company, of Cleveland, were the general contractors.

THE EASTERN TRIP

George Andrae, '16

The 1915 Senior Engineers' Eastern Inspection Trip is now in the class of by-gones, but there are numerous features and incidents of this trip which will make thoughts of it constantly recurring for some time to come. Connected more or less conspicuously with this enterprise were no less than forty-eight settled-in-full securities and two unpaid risks, to-wit, Professors R. C. Disque and G. L. Larson.

According to schedule, the trip-proper was to begin at the Northwestern depot at 5 a. m. on Saturday, October 30. It did. Roll-call showed most of the motley crew on deck, but wishing themselves in bed. The ride to Chicago was merely indicative of similar and subsequent periods enroute: "Bob smoked, and paced the car; we sang our repertoire."

Arriving in Chicago at about nine o'clock, we were kindly relieved of our baggage by Mr. Giles of the New York Central Lines, and immediately proceeded to the Fiske Street power plant of the Commonwealth-Edison Company. The visit here had special prior claims on our interest, since Mr. Insull of the Commonwealth Company had explained the plant and its workings in an illustrated lecture given last semester. Here we had our first look at a representative type of central station supplying a large city and surrounding area. Details of the plant are not deemed essential here; suffice it to say they were appreciated and mentally recorded by all of us for future reference and use. The company through their guides showed every consideration, and topped off the matter by serving us a noon lunch "on the house." The songs left unsung during our subsequent vocal thanksgiving-offering were not worth singing there, nor mentioning here.

Through at this plant, we went to Stagg Field to get our seats for the football game between Chicago and Wisconsin. The game began at two o'clock. There was an unusual amount of sky out that day; all in all, prospects were favorable.

Most of the boys had reported at the Hyde Park station long before one W. K. Walthers came strolling along with his ladyfair, so engrossed in a proper disposition of the few remaining precious moments as to be entirely oblivious of environment.

Spending the evening pleasantly on the train was no problem, since Pat McGilvary and Spike Royce had their ukeleles along. Having anticipated a nice rest-up until 7:10 the next morning, we are still looking for the fellow who stole an hour of our sleep as a penalty for going east of Detroit. All of Sunday was devoted to sight-seeing at Niagara Falls, the bunch breaking up into half a dozen groups, and strolling about Goat Island and vicinity. Cameras were much in evidence here as well as on the

The Boys at Play

Gorge-route trip made by electric car in the afternoon. For the benefit of our visiting party the Falls were turned on extra strong, and many excellent snap-shots were secured. Be it known that Buffalo and Niagara Falls are both closed up tight on Sunday, wiggle-shows supplanting regularly billed plays on this day. The evening was, therefore, well adapted to letter writing and sleeping.

On Monday the real inspection trip began, our morning's work including three power houses. To the casual observer there is a disinteresting sameness between such hydraulic power plants: large turbines, usually Parsons or Francis type; overgrown generators; and oil switches. But to the engineer the really interesting features are aside from the above trade-bulletin information; they include the means for leading in and later disposing of the water, the switchboards, and line protection methods. For example, the Ontario Power Company, located at the foot of the falls, utilizes a head of 205 ft. of water, secures its supply through 18 ft. conduits from a mile above the falls, and has its switches and control apparatus in a separate building on the bluff above.

During the afternoon the plants of the International Acheson Graphite Company, Niagara Falls Power Company, International Paper Company, and Shredded Wheat Company were inspected. At the graphite factory we saw and learned about the the process of manufacture from the raw materials to the finished product, much credit being due the very satisfactory guides furnished us. At the paper mill we realized the value of the lecture on paper-making machinery and processes given us before our departure by Dr. Kress of the Forest Products Laboratory, for it enabled us to observe and understand operations which the extreme speediness of our guide would otherwise have caused us to miss.

The ride from Niagara Falls to Buffalo was quickly disposed of, and seven o'clock Monday evening found us at the Hotel Statler in Buffalo, ready for all the town had to offer on the night before election. To get people down-town and have the various candidates' qualifications blatantly proclaimed before the crowd, an imitation Mardi Gras parade was instituted, terminating at the city Auditorium where speech-making and dancing were to follow. And the crowd was there, too; "there," in more ways than one, as some of the fellows reported next morning while walking to the Federal Telephone Company's exchange. The feature here, besides the comparative scarcity of girls, was the automatic operation of the telephone apparatus. An automatic telephone exchange was something new to most of us, but through the careful explanations of our guides and of Bob Disque, we went away knowing a little at least about this complex but well-developed mechanism. In the mean time the mechanical section had paid a visit to the Snow Steam Pump Company, but all of us were welcomed, chilled, frozen, and fed at Wheat's ice cream factory. With the statement that sub-station B of the Cataract Power Company and the Pierce Arrow factory both contained educational matter warranting and rewarding a careful inspection, let me hurry on to that memorable evening in the grill room of the Statler. How clearly in my mind's eye I see Bubbles Maurer ordering another service of buttermilk and nabiscos. Everything went along fine until "Bub" sang "Brother Noah" to us; then some one laughed, Ballard performing so uncontrollably as to have to leave the room; but wait,—I believe that Bubbles set Andrae off first, and then did the b'loon go up.

A busy day awaited us in Pittsburg on Wednesday, November 3. Not stopping to mention our eighty-cent-toast-and-coffee breakfast (Oh, ye shades of Jesse James!), I must on to speak of the wonderful things seen in the A. M. Byers and National Tube Company plants, at both of which high grade pipe of all sizes is manufactured. The Byers plant was never visited before by any Wisconsin party, but certainly should be included in the list of stops henceforth. The fact that Jamieson, Commerce '13, and several other college men held executive positions here, materially affected our reception and treatment. Several of these men, our guides during the morning, were guests with us in the evening at the smoker given in the Fort Pitt hotel by the Pittsburg alumni. And a uniquely enjoyable smoker it was! That, as the Lodi Spell-binder might say, "a good time was reported by all present," was due somewhat to the fine motion pictures displayed (with what prosaic themes the censored movies deal!) The Pittsburg crowd certainly showed our party a fine time, for all of which due thanks is here again rendered.

The president himself, did not meet us at the Westinghouse plant in East Pittsburg the next morning, but "Schimmel" Skinner and Ernie Lange were there instead. While the Mechanicals divided the morning between the machine shop and the electrical works, the Electricals gave the entire forenoon to the study of the big things built or being built in the Westinghouse Electric and Manufacturing Company. And be it said the entire trip was repaid in full by what we saw in this one plant. In fact, honors for the "Big Thing" of the trip lie between the National Tube Company plant at McKeesport, and the W. E. & M. Co. at East Pittsburg. The Westinghouse Company very kindly furnished our party a noon meal at their East Pittsburg club, after which we departed for Wilmerding to inspect the Westinghouse Air-Brake Company. During the evening most of us attended various theatrical performances, all getting together again at the Lake Erie depot at 11:30 p. m.

Hardly had we stopped at Cleveland on Friday morning before a Wisconsin alumnus boarded the train to distribute printed programs of our day's schedule. Inasmuch as several of the plants on the list were almost inaccessible to us by rail, eleven automobiles had been provided by the Cleveland alumni to take us about. Needless to say, the auto ride was in itself a treat greatly appreciated. In view of the fact that 146 different

The Sole Survivors Leaving Gary

makes of motor cars have Willard storage batteries, the manufacture of these batteries, carefully demonstrated to us, was a most interesting lesson. How simple the method in which ornamental shades, globes, and incandescent bulbs are produced, was appreciated after leaving the Ivanhoe Glass Works. At Nela Park the latest experimental methods and results were shown, but the actual lamp-making process was not disclosed. The employees here are largely girls, and experience has demonstrated, that the day's output of finished lamps by these girl employees is appreciably affected by having such a party of young fellows, as ours, go about viewing the work in progress. But we will forgive the Nela Park authorities many things in view of the fine meal they served free to we'uns, hungry as we were. As a thank-you, we sang all our songs for the other diners, employees, and hied us to the waiting automobiles. The afternoon disclosed nothing of exceptional value to most of us, and we were quite glad to get back to the hotel for a much-needed swim. Not enough was it for the Cleveland "old-timers" to furnish eleven machines for our convenience and enjoyment during the day, but to this was added in the evening, a dinner and entertainment at which everyone certainly must have enjoyed himself, and felt the extreme good will and kindness of his alumni brethren. This dinner was served in a recital hall of the Bell Telephone Company's building, since Mr. Allard Smith, manager of the Cleveland Bell exchange, is a Wisconsin man.

That night on the train has special claims on our memory and feelings. Much amusement did it afford one Buckmaster and McKinney to chuck pieces of ice in the berths or down the necks of those calmly sleeping. And how some fellows kept right on sleeping I cannot understand, nor will I go into detail on the results. But we weren't very particular any more at this stage of the trip, merely wishing to finish Gary as soon as possibly and then fly to Chicago, or home. The blast furnaces and mills at Gary have been so frequently described in lectures and otherwise, that, to use an expression of Bob Disque's, to recite their story here in detail to those who already know, would be "the most flagrant kind of superfluity." Immediately after arriving in Chicago at 1:40 p. m. of Saturday, November 6, our party broke up, some going to Madison, some to Milwaukee, and others remaining in Chicago.

In retrospect, be it said: the trip was a decided success from every point of view. We viewed many wonderful things which give the affair an educational value; we saw scenes of natural beauty for which alone such a trip is usually undertaken; and last, but by no means least, we all, I believe, by living and traveling together, learned to know one another better than ever before and feel our acquaintances strengthened by virtue of this intimate association. In fact the social side of this inspection trip, secondary though it is, should not be minimized nor misjudged. By drilling us in typical Wisconsin songs prior to our departure, Bob Disque did not over-emphasize this feature of the trip. At any alumni dinner, as in Pittsburg or Cleveland, the alumni ask not: "What have you seen to make the trip worth-while?" but apply the same question as put by several professors on our return, "Did you have a good time on the trip?" The Lord gave us eyes and ears whereby to insure the educational value of the trip, and that, then, is taken for granted. But what the alumni do want are songs and lots of them, Wisconsin dope, and "signs o' pep." On such occasions we must constitute ourselves, collectively and individually, messengers of the University to diffuse and renew that wonderful yet intangible something known as Wisconsin spirit, that by such renewal it may assert itself with added strength, to the honor of Alma Mater.

THE INSPECTION TRIP OF THE SENIOR CIVILS.

S. C. Hollister, '15

The seniors of the civil engineering department left on their annual inspection trip to Milwaukee and vicinity on November 1. Professors Corp and Van Hagan and Mr. Glaettli accompanied the party throughout the trip.

Through the courtesy of Mr. H. P. Bohman, Superintendent of Water Works for Milwaukee, arrangements were made for the inspection of the North Point pumping station and the meter testing station. Mr. Bohman lectured to us on the history and present status of the water system, and on the methods of accounting and keeping of records employed by the department.

The incinerator, one of the largest in the country, was visited and inspected.

One of Milwaukee's fire boats took us to the sewage testing station on Jones' Island. Mr. T. Chalkley Hatton, engineer in charge of the investigations for, and the design of, a sewage system to meet the various needs of the city, gave a brief talk, after which he and his assistants conducted the party through the station. It might be noted that this testing station is largely responsible for the practical development of the activated sludge process of sewage treatment.

In company with the Superintendent of Bridges, we inspected several of the draw and bascule bridges along the waterway. In each case the structure was operated for us that we might observe the various types of moving machinery for such structures.

The Grand Avenue viaduct, a massive structure made up of a series of concrete arches, was visited. In this connection, several concrete and steel buildings in the course of construction were carefully inspected. A number of Wisconsin men were found in charge of this work.

Through the courtesy of Mr. Charles Lapham, Division Engineer for the C. M. & St. P., and an old grad, the party was shown over the track elevation of that road, at present nearing completion. Their draw bridge and interlocking plant were also visited. An afternoon was spent in the company's extensive shops, in which are made all parts from a single bolt to a complete locomotive or coach.

Half a day was given to the inspection of the West Allis plant of Allis-Chalmers Company, and another to the bridge shops of the Wisconsin Bridge and Iron Co.

The comfortable part of the whole trip was the automobile ride furnished by Professor Smith, of the highway department, who joined the party on the last day of its stay in Milwaukee. In company with the superintendent of streets, Professor Smith showed a number of very interesting cases of good and poor pavements. Paving plants in operation were visited and inspected.

Through the courtesy of the Messrs. Morrison and Miller, of the Bucyrus Company, that company's enormous plant in South Milwaukee was visited by several of the students after the regular schedule had been completed at noon of November 4.

Professor Smith, in company with the students in Highways, took a two days' trip through the lake towns on a special inspection of highways and highway construction. Sheboygan, Oshkosh, and Fond du Lac were visited, and in each town the city engineer and the Mayor were on hand to extend numerous courtesies to the party.

COLUMBIA UNIVERSITY ESTABLISHES A SEPARATE DEPARTMENT OF CHEMICAL ENGINEERING.

Courses leading to the degree of Chemical Engineering have been offered in the Department of Chemistry of Columbia University for the past ten years but, in recognition of the rapidly increasing importance of those industries based upon the applications of chemisrty, and the consequent demand for men specially trained in the fundamental engineering practices as applied to the problems of industrial chemistry, the trustees of Columbia University have established a separate department of Chemical Engineering upon the same plane of importance in the Columbia Graduate Engineering School as Mining, Civil, Electrical and Mechanical Engineering. The head of the new department will be Professor M. C. Whitaker who has been professor of Chemical Engineering at Columbia University for the past five years.

The sudden demand for products previously secured from Europe has greatly stimulated activity among chemical manufacturers. In many cases it is necessary first to develop the raw material supplies, as for example for the manufacture of coal tar dyes, where large quantities of benzol, phenol, toluol, etc. are required. The demand for these materials is being met rapidly by the installation of large plants for the recovery from coke oven gases of these heretofore waste products. Such concerns as the Lackawanna Steel Co., United States Steel Co. and other large coke producers both in the United States and Canada are now recovering these products. Similar activity obtains in other fields; for example, on account of large demands for explosives, the production of sulphuric and nitric acids is being enormously increased.

Entirely aside from these abnormal developments, forced upon us by the war, it should be noted that chemical processes are being established in other fields. For instance, within the last month two enormous installations, one at the Anaconda Smelter and another at Chuquicamata, Chile, have been started for the extraction of copper by chemical methods. Plants for the production of sulphuric acid as a by-product from the roasting of sulphide ores along the lines of the plant at Ducktown, Tenn., have also been established at Langloth, Pa., Cleveland, Ohio, and by the United States Steel Corporation.

NOVEL DEVICE PREVENTS WASHING OF ROADS

A novel but thoroughly practical device is used in the State of Maryland to prevent the washing of road shoulders and gutters. According to H. G. Shirley, Chief Engineer of the Maryland State Roads Commission, these "breakers," as they are termed, answer their purpose so well that they will pay for themselves after two or three heavy storms.

Briefly described, the breaker consists of a low concrete barrier

Concrete "breakers" as used on Maryland roads. A simple device to prevent washing of shoulders and gutters.

extending from the edge of the road diagonally through the shoulder to the ditch. It is built flush with the surface of the road shoulder, and where highways are patrolled and shoulders kept in repair, it is no obstruction to travel. Breakers are spaced as occasion may require, and are neither expensive nor difficult to build. The Maryland breakers are 12 inches wide and 18 inches deep. As stated, spacing varies with the nature of the soil, grade, and the amount of water they encounter. Thus it would probably be necessary to space them closer at the bottom of a hill than at the top. On 5 to 6 per cent. grades and medium soil the breakers are spaced 25 to 30 feet apart. Where the soil is liable to wash and the grade steeper, they would be spaced much closer. The length as well as the grade of a hill would also influence the spacing.

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EDITORIALS

The current number of the "Engineer" contains an unusually interesting article by Mr. Walter J. Parsons, U. W. 1900, on the "Erection of the Hell Gate Bridge." This bridge across the East River at New York City is one of the largest bridges ever constructed and is, in fact, the longest arch span ever built. The erection of this structure had to be carried out without interfering with navigation and the plan used was the one which is commonly adopted for arch spans, namely, the so-called cantilever method, each half of the arch being constructed from the abutments towards the center of the span, meanwhile being supported by back stays anchored to the rear of the abutments. The critical point in such work is the joining of the two halves at the center and to enable this to be done the back stays are made adjustable by means of enormous hydraulic jacks. When the connection is made these jacks are operated so as to raise and lower slightly the ends of the overhanging or projecting ends of the arch so that the desired connection can be made.

Mr. Parsons has for many years been employed in the erecting department of the American Bridge Company and was in charge of the erection of this great structure. His paper gives a very interesting account of this important work and the "Engineer" is very fortunate in being able to secure such a good paper.

F. E. TURNEAURE.

* * *

In last month's number we announced that a new plan to interest the alumni was to be started. Since then letters have been sent to the members of three classes, asking for a short letter which might be published in the alumni section of the magazine. One hundred fifty-four letters were sent out. *Two* answers have been received. We do not like to think that only two members of these classes still have an interest in the University. If this is not true, there must be some error in our plan. Can some one tell us what is wrong? We want to make the magazine serve the alumni, and we hoped that this plan would be a step toward our goal. At present it seems that we have failed, and we would like some advice. Let us hear from you. Don't wait for a letter for we may not have your correct address.

* * *

The average engineering student has it said to him the moment he enters this building as a humble freshman, "The engineering course is a stiff proposition. You won't have time for anything else but your work." And immediately upon leaving the building he proceeds to proclaim to the world at large that the engineering course is a stiff course, and that the engineer has time for nothing but engineering. He proves it by enriching the Orph, and the movies see much of him.

The engineering course is a stiff course. It is an impossible course to the loafer. But it is not true that the engineer has time for naught but engineering. Every engineer is a man and has a man's duties toward other men. He must make of himself an individual who can appear before his fellows, not only those of his own profession, but before men and women of all walks of life, without having the least cause for feeling that he is out of place. First and foremost every engineer must be a man and a gentleman in the highest sense of the word. Then, if God has blessed him with the necessary talents, he can be a man of technical accomplishments and contribute his share, be it large or small, toward the constructive efforts of the land that harbors him.

The engineering course certainly leaves time for the cultivation of the necessary accomplishments of a gentleman. What it does not leave time for is the life of a social satellite. We all hope for success, not only in the sense of accomplishing great engineering works, but in a financial sense. Financial success always seems to bring with it an inevitable minimum of what we call "society." If the engineer does not acquire traits during his college career which make him better able to meet men, when is he going to do it? "You can't teach an old dog new tricks." It is hard enough to teach a young dog the old standbys.

There is only one means of learning to do, and that is by doing. Learn to meet men; learn to mix with People—How?—By doing it. Learn to tell a group of other men what you know, so that they can go away knowing it too. How? Practice in some engineering society. You will be surprised to find what good material you have to practice on. Learn to meet your fellows socially. Of course, you can see your old friends any time and "get away with it." Can you go among strangers and "get away with it?" Or do you leave the impression that you are a "roughneck?" The finest personality in the world will not stand the strain of long stagnation. A personality which is not so attractive naturally can be developed by practice to such an extent that people who meet you once will want to see you again. Do you want to do it?

The engineering course will not keep you too busy to permit your becoming a man of culture. What makes the course hard is not the work of the course by itself. It is the fact that an engineer must be all that other men are, and a first class technician besides. Your class work will develop the technician if you give it half a chance. It is your part to keep busy developing the man.

* * *

Dancers at the Engineers' All-University dance, Lathrop Hall, Dec. 10, will determine on slide-rule programs the order of popular music and characteristic Wisconsin songs to be played by Buech's Orchestra.

On the blue-print posters, typically announcing the event, are the gear of the Mechanicals, the nitrogen bulb of the Electricals, the graduated glass of the Chemicals, and the target of the Civils.

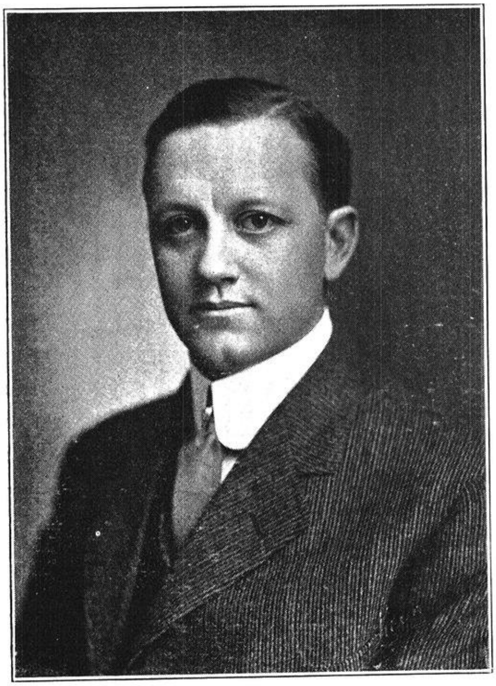
To facilitate the satisfactory arrangement of dance number engagements, the tickets have appended to them detachable preliminary programs.

Engineers' dances of preceding years have been social successes. Still, there is ample reason to anticipate that, with the presence of faculty members, to whom special invitations are being given, the event may become a recognized all-university affair—a conventional event.

Successful Wisconsin Engineers.

SUCCESSFUL WISCONSIN ENGINEERS

FRANCIS ARTHUR VAUGHN



The engineering college of the University of Wisconsin may well be proud to have Mr. Francis Vaughn as one of its alumni. If the high esteem of his colleagues, a long record of responsible positions held, and the accomplishment of a truly extraordinary amount of work of the most exacting nature entitle a man to be called successful, then Mr. Vaughn is successful.

Francis Arthur Vaughn was born at Prairie du Chien, December 6, 1871. He received his grade and high school education at Madison, and in 1895 received the degree of Bachelor of Science in Electrical Engineering. During the years 1893 and 1894 he was senior partner of the firm of Vaughn and Cosgrove, of Madison, electrical contractors. He was later employed in the testing department of the Standard Telephone Mfg. Co. of Madison, and as designer for the Gibbs Electric Co. From 1896 to 1910 he was with The Milwaukee Electric Railway and Light Company, in whose employ he held successively the positions of engineer in charge of power house operation, keeping of records and standards, maps, and inventory records of electrical apparatus and distribution systems; chief draughtsman in charge of power house design, substations, and electrical apparatus; superintendent of meter and testing departments in charge of designs, estimates, improvements, specifications, and overhead and underground distribution of all railway and lighting systems; and electrical engineer of the lighting department in charge of erection and design of power-houses and elecrtical substation equipment. His work has embraced practically all phases of low and high tension, direct and alternating current design, construction, operation, generation, and transmission. He was a pioneer in the development of long distance, high voltage transmission, and in 1,200 volt direct current railway practice.

Mr. Vaughn is senior member of the firm of Vaughn, Meyer, and Sweet, Milwaukee consulting electrical engineers. Since 1910 he has been consulting engineer for the State Board of Control of Wisconsin. He was also in charge of the street lighting survey of the city of Milwaukee in 1914, which had for its object the accumulation of data for the re-designing of the street-lighting system of the city. Thus far this project, which is one of more than merely local interest, has resulted in the authorization of a test district of about three-quarters of a square mile, in which the various proposed systems of illumination will be tried out and their suitability for the proposed work determined. The various forms of illumination for different duties, e. g., for boulevards, downtown streets, residential districts, etc., will all be represented, and an opportunity will be afforded to show that the present expenditure for lighting can be made to give far better results than are being obtained. The establishment of this test area and any steps that may be taken as a result of the tests, are entirely due to the efforts of Mr. Vaughn and his partner, Mr. Sweet. These gentlemen have acted entirely from motives of civic pride in agitating for better lighting in the city, and it is to be hoped that their efforts will bear good results.

In addition to his professional work, Mr. Vaughn has done an almost incredible amount of work for a large number of societies. He is a Fellow of The American Institute of Electrical Engineers, and an extremely active member of the following organizations: Illuminating Engineering Society, Engineering Society of Wisconsin, Milwaukee Electrical League, Milwaukee Efficiency Society, Wisconsin Electrical Association, and National Electric Light Association.

As Secretary of Publication of the Meter Committee of the N. E. L. A., he was in charge of the compilation and publication of The Electrical Meterman's Handbook, a classic in the field of electrical engineering handbooks. In addition, Mr. Vaughn has published several articles dealing with various phases of illuminating engineering.

The high regard in which Mr. Vaughn is held is well shown by the demand for his services as an expert witness in litigations involving engineering questions. Public service commissions in several states, and various public service corporations have on different occasions sought Mr. Vaughn's services either as consultant or as expert witness.

Mr. Vaughn's career, in showing what a busy man can do right in his own state, should be a comfort and an inspiration to those who fear that there is no future in the profession. There is nothing that succeeds like success, and the measure of a man's success is composed of two things: the record of his past activities, and his present activities. The more successful he is, the busier he is likely to be. And Mr. Vaughn is certainly as busy a man as has ever come within the range of our observation.

CAMPUS NOTES

Grant Showerman, Professor of Latin, University of Wisconsin, gave the first lecture to the engineering students on October 21st. The subject of his address was "The Achievements of the Ancients."

Professor Showerman illustrated his lecture with views of conditions and achievements of ancient civilization. The speaker created a classic atmosphere in which to move his people about, and left his listeners with a feeling of acquaintanceship with those people. He pointed out their needs, and the engineering skill they must have possessed in solving their problems, though handicapped greatly by lack of engineering equipment and appliances. The engineering student went away feeling decidedly thankful for the age in which he is privileged to live and to ultimately practice his profession.

It is hoped that there will be more lectures during the year of the type of Professor Showerman's. It is good that the technical student be reminded at frequent intervals of the more or less neglected liberal side of his education and his nature.

* * *

A blast furnace for the metallurgy of copper and lead has recently been added to the equipment of the mining laboratory. The furnace is so equipped that complete thermal tests may be made during operation.

* * *

Research in the mining department is being carried on regarding the electrolysis of sulphur ores and the heat transferred in the flues of hot blast stoves.

* * *

At the last report the arrangements for the Minstrels are well under way. The date set seems a long way ahead, but the time will go fast. Watch the bulletin board for the announcement of the tryouts, and meantime be on the watch for good material.

* * *

Adolph Meyer who was recently made Associate Professor of Hydraulic Engineering at the University of Minnesota, will appear here to give a lecture at some future date.

ALUMNI NOTES

OUR 1915 CIVILS

B. E. Anderson has accepted a position with the Eng. Dept. of the Penn. R. R. At present he is working on the Chicago freight terminals. His address is 517 W. 61st Place, Chicago, Ill.

R. A. Anderson is back again at the University pursuing graduate work.

F. J. Bachelder is consulting engineer at Chicago, Ill. He is located at 714 Hartford Bldg.

A. W. Case is with the Snase & Triest Co. He is now engaged on the construction of the New Elevated Ry. of Long Island City. His address is either 422 West End Ave., New York or 17 West 42nd Street.

R. T. Cavanagh is with the State Engineer of New York. His location is No. 3 Mark Bldg.

C. P. Conrad is fellow in Hydraulic Engineering at the University of Wisconsin. His address is 308 Prospect Ave., Madison, Wis.

Myron Cornish is in the Miami Conservancy District, Dayton, Ohio.

A. W. Crump is engaged with the Illinois State Highway Dept. as Junior Engineer. His address is 522 W. Jefferson St., Springfield, Ill.

L. H. Doolittle is with the Miami Conservancy District at Dayton, Ohio.

W. A. Goss is with the city engineer of Mason City, Iowa. He stays at 837 North Main St.

M. C. Hall is with the Johnson Service Co. at 1205 W. 31st St., Los Angeles, Cal.

W. W. Innes is working in the Engineering Department of the city of Milwaukee.

Paul Lillard is assistant engineer to the city engineer of Madison, Wis.

A. E. Nance is with the Ferris Bridge Co. of Pittsburg. His address is Warren, Ohio, R. F. D.

L. C. Rockett is with the North Western Ry. His address is 215 North Blount St., Madison, Wis.

L. C. Rogers is with the Bates & Rogers Contractors at the Old Colony Bldg., Chicago, Ill.

S. H. Seelye is with the Miami Conservancy District of Dayton, Ohio.

E. H. Tashjian is at present undergoing a treatment at the Mayo Bros.' Hospital, Rochester, Minn.

W. S. Todd is with the Illinois Highway Comm., at Springfield, Ill.

H. W. Wesle is with the Miami Conservancy District of Dayton, Ohio.

L. R. Wheeler is with the Illinois Highway Commission.

F. D. Bickel is asssitant to the city engineer of Beloit, Wis., at 833 Sherman Ave.

K. B. Bragg is working in the Miami Conservancy District of Dayton, Ohio.

E. R. Stivers is with the C. B. & Q. R. R. at St. Joseph, Mo.

C. S. Gruetzmacher is in the city engineers' office of Milwaukee, Wis.

J. H. Hendricks is with the New York State Highway Dept. as Highway Inspector. His address is 774 Gotham St., Watertown, N. Y.

H. C. Henze is located at Eloise, Mich. as assistant superintendent of construction for A. T. Smith & Co. of Detroit, Mich.

E. J. Hewitt is with the Illinois State Highway Dept. His present address is Morrison, Ill.

F. J. Thwaites is draftsman for the B. & O. Ry. at 565 Yale Ave., Chicago, Ill.

Byron Bird is in the work at the Miami Conservancy District of Dayton, Ohio.

R. B. Clement is also with the Miami Conservancy District of Dayton, Ohio.

MISCELLANEOUS

K. L. Van Auken, c e '13, has recently resigned his position as Associate Editor of the Railway Gazette to join the Bruce

V. Crandall Service, of which he is vice president. His address is 1824 Lytton Bldg. of Chicago, Ill. Mr. Van Auken has just finished writing a book entitled "Practical Track Work." Mr. Van Auken was formerly extra gang foreman with the C. & N. W. Ry. and is therefore well acquainted with the problems and difficulties the railway man must meet.

E. D. Gilman, fellow '14, has been appointed instructor in Hydraulic Engineering at the University of Minnesota.

The co-operation that we expected our alumni would give us in the successful carrying out of our new plan has failed to materialize. Out of the 154 to whom letters were sent, only two responded. We are publishing those herewith in order to show that there are still some alumni who have the welfare of the Engineer at heart and who give their Alma Mater an occasional thought.

Your plan for personal letters from the Alumni is very interesting. My own history since June, 1911, has been in two chapters. For the first two years I was in the steam engineering department of the Illinois Steel Co. at South Chicago. Since then, I have been mechanical engineer for Vaughn, Myer & Sweet, Consulting Engineers, Majestic Bldg., Milwaukee, in charge of all steam power plants, pumping, heating and ventilating work. I am an associate-member of the American Society of Mechanical Engineers.

Probably the most interesting feature of my work has been an extensive investigation for the State Board of Control of Wisconsin, of hot water heating and its appliances to groups of buildings more or less separated from each other, but all heated from a central power plant. The investigation was very favorable and I have designed a system of forced circulation hot water heating for each of the proposed new State Institutions. The Southern Home for Feeble Minded to be built at Union Grove, will comprise fifty-four buildings and require over 300,000 sq. ft. of radiation. The Industrial Home for Women to be built at Taycheedah, will have a smaller number of larger buildings. It is proposed to build fourteen buildings requiring about 100,000 sq. ft. of radiation.

In regard to matrimony I regret very much that I have nothing to say and no prospects for a favorable report in the near future.

I hope that these letters will be the means of starting a greater interest in looking up old classmates when in a strange city. I would be pleased to see more of the old class at any time.

Very sincerely,

LOREN L. HEBBERD, m e '11.

In compliance with your request I am making the following report to the class of 1911:

After leaving Madison in June, 1911, I headed straight for Rockford, Ill., my home town. There I had a position awaiting me as foreman of construction for the Rockford Interurban R. R. Co. But after some sad experiences in trying to put up concrete culverts with a pick, shovel, and foreigners, I "quit" to accept a position as instructor of applied mathematics in the Ohio Wesleyan University. While there I also obtained a position as assistant city engineer for Delaware, Ohio. I left the Ohio Wesleyan University feeling very rich—since I now had a wife and a big baby boy—to accept a position as instructor of mathematics in the Michigan Agricultural College, my present position. My summers have all been spent at the University of Chicago studying mathematics and astronomy. Incidentally I also manage to get in some time studying methods of obtaining approximate and accurate designs of tall office buildings.

Since leaving Madison, my "sky" has been clear most of the time, thanks to the training I received at Wisconsin. Though I am poor financially, I feel rich and happier than any millionaire, since I now have two children, a girl and a boy, to side track the worries of life. My sincere wish to the class of 1911 is always the greatest success and happiness.

Respectfully Yours,

WALTER A. REINERT.

The engineer presents the following list of books from which you may fill in your odd minutes. You will find them not heavy, specialized, or technical; but interesting, entertaining and broadening. They are recommended by our biggest engineers here at Wisconsin. Save this list and be sure that you are acquainted with a majority of the books which it names.

Addresses to Engineering Students	**Waddell and Harrington**
Engineering as Vocation	**McCullough**
Lecture Notes on Business Management	**Humphrey**
Adventures of a Civil Engineer	**Burge**
Autobiography of Sir Henry Bessemer	
Intellectual Development of Europe	**Draper**
Life of James Watt	**Carnegie**
Extracts from Chordal's Letters	**See**
Engineering Reminiscences	**Porter**
Floating Matter in the Air and its Relation to Health and Disease.	**Lyndall.**
General Lectures on Electrical Engineering	**Steinmetz**