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WATER HAMMER PROBLEMS SOLVED BY THE USE OF ALIGNMENT CHARTS

WATER HAMMER PHENOMENA REVIEWED WITH CHARTS FOR GRAPHICAL SOLUTION OF JOUKOVSKY'S AND ALLIEVI'S FORMULAE.

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THE use of alignment charts for the solution of problems in engineering has received considerable attention recently. Several articles showing the application of the alignment chart to problems in reinforced concrete, structural, machine design, hydraulics, etc., have appeared in the technical press, but as far as the writer knows, this is the first time the following formulæ for water hammer have been charted by this method. It is hoped that they may prove to be of some value to the engineer who has to deal with water hammer problems.

In order to make the curves more intelligible to those who are not well acquainted with the phenomena of water hammer and to whom the scattered literature on this subject is not immediately available a brief discussion of this phenomena will be given, followed by the generally accepted formulæ upon which the charts are based.

A bibliography of the important papers on this subject will be found at the end of this article.

When water is flowing through a pipe it contains a certain amount of kinetic energy in virtue of its velocity. If the velocity is changed the kinetic energy of the water must also change. If the flow of water is stopped by the quick closing of a gate, the kinetic energy of the water due to its velocity is changed to potential energy with a resulting increase in pressure in the pipe. This in turn is used up in stretching the walls of the pipe and in compressing the water. This increase in pressure is termed "water hammer."

"Maximum water hammer" and "ordinary water hammer" are both covered by the accompanying charts. Chart No. 1 for maximum water hammer, Chart No. 2 for ordinary water hammer respectively.

In order to obtain the conditions for maximum water hammer it is necessary that the time of gate closure be less than the critical time $\frac{2L}{a}$, that is, the time necessary for the pressure wave to travel from the gate to the reservoir and back. It might also be well to note that the excess head in the formula for maximum water hammer ($h = \frac{Va}{g}$) is independent of the length of the pipe, but directly proportional to the extinguished velocity and to the velocity of propagation of the pressure wave.

Maximum Water Hammer.—The only complete analysis of maximum water hammer is to be found in a paper by Prof. Joukovsky, published in 1897. The following description of this phenomena is taken bodily from O. Simin's translation of Prof. Joukovsky's paper, which was published in the proceedings of the American Waterworks Association, 1904.

In Fig. 1 let A B be a pipe, in which water flows with velocity, V, from the origin, A, past the gate, B. If, now, the flow is suddenly stopped by a rapid shutting of the gate, B, the kinetic energy of the water column A B will cause an increase of pressure in the pipe.

Let us consider the column of water, A B, as divided into *n*, very small, equal sections, 1, 2, 3—(*n*-1) and *n*.

The phenomena of water hammer takes place in a series of cycles, each consisting of four processes, as follows:—

(1) Section 1, meeting in the gate, an obstacle to its movement, will be compressed and will stretch the pipe wall surrounding it. All the kinetic energy of this section of water will be used up (*a*) in its own compression, resulting in the increase of pressure by an increment, P, and (*b*) in the corresponding stretching of the walls in section 1 of the pipe. As a result of this action, section 1 of the water column has left vacant behind itself a small space, to be occupied by a part of the next arriving section 2. Consequently it is only after section 1 has been stopped and compressed, and after the small space thus left has been filled, that section 2 can be arrested and compressed.

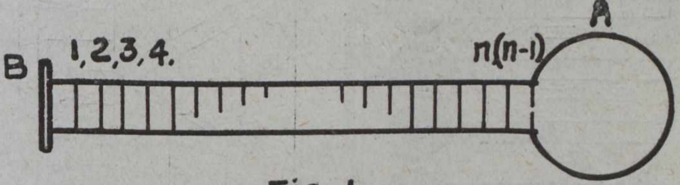

Fig. 1

Now the kinetic energy of section 2 must be expended in some way. Will it increase the pressure upon the gate, which has already been caused by the arrest of section 1? No, and for the following reason:

The pressure upon the gate depends entirely upon the pressure, P, sustained by section 1 which is now in static condition.

The pressure upon the gate could therefore be increased only if section 1 could be further compressed, and this could take place only if the pressure upon the surface between it and section 2 (which we may imagine to be a thin piston) could be greater from the side of section 2 than it is from the side of section 1; and this is impossible because section 2 has only the same kinetic energy as section 1, and this energy will (as in the case of section 1) be used entirely in compressing the water of the section (section 2) only to the same additional pressure, P, and in stretching that part of the walls surrounding section 2.

The same is true of each following section 3, 4,—$(n-1)$ and n; each of these sections, as it is arrested, being compressed to the pressure P.

During process (1) a small quantity of water flows from the reservoir into the pipe, to occupy the space formed by the compression of the water and the extension of the pipe walls. Finally, when all the sections have been arrested, the entire column will be under pressure, P. The entire energy of the water column is now stored (as potential energy) in elastic deformation, *viz.*, in the compression of the water column and in the extension of the pipe walls.

But this condition cannot be maintained: for (2) as soon as the additional pressure, P, has been produced in the last section, n, the water in that section will again expend, and the walls of that section of the pipe will again contract, restoring the original conditions in that section and pushing the water of that section back into the reservoir from which the pipe issues, and restoring the original normal pressure in section n.

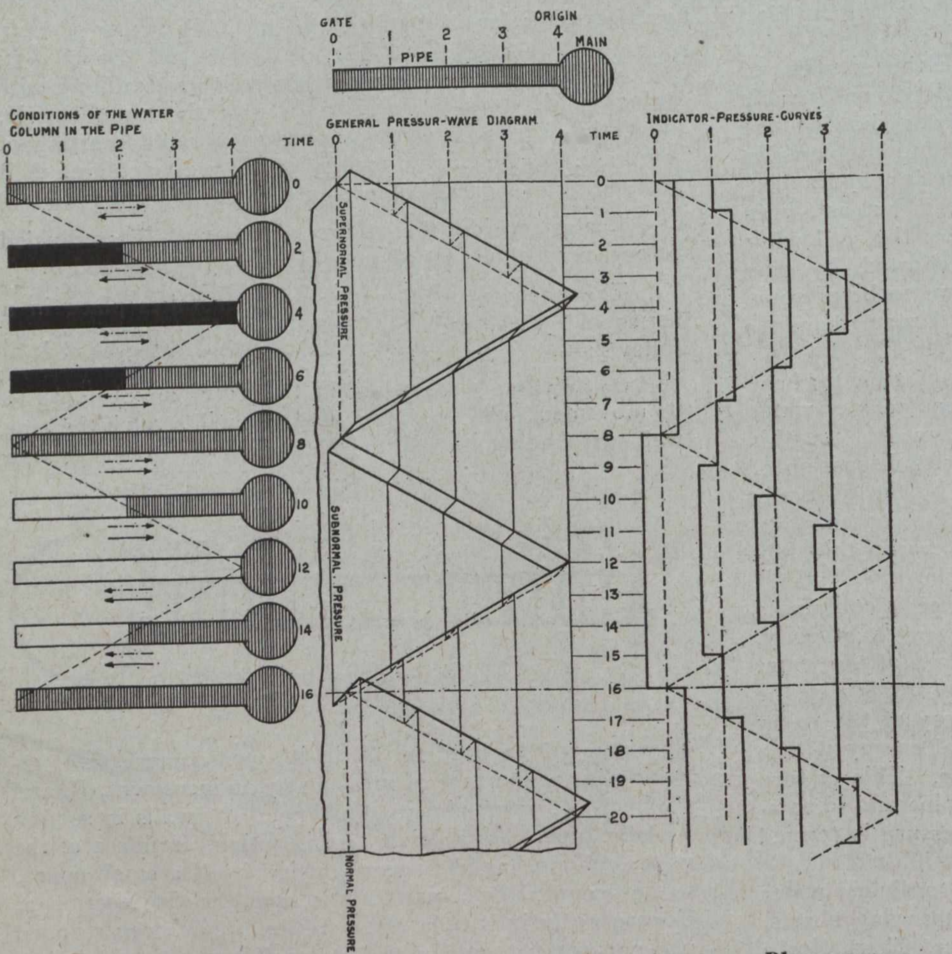

Fig. 2.—Diagrammatic Representation of Water Hammer Phenomenon.

This operation will now be repeated by each section $(n-1)$—4, 3, etc., in turn, until all the potential energy stored in the water column when it was under the pressure, P (neglecting the portion, lost in friction), has been reconverted into kinetic energy.

During process (2) the water which entered the pipe during process (1) is forced back into the reservoir. The condition of the water column is now what it was just before the gate was closed, except that its velocity, v, has now the opposite direction, *i.e.*, toward the origin.

(3) The kinetic energy of the water column, moving toward the origin or away from the gate, is now reconverted into potential energy, which manifests itself in an extension of volume of the water to a subnormal pressure,* beginning with section 1 and concluding only when the entire water column has been reduced to the subnormal pressure.

(4) When the subnormal pressure has been established throughout the length of the pipe, and all the water has come to rest, the water from the reservoir will again direct itself into the pipe, restoring the normal pressure, first in section n, next to the reservoir, and then, in rapid succession, in the other sections $(n-1)$—4, 3, etc., until, when the normal pressure reaches the gate, we have once more the conditions which existed just before the gate was closed, *viz.*, the normal pressure is restored and the water is moving toward the gate with the original velocity, V.

We have now followed these pulsations of pressure (with the accompanying transformations of energy and flow of water into and back from the pipe) through a complete cycle of four movements, each extending through the length of the pipe. For convenience, we may consider two successive movements of the kind as a "round trip" through the pipe.

The gate remaining closed, the whole process is now repeated in a second cycle, which, in turn is followed by a third, and so on, the amplitude of the pressure vibrations gradually diminishing (because of friction) until the pipe and the water come to a state of rest.

But although the intensity of the pressure becomes gradually less, the time required for each cycle remains constant for all repetitions. This propagation of pressure, consisting of its transmission through all points of the length of the pipe, each point successively repeating the same periodical movements, is in its nature, simply a case of wave motion, like that of a sound wave.

The velocity of wave propagation is independent of the intensity of the pressure, and depends only upon the properties of the medium through which the propagation takes place—in the case of water hammer, upon the elasticity of the water and of the pipe.

We now find that the time required for each cycle of pressure transmission (including two round trips through the pipe) is equal to $\frac{4L}{a}$, where L is the length of the pipe and a is the velocity of wave propagation. This is the period of an entire pressure vibration in every point of the pipe.

A general diagrammatic representation of the principles of water hammer, as just described, is given in Fig. 2. Here we see on the right, pressure curves corresponding to the different points of the pipe indicated at the top. On the left of Fig. 2 the conditions of the water column

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*During process (3) water continued flowing from the pipe into the reservoir.

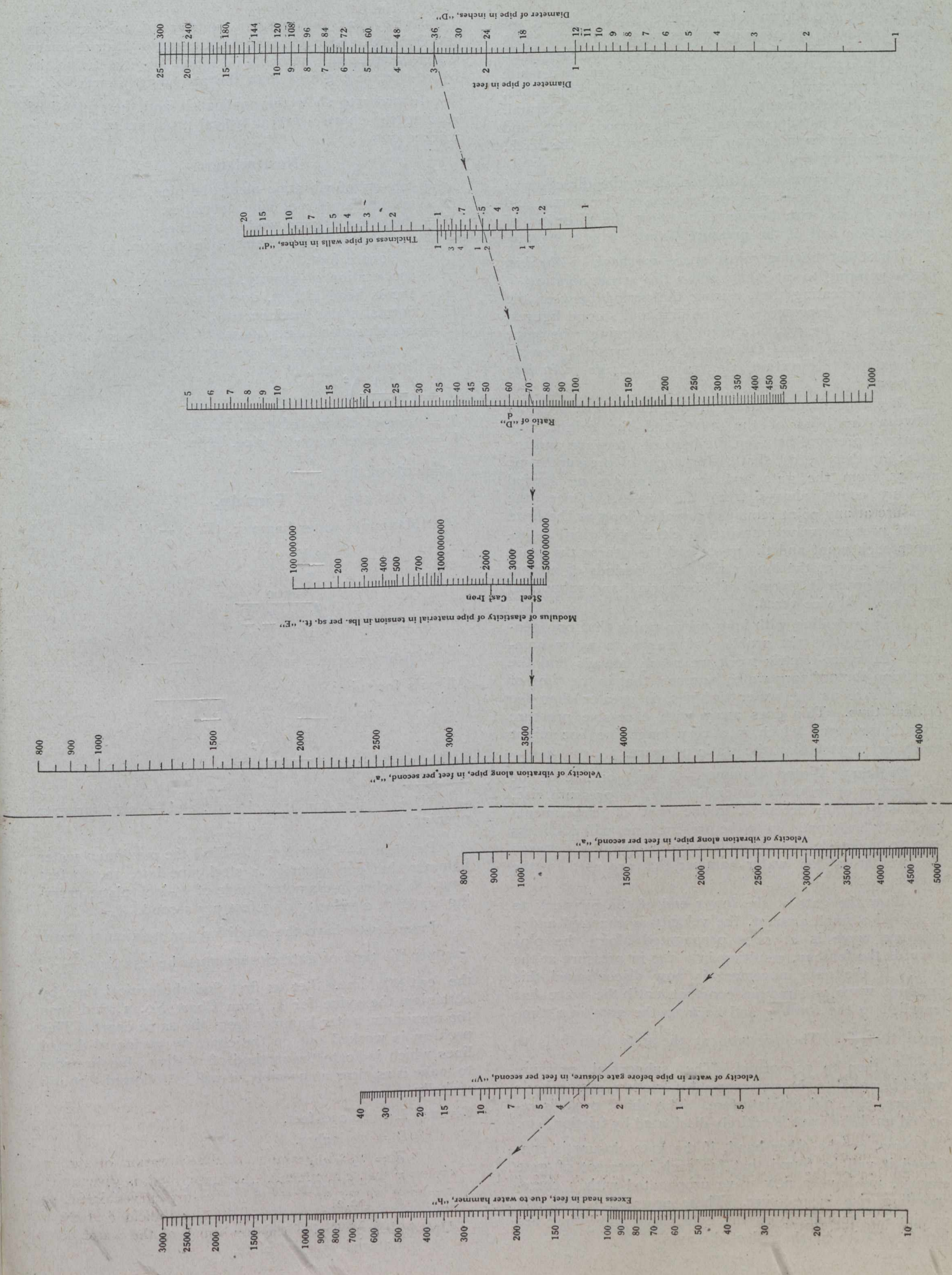

Chart No. I.—Maximum Water Hammer.

in the pipe are shown at different instants during the propagation of the pressure waves back and forth along the pipe, sections under supernormal, normal and subnormal pressure being indicated by black, gray and white shading respectively. To the right of the diagonal lines, crossing these sections, the pressure is always normal. To the left it is supernormal, in the second, third and fourth section from the top, and subnormal in the sixth, seventh and eighth.

Arrows drawn with full line show the direction of the water flow from reservoir to pipe or vice versâ, and arrows drawn with broken lines show the direction of propagation and of the pressure wave.

Thus, in the uppermost space we have a *broken* arrow pointing to the *right*, and a *full* arrow pointing to the *left*, indicating that, during the period between the two moments represented by the first and second figures, respectively, the *pressure wave* is traversing the pipe *from the gate toward the origin*, while *water* is flowing in the opposite direction, *viz.*, *from the large main into the pipe*.

It will be noticed that we always find *normal* pressure between the head of the wave and the *origin*, and *abnormal* pressure between the head of the wave and the *gate*; in other words, that disturbances of pressure come always from the gate and the restoration of normal pressure comes always from the origin. Hence, the pressure at any point remains normal so long as the head of the pressure wave (moving in either direction) is between such point and the gate; and the nearer the point is to the origin, the longer will be its periods of normal and the shorter its periods of supernormal and subnormal pressure, and vice versâ.

It is in dealing with long water mains that one generally encounters the problem of maximum water hammer. In hydro-electric work we nearly always find the condition for ordinary water hammer, that is the time of gate closure on the water turbines, is greater than the critical time. This does away with excessive pressure rises in penstock which in a very long pipe line might easily be greater than the static pressure.

Ordinary Water Hammer.—A brief outline of the phenomena of ordinary water hammer, or pressure rise, as it is generally accepted, in the light of experiments that have been made up to the present time, will doubtless help to make clearer the difference in meaning between the two terms for water hammer that are used on the charts.

Allow the gate at the lower end of the penstock to be closed a small amount, the velocity is changed and a pressure wave is at once propagated along the pipe towards the forebay, resulting in a rise in pressure at the gate. If the gate movement is now discontinued this pressure wave will remain constant until the wave has travelled to the forebay and back to the gate in a time equal to $\frac{2L}{a}$. The pressure at the gate then falls to normal, then to subnormal. The subnormal pressure would be equal to the supernormal if friction, atmospheric pressure, etc., did not interfere. The above cycle is repeated until the wave is entirely dissipated by friction, etc.

Now, on the other hand, if the gate closure is continued it will be found that for each increment of gate closure, we have a new wave propagated with a corresponding rise in pressure. These pressure waves will continue to mount up as the gate closes until they are interfered with by the reflected waves.

As by far the greater number of pressure rise problems fall under this heading, Chart No. 2 for ordinary water hammer will probably be found more useful to the hydro-electric engineer than the preceding Chart No. 1.

In order to show the application and the method of reading the charts, several typical problems will now be worked out.

Nomenclature.

a = velocity of vibration along the pipe, in feet per sec.
D = inside diameter of pipe, in inches.
d = thickness of pipe walls, in inches.
E = modulus of pipe material in tension, in lbs. per square foot.
g = acceleration of gravity, taken as 32.2.
h = excess head in feet, due to water hammer.
H = normal static head, in feet.
K = modulus of elasticity of water in compression taken as 42,400,000 lbs. per square foot.
L = length of pipe, in feet.
$N = \left(\frac{LV}{gTH}\right)^2$.
T = time of closing of gate, in seconds.
V = velocity of water in pipe, in feet per second.
T_0 = critical time, $\frac{2L}{a}$

Formulæ.

"Maximum water hammer, $(T < \frac{2L}{a})$"

$$h = \frac{aV}{g}$$

$$a = \frac{4660}{\sqrt{1 + \frac{K}{E}\frac{D}{d}}}$$

"Ordinary water hammer $(T > \frac{2L}{a})$ —"

Allievi's formulæ:

$$^*h = \frac{NH}{2} \pm H\sqrt{\frac{N^2}{4} + N}$$

$$N = \left(\frac{LV}{gTH}\right)^2$$

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*Use + sign for gate closure, and — sign for gate opening.

Problem 1—Chart No. 1.—Find the maximum water hammer that can occur in a steel pipe line, 10,000 feet long, 36 inches in diameter, made of ½-inch plate, carrying water at a velocity of 3 feet per second.

In order to have the condition for maximum water hammer the time of gate closure must be less than $\frac{2L}{a}$, the critical time. Let us first find the critical time by obtaining the value for a, from Chart No. 1, and then the maximum water hammer from the same chart. This problem is worked out on the chart by means of dotted lines which indicate the method of reading; but in order to make it as clear as possible, it will be followed through verbally.

Given: L = 10,000 feet.
D = 36 inches.
d = ½ inch.
E = 4,000,000,000 pds. per square foot.
g = 32.2.
V = 3 feet per second.
Material = steel plate.

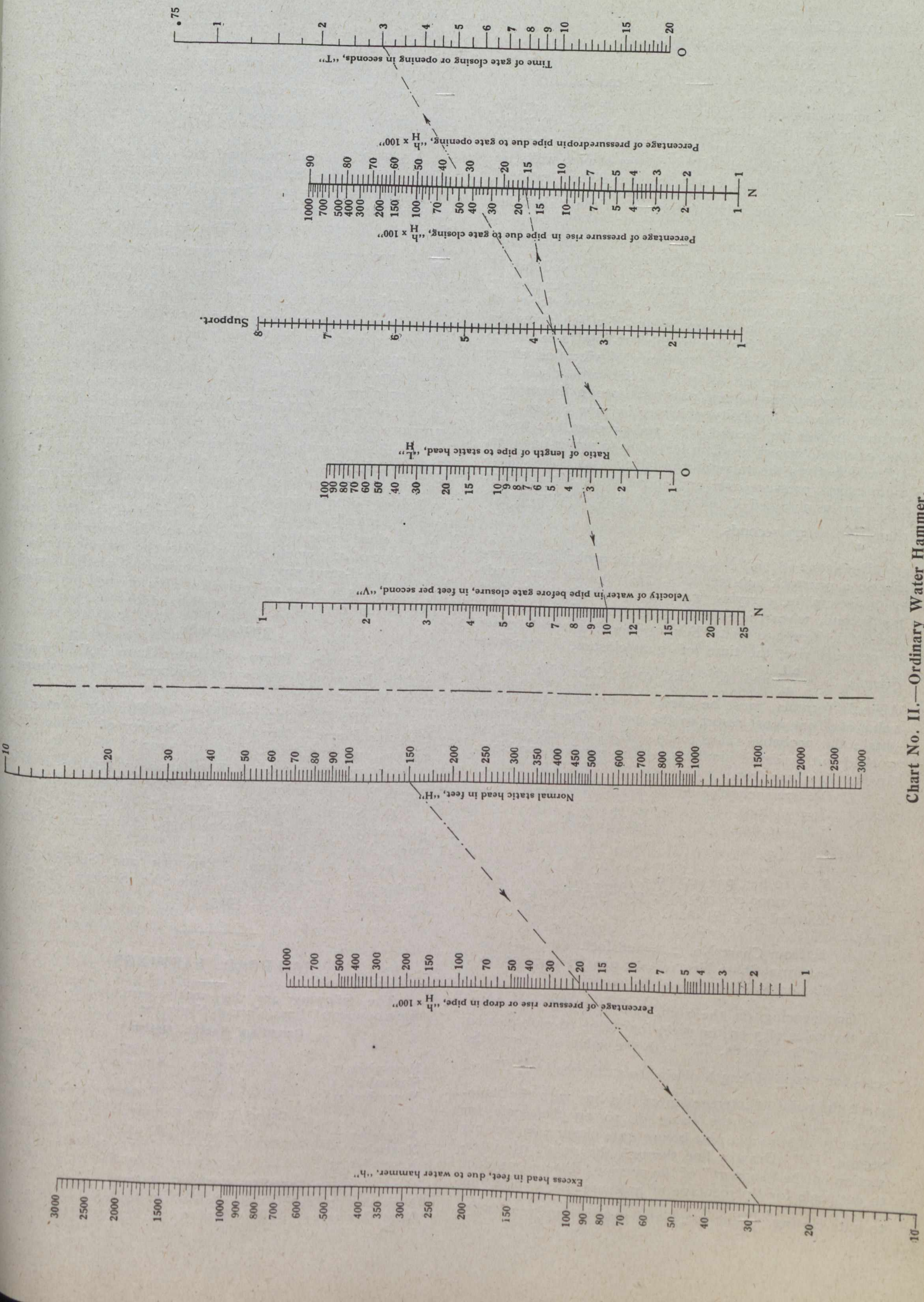

Chart No. II.—Ordinary Water Hammer.

Find from Chart No. 1—

$a = 3{,}504$ feet per second.

$h = 331$ feet.

Critical time $T_0 = \frac{2L}{a} = 5.7$ seconds.

Commencing on the right-hand side of the chart, we find on the scale for "diameter of pipe in inches, D," the value 36. From this value of 36 pass a line through value, ½ inch on the scale of "thickness of pipe walls, in inches, d," and produce line to cut scale for "ratio of $\frac{D}{d}$," which gives the value 72 for $\frac{D}{d}$. From this value of 72 on the scale for "ratio of $\frac{D}{d}$," draw a line through the value of 4,000,000,000 on the scale for "modulus of elasticity of pipe material in tension, in pds. per square foot, E," and produce to cut the scale for "velocity of vibration along pipe in feet per second," which gives the value 3,504 for a. Now go to the left-hand side of the chart, and on the scale for "velocity of vibration along the pipe, in feet per second, a," find the value 3,504, and from this point draw a line passing through the value 3 on the scale for "velocity of water in pipe before gate closure, in feet per second, V," and produce line to cut the scale for "excess head, in feet, due to water hammer, h," which gives the value of 331 feet. This is the maximum excess pressure over and above the static pressure that can be obtained if the time of gate closure is less than $\frac{2L}{a}$, or 5.7 seconds.

Problem 2—Chart No. 2.—Find the probable pressure rise in a penstock 240 feet long, 72-inch diameter, made of ½-inch plate, carrying water at a velocity of 10 feet per second, when the time of gate closure is 3 seconds, and static head 150 feet. For ordinary water hammer or pressure rise, the time of gate closure, T, must be greater than $\frac{2L}{a}$ and for this case Chart No. 2, for Allievi's formula, must be used. In order to check the value of T one must resort to the use of Chart No. 1, to obtain the probable value for a. This problem will be worked out in detail similarly to the previous problem.

Given: $L = 240$ feet.

$D = 72$ inches.

$d = \frac{1}{2}$ inch.

$H = 150$ feet.

$\frac{L}{H} = 1.6$.

$V = 10$ feet per second.

$E = 4{,}000{,}000{,}000$ pds. per square foot.

Material = steel plate.

Find—

h, from Chart No. 2, = 28 feet.

a, from Chart No. 1, = 2,950 feet per second.

T_0, critical time, = 0.163 seconds.

Commencing on the right-hand side of the chart, join the value of 3 on the scale for "time of gate closing or opening in seconds, T," with the value of 1.6 on the scale for "ratio of length of pipe to static head, $\frac{L}{H}$," and mark the point of intersection of this line with the "support." Next, find the value of 10 on the scale for "velocity of water in pipe before gate closure, in feet per second, V." Draw a line through the point of intersection on the "support" of the previous line and produce to cut scale for "percentage of pressure rise in pipe due to gate closing, $\frac{h}{H} \times 100$," and read the value of 18.5. Now go to the left-hand side of the chart, and from the value of 150 on the scale for "normal static head, in feet, H," draw a line passing through the value of 18.5 on the scale for "percentage of pressure rise or drop in pipe, $\frac{h}{H} \times 100$," to intersect the scale for "excess head, in feet, due to water hammer, h," and read the value 28 feet for h.

Chart No. 2 will be found useful for solving many problems in hydro-electric work. For instance, Mr. Wm. F. Uhl in his paper on "Speed Regulation in Hydro-Electric Plants," published in the proceedings American Society of Mechanical Engineers, 1912, uses the value of $\frac{h}{H} \times 100$ (percentage of pressure rise or drop), in his formulæ for speed variation. The above chart is therefore applicable to the formulæ found in this paper.

The value for pressure drop obtained from Chart No. 2 may be used for checking up pipe lines with long, flat gradients at the upper end, in order to see that the head necessary for accelerating the water for various times of gate opening is kept less than the static head on the pipe at every point. This will avoid any chance of inward pressure which might cause the pipe to collapse.

In dealing with pressure rise in wood-stave pipes the correct value for E (modulus of elasticity of pipe material, in pds. per square foot), to use in obtaining the value of a (velocity of vibration along the pipe, in feet per second), would logically appear to be that for steel, as the steel bands alone resist the water pressure. In order to figure the value of a, it would seem consistent to assume in place of the wood-stave pipe a steel pipe made of plate, of such thickness as to have an equivalent area of steel per lineal foot as that contained in the steel bands.

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RAILROAD EARNINGS.

The following are the weekly earnings of Canada's transcontinental lines during November:—

	1916.	1915.	Increase.
Canadian Pacific Railway.			
November 7	$3,036,000	$3,015,000	+ $ 21,000
November 14	3,051,000	3,035,000	+ 16,000
November 21	2,984,000	2,960,000	+ 24,000
Grand Trunk Railway.			
November 7	$1,244,959	$ 986,765	+ $258,194
November 14	1,283,901	971,715	+ 312,186
November 21	1,202,291	935,884	+ 266,407
Canadian Northern Railway.			
November 7	$ 885,000	$ 806,500	+ $ 78,500
November 14	825,100	820,800	+ 4,300

SUB-DRAINAGE OF WET CUTS WITH VITRIFIED TILE.*

By **W. C. Curd,**
Drainage Engineer, Missouri Pacific Railway System.

BETWEEN years 1905 and 1911 extensive use was made of vitrified tile for draining water pockets and wet cuts on the Missouri Pacific System. During this period approximately 714 locations were worked in the following States: Kansas, 417; Missouri, 180; Arkansas, 80; Colorado, 21; Oklahoma, 10; Nebraska, 4; Louisiana, 2.

Of this total about 79 locations or 11 per cent. were reported as failing to give benefits, with but two causes of failure assigned: (1) Tile not placed to sufficient depth; (2) tile not placed in proper location.

On this account and to determine the value of tile drainage for roadbed, an investigation was made of all the territory which had been previously worked.

In the conduct of the investigation locations were selected for examination where grade, soil, rainfall and other conditions widely varied. At seventy locations the drains were uncovered at two or more points and examined for line, grade and signs of clogging. In the stretches of track inspected the drains varied from 100 to 3,000 feet in length and were at depths of from three to seven feet below base of rail.

The investigation showed a remarkable benefit to have been derived through the strengthening of roadbed where drains had been properly installed and estimates made from most reliable information obtainable indicate a return of from 50 per cent. to 200 per cent. per year in the decreased cost of maintaining line and surface on the short pieces of track which were drained.

The failures reported were found to be due principally to improper installation, particularly with reference to depth of drain to the moving material in the roadbed. In these locations many of the drains were forced to the surface and completely filled. In those locations examined where proper methods of installation had been followed, the line and grade of tile was intact and entirely free of sediment or evidences of clogging.

The data gathered in the investigation dispels much of the doubt previously existing both as to the permanency of the drains and the benefit derived from them.

Generally speaking, the writer does not believe it can be found that tile drains will produce a direct saving in dollars and cents in track maintenance, but the benefit would seem to lie in the development of more efficient track in locations where it was formerly found to be impossible to maintain good track. The benefit comes from the removal of slow orders and a more even distribution of the time of the section forces over their territory. In some cases it has resulted in an actual decrease of section forces, but this is an exception rather than a rule.

The necessity for tiling cuts comes from neglect to provide and maintain adequate surface drainage. The change is gradual and is not always noticeable until we are confronted with the result. Just as efficient if not better track could be developed if cuts were projected by intercepting and side ditches properly constructed and maintained, but tile seems to afford the only practical relief where the roadbed has become water soaked and too soft to sustain the loads.

Conclusions drawn from our experience indicate if tiling be installed in accord with the following requirements, the greatest permanency and benefit will be assured:—

Drains should be laid with bell-end, vitrified salt-glazed sewer pipe of minimum diameter of 6 ins., with unsealed joints.

The top of tile should be placed one foot below frost line and a minimum distance of one foot below unstable or moving material. Depth in each case should be carefully determined by test holes or inspecting excavation.

Tile should be laid to grade established by level and with all fall obtainable.

Location of centre line of tile should be parallel to and from 4 ft. 6 ins. to 7 ft. from centre line of track.

Tile should be placed directly on bottom of trench. After it is laid to line and grade, and before backfilling, it should be covered with straw, grass or some such material to prevent loose particles in backfilling from entering the joints.

Trenches should be backfilled with cinders, with coarse material placed directly around and over the tile. Where walls of trench show signs of distortion from passing loads, sufficient quantity of riprap or coarse stone should be mixed with the cinders to brace the walls.

Pockets under track should be tapped with cinder-filled lateral trenches, and connected into tile drain trench, but without connection with tile drain except through the unsealed joints.

Remove all surface water from cuts by intercepting and side ditches, otherwise tile drain may be overtaxed and eventually fail entirely.

After drains have been installed it is essential to maintain free outlets to prevent backing water into tile.

The ends of drains should be surrounded and supported by concrete or dry masonry to guard against underwash.

To prevent small animals from entering tile, the outlet should be protected by rods or grating.

Failures of drains come from the following causes:—

Insufficient depth below moving material.

Shifting grade or alignment causing joints to open.

Insufficient grade to provide proper flow.

Location of drain in impervious material without providing adequate means for tapping saturated material with lateral drains or cross-trenches.

Distortion of walls of trenches.

Tile drainage is not a panacea for all wet cuts and its use is not recommended without a complete knowledge of the conditions to be corrected. When these are known and proper methods of installation are applied, much benefit is reasonably sure to follow.

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*Bulletin of the American Railway Engineering Association.

COBALT ORE SHIPMENTS.

The following are the shipments of ore, in pounds, from Cobalt Station for the week ended November 24th:—

Temiskiming Mining Company, 78,677; La Rose Mine, 87,345; Dominion Reduction Company, 174,000; McKinley-Darragh-Savage Mines, 162,332; Nipissing Mining Company, 302,135. Total, 804,489 pounds, or 402.2 tons.

The total shipments since January 1st, 1916, now amount to 29,262,568 pounds, or 14,631.2 tons.

CITIZEN CO-OPERATION IN GOVERNMENTS.*

THURSDAY evening last, November 30th, about sixty members of the Engineer's Club of Toronto sat down to dinner. After dinner had been served, Dr. H. L. Brittain, director of the Bureau of Municipal Research, Toronto, delivered a most instructive address. Inasmuch as many of his audience in the course of their professional work are thrown more or less into personal contact with governing bodies of all kinds, the following extracts from Dr. Brittain's address will be read with some interest:—

In the last analysis a government is simply a committee of the citizens appointed to do for the citizens as a whole what each citizen cannot do efficiently for himself.

Such a committee is in the nature of a board of directors, non-professional in character, but in control of work which must be carried out directly by professional men of various sorts. The chief problem of government is expressed in these two questions:—

1. How can the governing board supervise and control effectively the work of its specialists?

2. How can citizens control their boards of directors and make sure that they are getting done the things they were appointed to get done within the expenditure made available for the purposes?

If it were enough for citizens to say to one of its governing committees, "We want these things done. Here is the necessary money. Change this money into service"; if such committees responded by saying, "We accept the trust, fellow citizens. We shall spend this money to buy these services which you will begin to enjoy in the shortest time possible"; if performance always followed such promises; if governing committees said to their experts, "Here is so much money, with which we expect you to produce such and such services to be available within such and such a time"; and if experts always produced the goods, at the stated time, within the stated expenditure, government would be a simple process. . . .

A machine built of homogeneous materials can be depended on to do the work for which it is designed. A human machine cannot be constructed of homogeneous materials. Men are neither like one another nor like themselves. Men are neither homogeneous in time or space. Consequently when a human governing device is instituted you can't tell either how it is going to work at the start, or how long it will work after it has started. Again, pieces of a physical machine have no wills of their own. They stay put. Their wills, so to speak, form parts of the will of the whole machine. With a human machine, on the other hand, each human cog may desire and will desire something fundamentally different from the purpose of the machine. He may run in line with the general purpose one week and jump the track the next, according to the influences brought to bear on his action from the inside of his own heart, personal interests, or from the human world outside, often class and sectional interests. The human equation in government, as in engineering, is an unknown quantity. . . .

The only possible way which has yet been found to secure effective governmental action is to simplify the machinery to the greatest extent possible, reducing friction and liability of breakage while immersing every part in the lubricant of enlightened public opinion.

The citizens can control their governing committee only by defining its duties, giving complete liberty of action within the sphere of these duties, securing continuous reporting on the official acts of their committee and by continuous co-operation therewith through continuous constructive criticism and suggestion.

In the same way governing committees can control and supervise their executive specialists not by narrowly limiting their powers, periodically hauling them over the coals and humiliating them, but by giving them great responsibilities and powers adequate to those responsibilities, and requiring from them for the use of the committee and the public continuous reports of their work, such as have never yet been given to the Canadian public save sporadically. . . .

Scientific societies can be of immense service in the development of simple, direct, lucid and forcible reporting technique for every branch of community service. . . .

A second great force which can be exploited in the interests of efficient government lies in the immense amount of technical knowledge and specialized skill in the great body politic which has never been harnessed up to the work of government. I believe the time is not far distant when the head of every large department in every large city will have as a regular adjunct of his organization an advisory or consultative board appointed by himself from men skilled in the arts and learned in the sciences which are most closely related to the work of his department. I believe it will also come to pass that members of professional societies will come to regard it as a distinct honor and a worthy outlet for social instincts to be connected with such boards. . . .

As a preliminary step to the building up of advisory boards, I believe that all professional clubs and citizen organizations, no matter what their main purpose, should have a live civics committee which should be a clearing house for information as to civic affairs and should pass on important information and suggestions to other private organizations and to the city council or heads of departments. Complete information and intelligent suggestion never hurt anyone except someone who deserved to be hurt. The Bureau of Municipal Research would welcome the opportunity to co-operate with such committees wherever formed. In the field of engineering particularly the Bureau could add greatly to its usefulness were it in a position to tap the reservoir of technical skill and experience represented in this organization which I have the honor to address.

HYDRO RADIAL AND BOND ISSUES.

By-laws are to be voted upon by the various municipalities for the proposed hydro radial line from Port Credit to St. Catharines at the beginning of the year. The cost of the line from Port Credit to St. Catharines is estimated at $11,360,363. Of this Hamilton is asked to bear $5,869,286; the township of Saltfleet, $1,002,296; Barton, $284,484; East Flamboro', $266,626; and West Flamboro', $66,669. The rest is divided among the other townships, towns, villages and the city of St. Catharines, its share being $623,750.

The amounts of the bonds to be issued by the respective municipalities for deposit with the Ontario Hydro-Electric Commission are as follow, and total $11,360,363:—

Townships—Toronto, $243,087; Trafalgar, $538,735; Nelson, $374,812; East Flamboro', $266,626; West Flamboro', $66,669; Barton, $284,484; Saltfleet, $1,002,296; North Grimsby, $424,077. Clinton, $473,746; Louth, $563,595; Grantham, $128,280. Villages—Grimsby, $101,817; Beamsville, $51,469. Towns—Oakville, $203,098; Burlington, $144,536. Cities—Hamilton, $5,869,286; St. Catharines, $623,750.

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*Abstracts of an address delivered before the Engineers' Club of Toronto by Dr. H. L. Brittain, Director of Bureau of Municipal Research, Toronto.

ONTARIO FOREST PROTECTION SYSTEM.*

THE part played by the Canadian Forestry Association in relation to the Ontario forest protection system has had as its object the educating of public opinion upon the value of the forest possessions and the wisdom of guarding them against the waste of fire. Such questions as the extent of forest fire losses, the dependence of forest industries upon accessible and abundant supplies, the profitable results of modern patrol systems, the commonsense of the "permit plan" for controlling settlers' clearing fires, all required discussion and in affording the means for this we aimed to bring the people to intelligent conclusions as to their existing forest laws and administration.

The effect of the educational campaigns has been to stimulate public conviction and to provide necessary support for this government in adopting an advanced policy. We come before you to-day not to emphasize what we believe are the shortcomings of the system which has been inherited from previous governments but to assure the Minister of Lands, Forests and Mines of our full confidence in his desire to give Ontario the most useful plan of forest protection that can be devised. We congratulate him upon the investigations he has set in motion for the securing of full information, and do not doubt that the new basis of organization for forest protection purposes will bring the province of Ontario within reasonable reach of its great responsibilities.

Neither to the members of the government, nor to other sections of this deputation is it necessary to emphasize the high importance of the timber resources in sustaining the commercial vitality of the province. Fully 50 per cent. of the total geographical area is non-agricultural and can produce profit only if held under timber crops for all time to come. To such a proposal none can take objection. The demands of forest perpetuation collide at no point with any other constructive interest. The requirements of conservation insist that agricultural crops shall take precedence on agricultural land, and that forest crops shall be retained where the plow cannot make a profit.

This essential partnership of Ontario's forests with agriculture and manufacturing has long been threatened with catastrophe. While the province possesses over 70,000,000 acres of timber lands, their value must be gauged by their accessibility, and it is not to be disputed that the productiveness of non-agricultural lands has been materially lessened by the ravages of fire. It is also noteworthy that the original estimates of Ontario's merchantable timber are now regarded as exaggerated. The term "inexhaustible" has switched to a very opposite meaning.

Two considerations, thereby, are presented: The forest possessions represent, with agriculture, the mainstay of provincial prosperity. They account for a great distribution of created wealth—$40,000,000 in the lumber crop alone—and for a heavy total of employment. They stand in support of farm and factory, and in the event of their exhaustion Ontario's commercial existence would be jeopardized. Forests on the watersheds ensure the value of scores of our streams for navigation and power purposes and for the purity of water supply. They return to the provincial treasury every year in dues, rents, etc., from lumbering operations from $1,500,000 to $2,000,000 to help bear the cost of public administration.

That these vast advantages of forest assets should be preserved and developed, not only for this but for succeeding generations, few will dispute. That the pace of forest destruction by fire is unworthy of further toleration seems quite as elementary and reasonable to all acquainted with the success of protective organizations in some parts of Canada and the United States.

The position taken by the Canadian Forestry Association in regard to the present organization and administration of the Ontario Forest Service may be here summarized—

The Ontario Fire Ranging Service, entrusted with the care of more than 70,000,000 acres of timber lands, has no executive head, concerned exclusively in forest protection. To secure proper management of the large field forces, there is required a chief who has had wide experience in forest protection work and who is imbued with progressive ideas. This chief should be assisted by an adequate staff of competent inspectors. The appointment of such governing officials is the first and most vital step in the improvement of the present system. To be effective, their appointment should carry wide authority to reinforce the present means of fire prevention. In the hands of the chief officer should rest the engagement of rangers and inspectors, the extension of such permanent improvements as trails, telephone lines, lookout towers, fire-fighting equipment, and other absolutely necessary machinery which at present is confined to a very small percentage of the area urgently in need of protection.

With the right man in charge of forest protection work and assuming that he is given a free hand and sufficient appropriations, there is every reason to believe that the forward policy would preserve the province not only from periodical disasters to settlers' lives, and improved property, but avert the great losses in timber and young growth which are hastening the province toward an end of its accessible wood supplies. We are not convinced that any additional administration expense over the present outlay is immediately necessary, but were it found so the people of Ontario would surely approve such expenditure. The immediate problem is to secure full value for the money now being spent on this work. Nothing is more certain than that a radical change in organization is absolutely necessary in order to accomplish this object.

Apart from the necessity of establishing head office control of the protective work, the need for radical changes in the field arrangements is urgent. Present arrangements invite extravagance and inefficiency.

On the licensed lands of approximately 10,000,000 acres, the Ontario licensees are paying over twice as much per acre for fire protection as their neighbors in the privately administered areas of Quebec, yet the latter are as a whole unquestionably enjoying superior protection. On the 12,000 square miles of the St. Maurice Forest Protective Association during 1916 only one fire was traced to human hands and the total timber losses were $1,245 for all merchantable timber and young growth, and $3,500 for fires on cut-over lands. On the 12,000 square miles of the Lower Ottawa Forest Protective Association the 1916 experience was almost as good.

Undoubtedly the record of the Quebec associations as to low cost and efficiency is due largely to the co-operative plan under which they have abolished the serious over-lapping and patchy organization inevitable wherever each limit holder works independently of his neighbors. However, the great weapon of the Quebec licensees in fire reduction has been the settlers' permit law, which Ontario has yet to adopt. Furthermore, we submit that

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*Memorandum of Canadian Forestry Association presented before the Hon. G. H. Ferguson, Minister of Lands, Forests and Mines, of Ontario, Nov. 28th, 1916.

the close organization of the Quebec licensees co-operative patrol systems might reasonably be initiated and encouraged by the Ontario Department of Lands and Forests, with substantial saving to the licensees, and a reduction of the annual timber losses. As matters stand at present, not only are the timber berths helpless against the inroads of settlers' fires, but the work of the rangers is disjointed and wasteful for lack of co-ordination.

A system of close supervision of the rangers by government inspectors would secure improved results from the machinery in operation. Yet the department employs only eight supervisors to cover 286 men on the timber berths, extending over 10,000,000 acres. The task of supervising with such a small force is manifestly impossible, nor do many of the field men seriously pretend that any really adequate inspection of the work can be maintained on this meagre basis. One inspector to about ten men is the ratio which modern forest services recognize as a desirable proportion. Ontario's ratio on timber berths is one inspector or supervisor to 36 men.

The situation on unlicensed Crown lands demands a direct reversal of the present policy of virtual abandonment to fire. The Dominion Forestry Branch estimates that Ontario has 70 million acres of land containing more or less merchantable timber, in addition to very large areas which have been rendered unproductive on account of muskeg, repeated fires, climatic conditions, etc. Excluding the preserves, parks and timber limits there are probably 50 million acres of lands chiefly valuable for forest purposes. Repeated fires have wrecked great areas and in many instances have turned thousands of acres into permanent barrens. It is noteworthy in this connection that the area of timber berths is decreasing year by year, thereby transferring additional territory to the total of unlicensed forest lands. On the 50 million acres unalienated from the Crown in any way or abandoned by limit holders, Ontario placed in 1915 one hundred and seven rangers, an average of one ranger to cover 450,000 acres. Few will contend that the unlicensed lands can be as closely patrolled as licensed lands, but the obvious necessities of keeping fire out of the province's great reserve of timber and pulpwood lands cannot be served by a staff of 107 loosely inspected patrolmen.

Within the forest system of Ontario itself lies corroboration of the criticisms we have offered. While the government has done nothing on licensed or unlicensed lands in building up mechanical equipment such as trails, telephone lines, and lookout stations, it has permitted those in charge of some of the reserves, notably the Nipigon, to apply wide-awake ideas for elimination of fire hazards. In the Mississaga Forest Reserve, one inspector is employed for every ten men. In the Nipigon Reserve the energy of Chief Ranger Bliss has developed 125 miles of bush telephone line, four lookout towers, excellent equipment such as motor car and motor boat, and an exacting system of inspection of the men. The result has been a freedom from serious fires in these Ontario reserves.

Such mechanical equipment cannot be found outside the reserves and parks to any noteworthy extent. The employment of great numbers of rangers on the old-fashioned plan, devoid of equipment, trails, telephones, or centralized control, is a precise equivalent to that of a bucket-brigade for city fire protection.

We recognize that the rousing of public sentiment on the question of Ontario's forest service has been due more to the terrible loss of life in the Claybelt fires than to any other consideration. The lack of official data on provincial forest conditions, annual losses from fires, etc., as reflected in the annual reports of the Department of Lands and Forests, has been partly responsible for previous public indifference to the seriousness of the situation. What was not reported upon by the department was too often accepted as a matter of no public concern.

The proof of the efficiency of modern protection systems is available on every hand, in the 24,000 square miles of privately managed limits of Quebec, in the whole of British Columbia, in the Pacific Northwestern States, and in some of the Ontario reserves.

In practically all of these areas, the freedom from forest fire damage to life and property can be ascribed to three main features:—

Power of control by the rangers over settlers' clearing fires through the "permit law."

Centralization of ranger control; skilful management; with frequent inspection.

The development of mechanical equipment, as trails, telephones and lookout towers.

It is to these foundations of every successful protective organization now in existance that we direct the attention of Ontario, feeling confident that the government will not hesitate to place the forest guarding system upon the most modern and efficient basis.

USE OF GAS INCREASING.

According to the U.S. Geological Survey, the use of artificial gas as a domestic and industrial fuel is increasing more rapidly than the use for illumination is falling off. In 1912 47% of the artificial gas sold was for illuminating, while in 1915 only 30% was so used. During 1915 the total amounts sold (by thousands of cubic feet) were as follows: For illuminating purposes, 80,796,873; for domestic fuel purposes, 129,889,230; and for industrial fuel purposes, 55,518,145. Water gas formed 59% of the first, 51% of the second, and 19% of the third; by-product gas being used for 70% of the industrial fuel purposes. The total amount of artificial gas used last year was 25% greater than in 1912, the next preceding year for which the statistics of this industry were collected by the Geological Survey.

Water gas enriched with oil—carburetted water gas—is more generally used in cities than coal gas. It amounted to 47% of the total quantity of all artificial gas sold in 1915. Gas made from oil is used almost exclusively in California, Arizona and Oregon, and to a less extent in a few other states.

Thermalene is a gas, the discovery of which was recently announced from Zurich, Switzerland. It is used for welding and cutting in the same manner as acetylene is used with oxygen. It is produced by the decomposition of calcium carbide with water and is enriched or compounded with the heated vapors of crude oil. There are several claims made for it. It is heavier than air, specific gravity 1.1, and it is said it can be used at a lower pressure than the other gases. It is not explosive when liquefied, and its explosive range is narrow, the explosive ratio from 12 per cent. to 30 per cent. air. It can be liquefied at a pressure slightly over 1,400 pounds and at the ordinary atmospheric temperature. An excess of oxygen is not required in the welding flame, so that there need not be any reduction of the carbon in the iron or steel that is being welded, thus producing a soft weld. It is generated automatically in a portable apparatus as needed and delivered to the torch at 15 pounds pressure. The special feature in its production is the use of cartridges of material, consisting of alternate layers of calcium carbide and sawdust soaked in oil. It is necessary to wash, purify and cool the gas. The introduction of this gas into the iron and steel industries of the United States will be watched with interest.

NEW WESTMINSTER WATERWORKS CONSTRUCTION

SECOND AND CONCLUDING PART OF ARTICLE BEGUN IN THE NOVEMBER 23rd ISSUE, REVIEWING DESIGNS, MATERIALS AND METHODS USED IN OBTAINING GRAVITY WATER SUPPLY FROM LAKE COQUITLAM.

By **JOHN WILLIAM BERNARD BLACKMAN**, M.Can.Soc.C.E., M.Am.Soc.C.E.,
City and Water Engineer, New Westminster, B.C.

PART II.

Co-efficient of Friction and Discharge of Pipe.—As before mentioned, the first calculation for the size of the main was based upon the requirements of about 6 million Imperial gallons per day. With the lake head at level 442 ft. above sea-level and Queen's Park reservoir at level 250 ft. and length 74,700 ft., using a modified Kutter's formula with a co-efficient for friction of $n = 0.013$ for a smooth lapwelded pipe it was found that a 24-in. diameter pipe would discharge 6,164,654 Imperial gallons per day (6.232 cu. ft. taken to a gallon). This size was therefore decided upon as a basis. As previously mentioned, a 25-in. diameter riveted steel pipe was adopted. The writer calculated that using Kutter's formula $n = 0.01385$ for a riveted steel pipe, that this diameter pipe would, with the lake level at elevation 442 ft., discharge 6,370,000 Imperial gallons per day. On the 4th July, 1912, the full amount of water was passed through the main, and it is interesting to note that the self-recording Venturi meter read 6,650,000 gallons per day, which would give a co-efficient friction of $n = 0.01356$. The calculated velocity for the 24-in. pipe was 3.629 ft. per second, with an hydraulic gradient of .257 per cent. As the lake level can now be raised to elevation 503 ft., that is, the elevation of the spillway adjoining the Coquitlam dam, using the first calculation with $n = 0.01385$, a discharge may be obtained of 7,335,000 Imperial gallons per day. The highest elevation recorded over the spillway is elevation 503.50 ft. For estimating purposes the minimum discharge only can be taken. During the first year after the building of the dam the lowest observed water level in the lake was 488.11 ft. during the month of August. It would be difficult to estimate how low the level of the lake might stand at the end of a dry season, but so far as the municipality is concerned the water cannot be drawn off at a lower level than 435 ft., which is the elevation of the floor of the draw-off tunnel to the Vancouver Power Company's plant, whereas the lowest elevation to the floor of the New Westminster water tower is 430 ft. It is estimated that the lake level will never go much below elevation 450 ft. Elevation 442 ft. has been taken as a base for calculating purposes.

Assuming the lake area to be 2,328 acres at the original elevation and that 5 feet was left for the city to draw from, there would remain 507,038,400 cu. ft., which at the maximum draw-off from the city mains (25 ins. and 14 ins.) of, say, seven million gallons per day, would last 452 days. The corporation is thus amply protected.

Discharge Chamber.—The design of the discharge chamber into Queen's Park reservoir was made so that the 25-in. main terminates with a specially constructed concrete bell-mouthed orifice 3 ft. 0 in. in diameter. (See Fig. 8, Nov. 23.) The water discharges from this opening into a water cushion, passes over a concrete weir and then down a series of steps. The steps and the floor of the chamber are composed of cobblestones set in cement mortar. A concrete wall partially surrounds the discharge chamber. The advantages of this form of discharge into reservoirs are as follows:—

(1) In case of a sudden rupture in the pipe line, the reservoir could not be emptied and in some cases it would eliminate the use of a check valve.

(2) A large air valve is not required at the reservoir.

(3) The water gets a certain amount of aeration.

(4) Inspectors and other waterworks employees can see at a glance the water entering the reservoir.

The only disadvantage is a small loss of head, as the top of the orifice is above the level of the overflow of the reservoir.

The writer had no option but to construct this form of discharge chamber, as the reservoir had been constructed some years before, while to break through the embankment was not a practical undertaking, as the low-level system depended upon this reservoir for its supply.

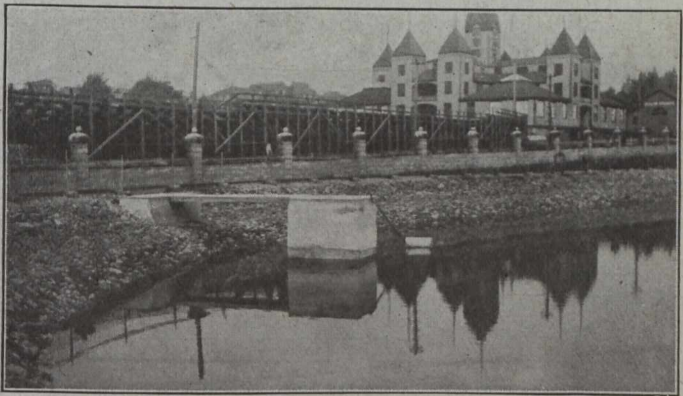

Fig. 12.—Floating Arm Intake, Queen's Park Reservoir.

Overflow Chamber and Pipe.—The overflow chamber was placed as far away from the discharge chamber so as to give the water in the reservoir as much circulation as possible when the water was spilling over the waste weir. The chamber is of simple construction in concrete. (See Fig. 8.) From the weir the water flows into the bell-mouth opening of a 16-in. diameter concrete pipe, the entrance to which is protected by a wrought iron grid. The size of the overflow pipe was designed so as to take care of the maximum discharge. The overflow pipes are concrete and discharge into the Fraser River, some half a mile distant.

Relief Valve.—It was thought desirable to place a relief valve on the lowest level after the pipe line had descended from the altitude known as Cape Horn. This relief valve is composed of three 6-inch openings and was specially constructed for these works.

Check Valve.—A check valve was installed on the main some 300 ft. below the reservoir and was only necessary because of the construction of the by-pass to the town supply. This by-pass is used to feed the town supply when the reservoir is being cleaned out. When feeding from the 25-in. main direct, the pressure is controlled by the use of a pressure gauge and the opening of a sluice valve nearby. It must be further explained that this by-pass connection feeds the low-level system only, but in case of a large fire, a fire valve might be opened at any moment, putting on high pressure to the low-level service. This might be balanced by the regulation of the sluice valve or not, depending upon the skill of the man operating the gate. The introduction of the human factor is always best eliminated, and the risk of leaving the by-pass gate open after the water was turned into the reservoir might occur and a break in the main would be fed through the by-pass from the high level one if that pressure were suddenly turned on for fire prevention purposes.

without shutting off the water was carried out by means of a Smith tapping machine. This is quite a different machine to the ordinary tapping machine. A split sleeve with a flanged connection and valve of the diameter required is first fixed on to the larger main. The split sleeve is caulked all round in the usual way with lead. The Smith machine is then attached to the flanged end of the valve. The valve is then opened, and the cutting edge of the machine is pushed through the valve to the side of the large main. The cutting edge is then operated by a spindle, and this spindle turned by a ratchet brace. When the pipe is cut, the cutting edge and the section cut is withdrawn into the stuffing box and the small gate shut; the machine is then detached.

The Supply to Richmond and Lulu Island.—This article would not be complete without a description of the supply to the municipality of Richmond and Lulu Island, which was constructed at the same time as the larger main. The corporation of New Westminster entered into an agreement with the municipality of Richmond for the maximum daily supply of one million gallons per day. The municipality of Richmond is a large rural district lying to the southwest of New Westminster and takes in practically the whole of Lulu Island. The island is perfectly flat and extends south to the mouth of the Fraser River. The land is nearly all agricultural and at the mouth of the river many large salmon canneries are operated. The necessity of a good water supply to them was of vital necessity. The consideration paid by Richmond was $125,000 for one million gallons per day for the length of the life of the pipe line, and subject to certain other conditions as to upkeep, etc.

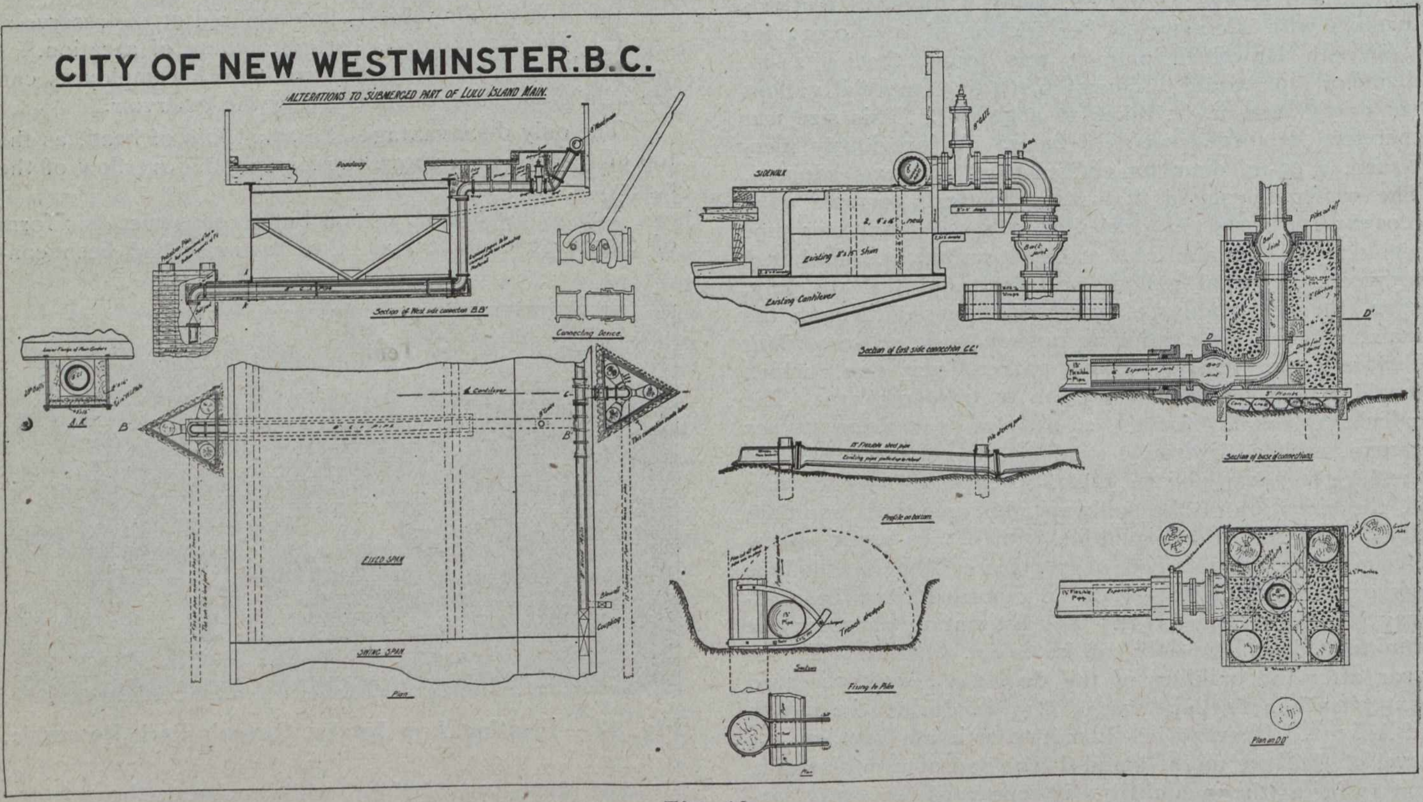

Fig. 13.

Venturi Meters.—A self-recording Venturi meter was installed on the 25-in. main just before discharging into Queen's Park reservoir. Although strictly speaking not a necessity, the then waterworks committee thought that it should always be known what amount of water passed into the reservoir daily. The type used was a self-recording type with a 9-in. throat. A drum driven by a clock holds a 24-hour roll of ruled paper on which a pen marks the number of millions of gallons per day every ten minutes. The instrument is enclosed by a concrete house. The meter is read daily and the records torn off and kept on file at the city engineer's office.

Connections to Main.—Water is at present sold to the municipality of Port Coquitlam, the provincial government asylum and colony farm, and the municipality of Fraser Mills; their supply is taken direct from the 25-in. main.

The largest pipe taken off the 25-in. main is 6 ins. Two of these institutions took their supply after the main was in, and the only method to make a 6-in. connection

The Intake.—The intake for a waterworks system by a floating arm is perhaps unique; but this form of construction the writer used as a safe protection from entirely emptying the Queen's Park reservoir. The pipe line follows the streets of the city, commencing at elevation

250 ft. at the reservoir. The elevation at Lulu Island bridge is 15 ft. where the pipe crosses. From this point for a distance of seventeen miles the line passes through a flat, and in places marshy ground, and sparsely populated.

The pipe is 13 ins. in diameter until it reaches Lulu Island, where a 6-in. main is taken off for the city use. From this point a 12-in. main continues. The floating arm inlet is secured by a chain which only allows the water to be drawn down to the level of half the capacity of the reservoir by the Richmond main. (The reservoir holds only 2.4 million gallons.) The intake chamber has a control valve inside and an open air pipe 6 ins. in diameter; the approach is by a reinforced concrete slab 6 ins. thick. The opening of the floating arm inlet is covered with a screen. The main is entirely of ¼-in. steel lap-welded pipe 13 ins. and 12 ins. in diameter and the length laid by the writer to the boundary of the Richmond municipality was 17,970 ft.

Crossing the North Arm of the Fraser River.—Lulu Island is connected to the city by a steel bridge over the north arm, and the river at this point is 1,200 ft. wide. Tenders were called for the supply of pipes with flexible joints, and makers of various flexible joints had to supply drawings of the joint made by them. The tender of the Canadian Boving Company for the supply of 1,300 ft. of 13-in. lap-welded steel pipe ¼ in. thick with their patent flexible muff joint was accepted. The pipe was supplied in lengths of 12 ft. and 16 ft. The makers supplied specially prepared yarn which was caulked into the joint, the ball and socket being well greased in the first instance. After the yarn had been placed in the joint, lead wool was caulked in. The rings were then bolted together, all bolts being evenly drawn, so that no uneven strain should come upon the ring at any part. The lip on one ring was drawn tightly against the lead in the pipe. Before the pipe was laid the writer had a trench dredged by suction dredge with an agitator on the end of the suction. The work of laying the pipe was carried out in the early autumn after the flooding of the river during June, July and August. The pipes were jointed together on small pontoons and lowered by means of blocks and tackle from the sides of the bridge. (See Fig. 14.) Great care had to be taken in lowering that at no place did the pipe take an angle greater than the joint was designed for, the maximum angle being 14°. The submerged main was joined to the mains on land at low tide and no diver was employed up to this time.

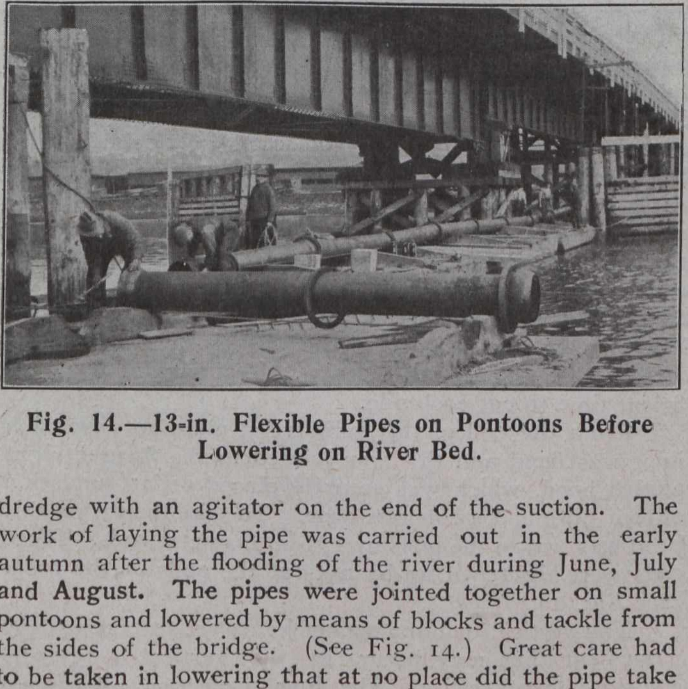

Fig. 14.—13-in. Flexible Pipes on Pontoons Before Lowering on River Bed.

The water was turned on but it failed to reach the other side of the river. Upon personal investigation by the writer, a large leak was found about mid-stream. A diver was employed and after the sand had been pumped away from the pipe the diver brought up one of the rings in two pieces. The ring had broken through a defect in the casting and the lead had blown out. A specially constructed split ring was made and replaced by the diver. The water was turned on and no leaks were discovered. The water ran through the submerged pipe successfully until the summer of the following year, when during the freshet of the Fraser River the pressure in the pipe began to drop. A diver was sent down and reported several leaks. These were started by (a) the shifting of the bottom of the river bed, which is entirely of sand, and (b) the undermining of the pipe caused by eddies from the close proximity of water-logged trees, washed down by the flood, some of them with their roots 10 ft. and 12 ft. in diameter. The joints of the pipe were unable to stand the strain and the small leaks that started rapidly increased to larger ones. The squirt from the leak in the sand caused the sand to make cuts in the pipe of all shapes and sizes. Some of the ¾-in. bolts were cut clean through in a few days. Immediate action was necessary as it was evident that the existing main could not be of service for many more days. The following work was therefore carried out:—

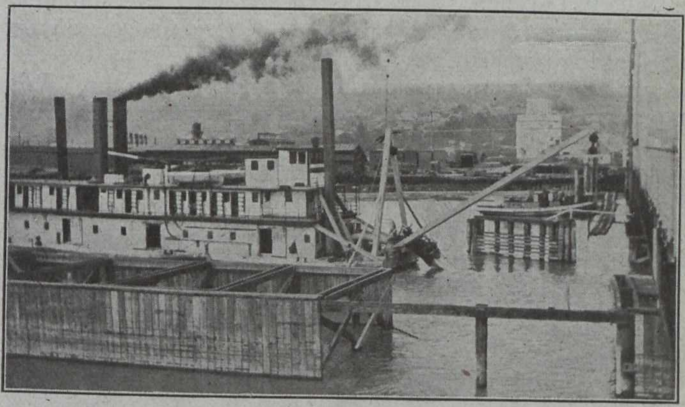

Fig. 15.—Dredge at Work Digging Trench for Submerged Main. Note Timber from Draw Protection Pier Has Been Temporarily Removed.

The 13-in. pipe was cut on the land near the bridge and a special casting and gate installed; from this point an 8-inch diameter wire-wound wood pipe was laid on the bridge, connected by two special couplings, at the intersection of the swing span portion of the bridge and the approaches, and carried across to the island. It was there connected to the main. The bridge is opened from 15 to 20 times a day and provision had to be made for connecting and disconnecting the main rapidly. The coupling device (a sketch of which is included in Fig. 13) consisted of three brass castings, one of which was movable and actuated by a hand lever. The movable part worked through a stuffing box and its tip was machined to a cone shape, which exactly fitted the opposite casting so as to make a tight joint. The parts were brass and spherically ground. Any slight settlement in the swing span was taken up in the cone-shape connection. During the six months the joint was in operation it gave excellent service, was perfectly tight and required no repairs of any kind. The length of pipe on the draw-span of the bridge was 450 ft., and as it was a summit, two small air valves were fixed in the pipe. On the side of the bridge whence the water supply came a gate was inserted and operated by a hand wheel, and just on the other side of this gate a 6-in. blow-off pipe and valve were placed to relieve the pressure and water hammer when the 8-in. gate was closed to operate the bridge. The blow-off pipe discharged into the river. The writer issued the following instructions to the operators: "Before the bridge is opened, the 6-in. blow-off must be gradually opened to its full extent. The 8-in. main gate may then be closed gradually and the couplings released. To turn the water on again, wait until the wedges under the swing span have been set, then connect the couplings, gradually open the main 8-in. gate and close the 6-in. and watch the pressure gauge, so that the pressure rises gradually. When 50 lbs. is reached wait five minutes. Ten minutes must be occupied before the maximum pressure is reached, etc., etc."

The maximum pressure at the bridge is 100 lbs. This temporary scheme gave to Lulu Island a water supply but was disturbed every time the bridge operated. But from from a fire protection point of view was perfectly satisfactory, as instructions were given not to open the bridge when the fire bell rang, so that the supply could not be cut off during a fire. The insertion of an 8-in. pipe instead of a 13-in. diameter pipe for the short distance only slightly reduced the supply. This was clearly demonstrated by the reading of the Venturi meter at the junction of the 12-in. main which supplied Richmond only.

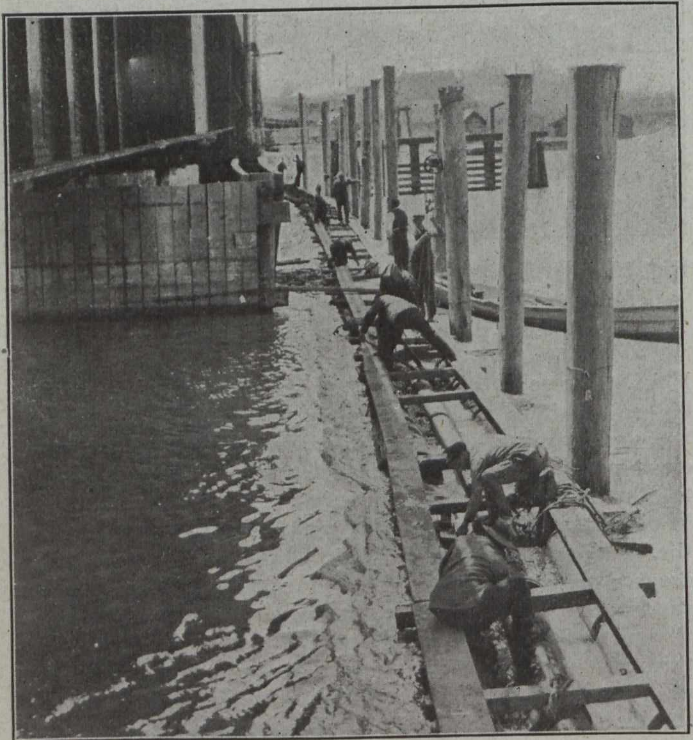

Fig. 16.—13-in. Flexible Main on Raft in Position and Ready to Lower on to the Brackets on the Piles, which are Afterwards Cut Off.

For an uninterrupted supply to Lulu Island the writer again started upon fresh designs, and with experience as his best teacher evolved the following scheme which was successfully carried out:—

To relay the 13-in. main for the length of the draw span only, on piles, on the down-stream side of the bridge, a trench was dredged on the line the pipe was to take so as to place the pipe about four feet below the original bed of the river. (See Fig. 15.) Pipes were raised from the old line, thoroughly examined and recoated, all joints taken to pieces and remade. The lengths of the pipe were 16 feet. In this trench and true to line a pile was driven every 16 feet. Each pile was driven 11 feet below the river bed. Before the piles were driven, the iron brackets shown on the drawings were fixed on and the exact measurement taken to the top of the pile, the bracket being placed 11 feet from the bottom of the pile. A engineer with a level was placed upon a cluster of piles standing near the approach to the bridge opening, to watch for a mark placed on the pile as it was being driven, so that each bracket should be at the same level. In designing the bracket the requirements were:—

(a) Strength sufficient to carry the weight of the pipe should the river bed scour from beneath.

(b) That the fastening device should be capable of easy adjustment by a diver.

The bracket used was so shaped that if the pile was slightly out of grade the curve of the bracket would guide it against the pile, after which the upper arm would be swung into the closed position and spiked by a diver.

The brackets were placed on the up-stream side of the piles. The piles were about 50 feet in length and were left standing until after the pipe was lowered so as to act as a guide for the pipe in lowering.

The pipes had been bolted together on a raft, shown in accompanying illustration. (Fig. 16.) The special ends were closed with blank flanges to prevent sand from entering. To draw the raft and pipes required the services of a tug, as the current in the river was running at about four miles per hour. This current held the raft so firmly against the piles that the tug could only make small headway going at full speed. After considerable difficulty the raft was moved into place and the pipes filled with water. Chain blocks had been provided and fixed to the piles to lower the pipe into its resting place but the current held the pipe so firmly against the piles that it was found necessary to weight the pipe down with bags of sand before it would sink. When the pipe had been lowered about 2 ft., an obstruction was found at the south end which proved to be a large tree, whose roots had encircled pipe and pile. Although only four and a half days elapsed between the dredging of the trench and the laying of the pipe, it was found on taking soundings that the trench had at the extremities silted up and that the pipe was for a short length level with the river bed. This was not considered serious, as the grade was very gradual. The last few lengths of pipe were chained up to the piles. After the pipes were lowered the piles were cut off level with the river bed. This operation was carried out by two men from a boat. A cross-cut saw suspended by two converging iron rods, with an eye at their junction through which a spike was driven, and fixed to the pile. The saw was drawn across the pile by means of wires attached at each end of the saw. Ten minutes was sufficient time to cut each pile.

From the end of this submerged main an expansion joint was fixed and this was jointed to the flanged right angled bend, which was securely placed on a foundation of four piles and a concrete base. To take the thrust this bend was tied to the piles by 1⅛-in. diameter rods. These rods were tightened up by nuts at the ends of the rods. (See Fig. 13.)

The vertical ball and socket joints are to take up any movement that may occur in the vertical length, by collision or otherwise. The four protection piles were driven quite clear of the foundation piles and the pipe. From the bend in the bottom of the river an 8-in. pipe is used and this is connected to the 8-in. pipe on the bridge. The connections below water were made by a diver. A crew of ten men was employed in lowering the main. Navigation was stopped for four days.

The water has been running through this main for 18 months successfully, with the exception of one small leak which has been repaired by a diver. A pressure gauge is kept on the bridge and inspected twice daily. The emergency main was left on the bridge and can be operated at any time should any accident happen to the submerged main. The relaying of the submerged main was carried out under the direct supervision of the writer.

Expenditure and Revenue.—To arrive at the total amount of interest and sinking fund chargeable to the ratepayers of New Westminster, $125,000 must be deducted since the municipality of Richmond has paid that sum to the corporation in cash, and the Vancouver Power Company has paid the cost of the water tower and tunnel approach amounting to $927,905.

Looking at the financial or business side of the undertaking it is interesting to review a few facts that are of vital interest to see whether it is going to be a profitable undertaking.

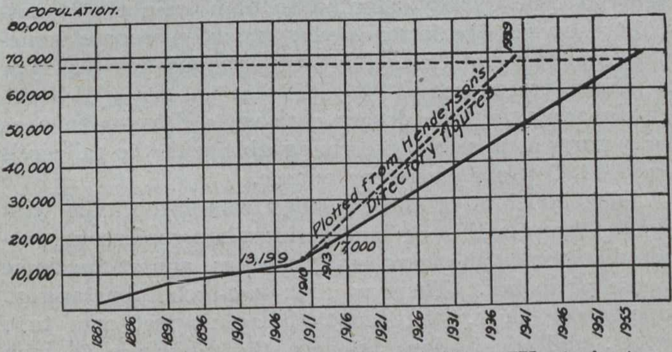

Fig. 17.—Population Curve, City of New Westminster.

The corporation has to find annually the sum of $35,263 for sinking fund and interest on works already constructed.

The new works add $15,774 to the annual liability for the next 50 years.

The annual cost of operating the waterworks department is about $16,500.

The returns from the treasurer's office show the annual revenue to be $85,000 to $100,000, which includes rates received from the ratepayers and for water sold outside the city limits to other municipalities. As the city and the surrounding neighborhood grow, the sales will increase and show a good profit.

The writer has drawn a population curve (see Fig. 17) which may prove interesting, although it is very uncertain. Western Canadian cities must grow and grow rapidly, and are building for a golden future. He cannot close this article without acknowledging the valuable assistance rendered by his resident engineer, Mr. A. R. Lewis, A.M.Inst.C.E.

APPENDIX I.

Cost of Work.

Manufacture of 25-in. pipe	$204,686.76
Purchase of 12-in. and 13-in. pipe	20,113.36
Purchase of 13-in. flexible pipe	7,501.20
Sluice valves and air valves	3,168.51
Cast iron specials, etc.	3,024.31
Cast steel specials	762.15
Bolts, anchorage, etc.	181.36
Wood pipe for blow-offs	92.48
Venturi meters	2,389.70
Stacking pipe at Westminster Junction	485.22
Testing steel	617.50
Contract price for digging trenches and laying 25-in. main, etc.	101,444.65
Contract price for digging trenches, 12-in. and 13-in. main	10,916.48
Floating arm and fittings at reservoir	386.37
Laying submerged main	1,012.56
Repairs to submerged main	1,472.73
Extra work authorized	500.00
Engineering expenses, including inspection	14,806.97
Legal expenses, advertising	4,437.69
	$378,000.00
Cost of water tower and approach	191,307.00
Cost of tunnel to tower pipe and shafts	87,308.00
Cost of clearing banks of lake, to be submerged by raising lake level	649,289.00
Total cost of works	$1,305,904.00

SPECIFICATIONS FOR CONCRETE.*

By Cloyd M. Chapman.

To be generally acceptable, specifications for concrete should fulfil two requirements, namely: (1) they should insure the production of suitable concrete if the aggregates are properly used, and (2) they should permit the use of materials found in the vicinity of the work, if such materials are capable of producing concrete of the required quality.

The present method of specifying may insure the quality of the material, but it does not permit the use of a wide choice of aggregates from which first-class concrete may be made.

Concrete is a cheap building material because it is composed largely of inexpensive aggregates, and for economic reasons these aggregates should be secured from deposits in the vicinity of the point of use. Whatever materials are locally valuable for aggregates must be used in the great majority of cases, for aggregates which must be transported long distances are no longer inexpensive. The material at hand capable of making concrete of fair quality will generally be used in preference to a better material which must be brought from a distance at considerable cost for transportation.

It is generally true that even a very poor sand, that is, one which compares very unfavorably with standard sand when tested in 1:3 mixtures with cement, will give a suitable compressive strength if sufficient cement is used. Where most excellent materials are available, the present style of specification does not permit a variation of the proportions however good the materials may be. For instance, some well-graded sands give strengths 40 per cent. higher than that obtained with standard sand in the proportion of 1:3. Yet such sands receive no credit for quality under the present form of specification.

Specifications serve their purpose when they secure the products described, but they serve the industry best when broad enough to cover all the materials capable of furnishing a product of the desired quality.

In order to cover and include all materials which are capable of producing concrete of the quality required for the particular service it is to perform it is only necessary to specify the result required instead of specifying the materials used. In this way it would be possible not only properly to safeguard the product but to permit the use of such materials as are available in each locality.

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*From a paper read to the American Society for Testing Materials.

It is also true that in many cases the local materials are of such poor quality and would require such a large proportion of cement to fulfil the specifications, that it would be economical to bring in better material even from a considerable distance, the saving in cement paying the freight. Specifications of this kind might take some such form as the following, in which all figures are purely arbitrary and in no sense proposed as standard:

The materials used shall be of such quality and shall be used in such proportions as to produce a concrete which shall show a compressive strength of 2,500 lbs. (or 2,000 lbs. or 1,500 lbs.) per square inch at the age of 28 days when tested in accordance with the standard methods of testing.

This form of specification is obviously open to modification to cover varying conditions. For instance, to insure against concrete which sets or hardens slowly, and consequently requires forms being kept in place an unusual length of time, the specification may require a certain minimum strength to be attained in three days. Again, in sea wall or tunnel work, requirements as to permeability or density may be inserted either in place of, or in addition to, the strength requirement.

It would probably be desirable to add some further qualifying clauses, such as the limit of size of particles, the character of the materials composing the aggregates, freedom from constituents liable to cause deterioration, and the like.

The method at present most commonly employed is practically to ignore the quality of materials except the cement and arbitrarily to specify proportions that will give good results with almost any aggregates. Wherein lies the incentive to a contractor or builder to use any better materials than the cheapest if he is compelled by the specifications to use a certain arbitrary mixture, regardless of quality or material?

Any specifications for concrete aggregates which are to be used all over the country, must be so drawn that any material which will make concrete of the required quality will be included.

In operating under such specifications, it is of great importance that specimens of the concrete produced be regularly made and tested. It is also of the greatest importance that a close day-to-day check be maintained on the quality of the materials used, so as to insure a reasonable uniformity, and to know that these materials are at least equal in quality to the materials used in arriving at the proportions required to give the quality of concrete called for in the specifications.

Having once established by test the suitability of sand and stone for any grade of concrete and having determined the proper proportions in which to use them to attain a certain desired result, it is only necessary thereafter to see that the size, grading and proportions of these materials are reasonably constant to insure uniform quality of concrete. Such a check on size and grading should be had on each and every shipment of material and is easily obtained with a small set of sieves, or in the case of sand, which is by far the more important material, by means of a self-contained sand tester.

The regular and systematic testing of the size of the aggregates gives data which will permit the engineer to tell without further tests, whether the aggregates will produce a better or poorer concrete than that produced by the original or standard sample. This fact is based on the well-established principle that, other things being equal, the aggregate whose granulometric-analysis curve most nearly approaches the line of maximum density will produce the best concrete. This makes it possible to determine with reasonable certainty which two sands of the same kind and from the same source, but differing only in fineness, will make the better concrete.

NEW LOCOMOTIVES ON THE T. & N. O. RY.

The Temiskaming and Northern Ontario Railway has recently purchased from the Canadian Locomotive Co., Kingston, six Mikado locomotives. These are the first engines of this type to go into service on this road, up to the present time the ten-wheel and Pacific type having been used in handling their passenger trains, and ten-wheel and Consolidation type being used for freight service.

In purchasing these locomotives, the commission, after careful consideration of the question, decided to secure a type equally adapted to both freight and passenger service, the latter having recently become somewhat too heavy at times for their previous heaviest type of passenger engine.

In arranging the design care was taken to have as many parts as possible interchangeable with the railway's standard Consolidation type engine.

The boiler is of the extended wagon-top type with sloping throat and back head and fire-box roof sheet, outside diameter at the front end 71 inches, and at the dome course 78 inches. There are 202 two-inch tubes and 32 superheater flues, the length being 20 feet over tube sheets, and the bridges between the tubes are ⅞ inch wide. The fire-box is 96 ins. long by 75¼ ins. wide inside the sheets and the back tube sheet is ⅝ in. thick. Water space at the front of fire-box is 5½ ins. wide and at the sides and back 4½ ins. The total heating surface, including superheater, is 3,981 sq. ft., and the grate area 50 sq. ft. The smoke boxes of four of the engines are equipped with the usual Master Mechanic's standard arrangement for front end, while the remaining two are fitted with the Mudge Slater arrangement, these latter being for test purposes. On account of the line of the T. & N. O Railway running for the greater part through forest country, it is the endeavor of the railway to provide the most modern devices obtainable for the elimination of danger of fires from engines throwing sparks.

The main frames are of vanadium steel 5 ins. wide throughout, spaced 43-in. centres, the front extensions being cast integral with the main frames. The equalization system divides between the second and third pair of driving wheels and the springs throughout are of vanadium steel, the driving springs being composed of 5-in. 7/16-in. plates.

The cabs of these engines are of a type new on the T. & N. O. Railway, and are an adaptation of the design used by the Russian government on the engines built at the Canadian Locomotive Co.'s works for the Siberian railways. This design provides considerably more protection for the engine crew in winter, which is very necessary in this climate and although enclosed all round should not be uncomfortably warm in summer as provision has been made for ample ventilation.

The principal dimensions of these locomotives are as follow: Gauge, 4 ft. 8½ ins. Cylinders, 25 ins. by 30 ins.; driving wheels, 63 ins. diameter; working steam pressure, 180 lbs. Weight on driving wheels in working order, 197,000 lbs.; on front truck, 29,550 lbs.; on trailing truck, 31,500 lbs.; total, 258,050 lbs. Weight of tender loaded, 145,000 lbs. Driving wheel base, 16 ft. 6 ins.; total engine wheel base, 34 ft. 8 ins.

HIGH-TENSION TRANSMISSION LINES AND STEEL TOWERS

By Lesslie R. Thomson, B.A.Sc.,
Dominion Bridge Co., Montreal.

(Continued from last week's issue.)

Unit Stresses.—Working stresses for the towers of a transmission line are to be used with loads that may actually occur at not infrequent intervals; there being no impact whatever. On the other hand, their maximum values are capable of being actually determined. Hence it is a little difficult to relate them intelligently to bridge stresses. Certain engineers feel that conservative unit stresses for towers are somewhat in the nature of an insurance or guarantee and that for lines not so important as trunk lines, higher stresses may justifiably be used. In this connection R. Fleming divides proposed towers into three classes, A, B and C, and allots unit stresses for each class, depending on their importance thus:—

Class A.—Towers for a line whose purchaser insists upon uninterrupted service, with heavy penalty clauses. Cases where failure of tower would mean probable loss of life, as in thickly populated regions.

Class B.—Towers for a line where certain interruptions are not inadmissible. Towers for a line through sparsely settled country.

Class C.—Towers that must be put up as cheaply as possible, independent of all other considerations.

He then gives the following unit stresses for open-hearth structural steel: Class A, 22,500 lbs. per square inch; Class B, 27,000 lbs. per square inch; Class C, no definite figure given, but the inference is that certain engineers assume that wind and ice-covered cables are not considered as occurring simultaneously, and the resulting loads are figured at 30,000 lbs. per square inch. He condemns this high figure as being too near the elastic limit, and does not commit himself as to the assumption.

Before this question of the unit stresses to be used can be finally settled, their relation to the test safety factor must be discussed briefly. It was noted in the preceding paragraph that many purchasers insist on test loads of double the actual calculated loads. If, for example, the tower under test belonged to Class B of Mr. Fleming's list, and the material were closely designed, the resulting stress in certain of the members would be 54,000 lbs. per square inch. This is much beyond the elastic limit and the tower would probably fail. If, however, instead of an arbitrary test factor of two, the purchaser would insist upon a test safety factor having for its magnitude the ratio between extreme elastic limit and unit stress desired (which should be conservative), and would at the same time stipulate that the maximum combination of loads must be used, the resulting towers would be in no danger of being weak or badly detailed, and rigid tests to elastic limit would be not only possible but would be welcomed by the manufacturer.

Adopting in the meantime Mr. Fleming's very reasonable classification of towers, the writer would recommend that the following unit stresses be used with the clear understanding that in each case the maximum for any combination of loads A, B and C be used:—

Class A, 20,000 lbs. per square inch; Class B, 25,000 lbs. per square inch; Class C, 30,000 lbs. per square inch.

The foregoing stresses are for tension, and the following formulæ, similar to the formulæ of D. G. Span, 1908, are recommended for use with struts in compression:

$$\left.\begin{aligned} \text{Class A, } f &= \frac{16{,}000}{1 + \dfrac{1}{24{,}000}\left(\dfrac{l}{r}\right)^2} \\ \text{Class B, } f &= \frac{20{,}000}{1 + \dfrac{1}{24{,}000}\left(\dfrac{l}{r}\right)^2} \\ \text{Class C, } f &= \frac{25{,}000}{1 + \dfrac{1}{24{,}000}\left(\dfrac{l}{r}\right)^2} \end{aligned}\right\}$$

These formulæ are for rigid end connections. When one bolt (or pin) per end is employed use factor $\frac{1}{18{,}000}$.

Where f is unit stress to be used in lbs. per square inch.

The following ratios for $\frac{l}{r}$ are also recommended:—

Class A—For main member $\frac{l}{r}$ not more than 125; for bracing, carrying live load, $\frac{l}{r}$ not more than 175; for struts without load $\frac{l}{r}$ not more than 200.

Class B—For main members $\frac{l}{r}$ not more than 150.

Class C—for bracing $\frac{l}{r}$ not more than 200.

The foregoing recommendations enable the purchasers to have the following test safety factors. At first sight they seem small but they are thoroughly rational and in consequence of the relation between unit stresses and assumed elastic limit, these factors may be applied rigidly, and with full confidence:—

Class A, 1.80; Class B, 1.44; Class C, 1.20.

NOTE:—These safety factors should be applied to the maximum combination of all possible loads.

Conductors and Wires.—(*a*) Conductors are in general of three different kinds—(1) copper, (2) aluminium, (3) steel reinforced aluminium. The latter two are the ones frequently used in transmission lines to-day owing to the high price of copper. A cable often used by the Montreal Light, Heat & Power Co. for high-tension service consists of a steel stranded core of 78,500 c.m. and a stranded aluminium sheath of 336,420 c.m., with a total diameter of about 0.74. As mentioned above, this paper does not intend to do more than touch upon those purely electrical features that may need, however, to be mentioned in passing.

(*b*) *Ground Wires*: These wires may be of either stranded or solid steel and are about ½ in. in diameter. Those engineers who place reliance in the capacity of these ground cables to save the line from lightning, usually assume that they protect all conductors underneath and within 45° lines. It may be interesting in regard to their serviceability to read "Lightning Rods and Grounded Cables as Means of Protecting Transmission Lines Against Lightning," by Norman Row,* and the subsequent discussion. Ground cables should be grounded thoroughly at each tower.

(*c*) *Stresses and Sags*: The stresses and sags in any of these conductors may be found from the well-known equations which are presented in very clear form in an article entitled "Mechanical Stresses in Transmission Lines," by A. Guell, Bulletin 54, University of Illinois, Eng. Exp. Station.

A very simple group of sag and tension equations is given by Kenneth Wilkinson in a paper entitled "Sag in Overhead Conductors," which appeared in the "Electrical World" for February 6th, 1915.

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*Trans. Am. Inst. E.E., vol. XXVI., Pt. 2, p. 1239.

(*d*) *Swings*: As the swing of wires between supports often affects the width of right-of-way, the following vertical swing angles will be of service in allowing for this characteristic:—

Copper conductors, 45°; steel aluminium, 50°; aluminium, 55°.

(*e*) *Insulators*: Insulators are of two main types—the pin and the suspended. The former are used almost universally up to voltages of 60 or 70 kv., while for higher voltages the suspended insulators are preferred,—the number of units being dependent on the amount of the voltages.

Pin insulators for high-tension service are always of the petticoat type and are manufactured in a great variety of designs. The modern practice is to use wrought iron or steel pins and care should be taken that the insulators are strong against electrostatic puncture to the pin. The ratio of the resistances to puncture and to flash over should be about 1.6.

If possible, pin insulators should be used on account of their many superior characteristics, chief among which should be mentioned their rigidity. The advantage of a rigid support for the conductor is manifest should there be any tendency of the wire to "whip" under the following conditions: Suppose, for example, there is a heavy coating of sleet on a conductor with a warm sun and wind. The sleet will in general be melted off in large blocks rather than gradually. These long blocks of heavy ice suddenly released impart to the wire a whipping effect in a vertical plane which is transmitted along the wire by a wave-like motion. If the point of support is rigid the whipping is arrested, but if not it may jump high enough to touch part of the tower or even meet another conductor. For this reason conductors on suspended insulators are seldom if ever in modern design placed vertically over one another. Often each conductor is suspended by two strings of insulators each set at a good angle to the other in order to secure greater rigidity.

Suspended insulators are of two or three main types, each unit being a duplicate of every other one. The bell or petticoat units are familiar to all. A design presented by E. M. Hewlett has several new points,* but has not proved very successful.

With whatever type of insulator a high-tension line be equipped, it is to be borne in mind that the first two or three years will be in the nature of test years, for electric storms will in that time be pretty sure to have discovered the weak insulators, and irrespective of any lightning protection a marked improvement in the annual insulator cost should be apparent by the end of the third year. The whole question of high-tension insulators is, however, a very large one and the reader is referred for a further discussion of the subject to an able article by O. A. Austin.†

(*f*) *Ties*: The design of the tie is always dependent on its required function. Certain ties are designed to be rigid, and to hold the wire not only from vertical displacement but from longitudinal movement as well. Such ties would be placed on any dead-end or anchor tower. Sometimes it is desired that in the event of a cable breaking, the entire longitudinal pull shall not be given to only one tower but rather distributed over two or more. In this latter event the tie is designed to allow a certain amount of slip. In certain instances it or the pin is designed to break absolutely should the load become more than nominal (*e.g.*, ties to a so-called "flexible" tower). Whatever type of tie to pin insulators be adopted there are two points that should not be overlooked:—

1st.—Protection must be given the conductor against arcing from it to the grounded pin.

2nd.—Protection must be given the cable against confined arc occasioned by a puncture of the insulator. The first is usually afforded by a large amount of serving in the cable by the tie wire end and the second is accomplished by extra parcelling around the cable with either soft copper or aluminium plate.

For detail of ties, etc., the reader is referred, among many other sources of information, to Messrs. Ralph D. Mershon, J. H. Finney and W. G. Chace.

Before leaving the question of ties it may be well to note that in certain designs, iron or steel clamps are often used when extra security against longitudinal displacement is desired. These clamps are, of course, well insulated. For illustration see article by R. D. Mershon already quoted.

It may be remarked in passing that the ground wire cable is usually attached directly to the tower by a clamp of some standard type.

(Concluded in the next issue.)

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*See "New Type of Insulator for High Tension Transmission Lines," by E. M. Hewlett, and "H. T. Lines," by H. W. Buck, together with subsequent discussion. Trans. Am. Inst. E.E., vol. XXVI., pt. 2, p. 1259.

†See Trans. Can. Soc. C.E., January-June, 1911.

SHIPBUILDING ON PROFITABLE BASIS

"During the present year real and substantial progress has been made in the direction of establishing the shipbuilding industry on a permanent and profitable basis," said Hon. J. D. Hazen, minister of marine and fisheries, after the launching of dredge No. 16, the largest dredge ever built in Canada for the department of marine and fisheries, at the shipbuilding works of Canadian Vickers, Limited, Maisonneuve. The dredge was built by Canadian Vickers, Limited, for the use of the department in making the north channel, Beaujou, about 35 miles below Quebec, passable for big ships, and is 292 feet in length, 48 feet in breadth, with a depth of 20 feet 6 inches, capable of dredging at a depth of 57 feet and having a capacity of 1,500 tons per hour.

Plants at Montreal, Toronto, Collingwood, Port Arthur and Vancouver were splendidly equipped for the construction of steel ships, and, in addition, Hon. Mr. Hazen reported the successful building of wooden vessels in Nova Scotia. A large number of the highest class of auxiliary schooners for use in the timber trade between British Columbia and Australia and the Orient are under construction in Vancouver.

Canadian yards have secured a number of contracts for ships for Norway. Following the outbreak of the war the Dominion parliament decided to prohibit the export of ships from Canada without first obtaining approval from the government, and permission has been granted for the export of ships to be constructed as follows:—

Messrs. J. Coughlan and Son, Vancouver, B.C., three large steel freighters, with a carrying capacity of over eight thousand tons each, for a price of approximately $1,200,000 each; the Wallace Shipyards, Vancouver, four large steel freighters; the Western Drydock Company, Port Arthur, three full canal-size steel freighters; Thor Iron Works, Toronto, two full canal-size freighters; Polson Iron Works, Toronto, two steel freighters of approximately 3,000 tons capacity, and two of 4.250 tons capacity; Canadian Vickers, Limited, Montreal, two steel freighters of about 7,000 tons capacity; the Nova Scotia Steel Company, New Glasgow, N.S., three steel freighters.

RECENT DEVELOPMENTS IN PITCH-SAND MASTIC FILLERS..

By John S. Crandell,
Formerly Professor of Highway Engineering, Pennsylvania State College.

ONE of the important changes in specifications made by the American Society of Municipal Improvements at its meeting in Newark, N.J., October, 1916, was that governing bituminous fillers for stone block pavements. The specification that the society has had for years called for a pitch and pebble filler, where a layer of pebbles is swept into joints followed by a pouring of pitch, then another layer of pebbles and more pitch, and so on until the joints are filled. The new specification rejects this method and substitutes pitch-sand, or asphalt-sand mastic as being superior. In general, the specification is similar to that which has been in successful use in New York City since 1913. The wording has been simplified; and more important, the range of melting point has been increased to permit the adoption of the specification in all parts of North America. The specification is as follows:—

"The joint filler used shall be the paving pitch hereafter described, thoroughly mixed with as much hot, dry sand as the pitch will carry, but in no case shall the volume of the sand exceed the volume of the pitch. The sand shall be fine and clean, and all of it shall pass a 20-mesh screen. It shall be heated to a temperature of not less than 300° F. nor more than 400° F. and shall be between these limits when mixed with the paving pitch.

"The paving pitch shall be heated in kettles properly equipped with an approved thermometer, which shall register the temperature of the pitch.

"The mixture shall be flushed on the surface of the blocks and pushed into the joints with suitable tools, reflushing or repouring if necessary, until the joints remain permanently filled flush with the surface of the pavement. As little as possible of the mixture shall be left on the surface.

Fig. 1.—Finishing Mastic Filler on Brick Pavement.

"The tar pitch shall comply with the following requirements:—

"(*a*) It shall have a specific gravity between 1.23 and 1.33 at 60° F.

"(*b*) It shall have a melting point between 115° F. and 135° F. determined by the cube method in water.

"(*c*) It shall contain not less than 20%, nor more than 35% of free carbon insoluble in hot benzol or chloroform.

"(*d*) It shall contain not more than one half (½) per cent. of inorganic matter.

"(*e*) It shall be free from water.

"(*f*) It shall have a ductility of not less than sixty (60) centimetres at 77° F.

"The tar pitch shall be used on the work at a temperature of not less than 250° F., and shall at no time be heated above 325° F.

"It shall be delivered where directed by the engineer in time to allow for examination and analysis.

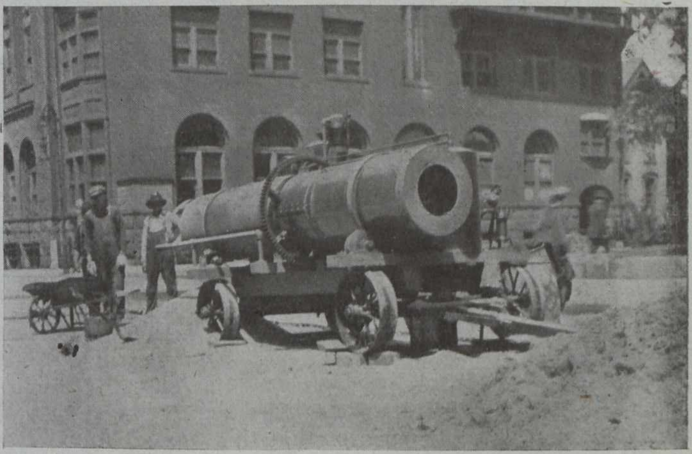

Fig. 2.—Siemens Sand Heater.

"In applying the filler, care shall be taken that the pavers are closely followed by the filler gang, and in no case shall the paving be left over night, or when work is stopped, without the filling of the joints being completed. In case rain stops the filler gang before its work is finished, the joints shall be protected by the use of tarpaulins, or other means, to keep out water. Under no circumstances shall the filler be poured into wet joints."

It will be noticed that the melting point range is from 115° F. to 135° F. Cities that are subject to cool weather for the greater part of the year should adopt a modification of this specification, using a melting point of from 110° to 125° F., while southern cities which have continued hot weather should specify the higher ranges. Also, on hillside work the higher melting point pitch should be used. On grades over 5% and less than 10%, a pitch of 135° should be specified, while for steeper grades, a pitch of 140° to 145° should be used, if the street is exposed in summer to the direct rays of the sun.

During the past year considerable yardage of brick pavements with pitch mastic filler has been laid in the middle west. Fig. 1 is a picture taken on Ionia Street, Grand Rapids, Mich., showing Tarvia mastic filler being applied to a brick pavement. The sand was heated in the Siemens sand heater shown in Fig. 2. Cold, wet sand, so wet that water could be squeezed out of it by hand, was dried and heated to 350° F. in one minute and forty seconds. A Siemens gasoline torch is the source of the intense heat which so quickly and thoroughly dries and heats the sand. Four men can easily move the heater forward as the work progresses. Its capacity is about 2,000 lbs. of sand an hour, raised from 40° F. to 400° F.

Fig. 3 shows the Cleveland sand heater. This is really a plate heater on wheels; its capacity is about 1,200 lbs. of sand an hour raised from 40° F. to 300° F. It is not necessary to have either type of heater, as the sand can be heated on an ordinary plate heater set up temporarily anywhere along the line of work. In fact, all the New York work has been done with sand heated in this way, and New York uses nothing but mastic filler for all block pavements.

In adopting the pitch mastic specification given above the American Society of Municipal Improvements recognized that the addition of hot sand to a bituminous filler is a definite step forward toward the goal of a perfect joint compound. The success that this type of joint filler is enjoying shows that it fills an actual need.

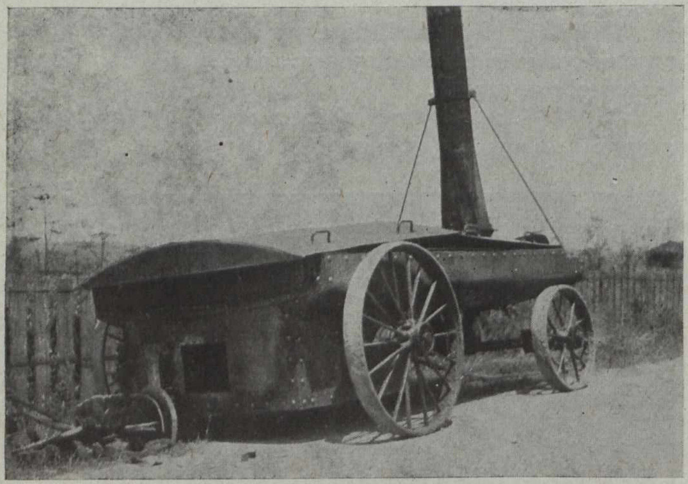

Fig. 3.—Cleveland Type of Sand Heater.

PAINT FOR STEEL AND IRON STRUCTURES.*

THE two most generally accepted theories to account for rusting are that which considers that the iron is attacked by carbonic acid in the water, and the electrolytic theory, which assumes that a flow of electric current dissolves the iron, forming an iron hydroxide, which is then turned into ferric oxide or rust. In either case water must be present, and rust prevention consists of excluding moisture or preventing the results accompanying its presence. The most minute quantities of water suffice to cause rust.

There are four general methods of protection: Covering by inert materials to exclude water, as tinplating and painting; covering by materials which contain active alkalies, as by concrete; covering with an electrical positive, as in galvanizing; and covering with some substance to render the iron passive, as by chromates. The first system is based solely on an effort to exclude the water; the other systems endeavor to exclude as much water as possible and at the same time to mitigate the action of such moisture as does reach the steel. Usually this mitigation is of a temporary nature and engineers must realize that not much success can be attained in rust prevention when moisture is present.

It has been customary to use paint for the protection of exposed ironwork. Such paints are usually composed of a vehicle and a pigment. They must be free from all elements which are deleterious, as sulphur; they must adhere; they must be permanent; they must be as nearly impervious as possible. Paint pigments used generally are iron oxide, graphite, carbon, the bitumens, zinc oxide and the leads. There are also adulterants, frequently called inert pigments, such as carbonate of lime, chalk, whiting, gypsum, koalin, marl, talc, etc., most of which are valueless.

Zinc oxide is liable to form zinc carbonate, which compound, as it has a volume about twice as great as that of zinc oxide, causes blistering and peeling of paint films.

The lead pigments, particularly the red lead and blue lead, are valuable because they are manufactured under such conditions as to insure a minimum of dangerous ingredients. They are usually, as sold, very fine and react with oils in which they are mixed in such a way as to become practically an integral part of the paint film, while other pigments act more in the manner of stone imbedded in mortar.

As to the inert pigments or, more properly, the adulterants, most of them are valueless. Some are soluble and are leeched from the paint film, rendering it porous. Some contain or absorb water and others hold acids in combination which may attack the paint film or the iron structure. Some of them are not wholly inert and may undergo injurious chemical interactions.

Linseed oil is the principal vehicle used and is the best. Boiled oil has the advantage of containing less water than raw oil. Oil which has been purified by use of sulphuric acid is worse than valueless, as the acid cannot be entirely removed and will act on the iron.

In conclusion, any engineer who uses red lead or blue lead for priming coats and covers this with a high-grade graphite will have the best combination possible, if these pigments are mixed in good, carefully prepared, boiled linseed oil. However, there are conditions where cheaper paints will serve, as for temporary coverings for special purposes, and many of the cheaper pigments are suitable for use in such cases. But for general open-air structural work such as bridges, steel towers, etc., the lead and oil paints are the most reliable.

No matter how good the paint or how carefully prepared, it may be rendered valueless by careless application. It is useless to try to stop rusting by covering up the rust with paint. If paint is to be put on over a film of moisture and a layer of rust, a cheap coat of whiting is as effective as expensive lead and oil. It costs, in some cases, a large sum of money to properly clean a steel structure; but unless it is done, even the most expensive grades of paint will not prevent its rapid destruction. Cleaning by sand blast is the best method.

The use of volatile driers is detrimental to a paint film because their use brings about a condition of drying by subtraction, the film losing in weight. Also, as the film becomes drier, the escaping bubbles of gas make holes which are not closed. Consequently the film is rendered porous and the underlying metal accessible to attack.

Paints are often applied too thick. If a paint film is too thick, it dries on top but remains plastic underneath. In this condition a film is likely to peel or, if subject to abrasion, is easily ruptured. Moreover, two thin coats are better than one thick one, since the second coat will, to a large extent, correct the deficiencies and inequalities of the first coat. The Bureau of Standards has found four coats of paint the minimum that could be depended on to give an impervious film.

While no paint coat can be considered a permanent protection against rusting, much better results will be secured if high-grade ingredients are used than if no care is taken in the selection of the paint materials. As in many other cases, the best is cheapest in the long run and this applies to the application of the paint as well as to the selection of the ingredients.

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*Abstract from Quarterly Bulletin.

Editorial

FINANCING OUR ENGINEERS ABROAD.

The participation of the Canadian Bank of Commerce in the British-Italian Corporation is an important development in Canadian trade, and it is of considerable importance to Canadian engineers and contractors who are giving more attention to the question of foreign trade and contracts. Already one large Canadian firm has signed a contract for a large construction enterprise in Russia. Canadian engineering and similar firms cannot afford to let drift their peace business prospects at home, because of activity on war orders. There is an unfortunate inclination to do this and to allow the buying public here to forget, in these war times, that certain firms still exist for certain business in Canada after the war. While that point must not be overlooked, some attention may be given to post-bellum prospects abroad. The financing of that business is of great importance and the participation of a Canadian bank in the first British trade bank to be formed indicates that we may reasonably expect our own banks to help finance contracts abroad to some extent, in conjunction with their European banking connections.

The British-Italian Corporation and similar organizations which will be formed, are intended to carry on the sort of financial business conducted by continental banks and more especially by the banks of Germany, for the fostering of trade and assisting manufacturers. The British-Italian Corporation and its Italian counterpart will develop economic relations between Great Britain and Italy,—and through the Canadian banking connection, with Canada—and will promote undertakings in the commercial and industrial field in Italy.

It frequently happens that contracts for the supply, for example, of electrical apparatus for new factories or for the electrification of railways running into many millions of dollars are offered to manufacturers on the understanding that payment will be made in securities on the completion of the contracts.

Hitherto it has not been possible for British manufacturers to accept these contracts in the same manner that German manufacturers have been willing and able to accept them. In Germany, bankers have always been ready to finance operations of this kind, and have been willing to accept the securities received by manufacturers in payment of contracts in satisfaction of their loans. This has been the case to some extent also in United States trade with Canada.

In England, as in Canada, the process has been first to issue securities to investors, and only to construct the works after investors have provided the money, whereas the continental method is to construct the works first and find the money after. The sounder of the two schemes is obvious, but if the British countries are to do a greater business successfully and obtain a large share of trade which hitherto went to Germany, they must be more adaptable to circumstances, studying the requirements of each market.

Canadian engineers and contracting firms will watch with interest this new development in British trade banking and its Canadian financial and business connections.

ADVISORY COUNCIL ON INDUSTRIAL RESEARCH.

Recognizing the importance of a more intelligent advance being made along the line of industrial research, the minister of trade and commerce, Sir Geo. E Foster, has secured the appointment by the government of an honorary advisory council on industrial and scientific research. This council consists of professors in the departments of applied science and men who are prominent in engineering work. The personnel of this council is as follows: A. Stanley Mackenzie, Ph.D., president of Dalhousie College, Halifax; F. D. Adams, Ph.D., dean of the Faculty of Applied Science, McGill University, Montreal; R. F. Ruttan, M.D., professor of organic and biological chemistry, McGill University; J. C. McLennan, Ph.D., professor and director of the physical laboratory, University of Toronto; A. B. Macallum, Sc.D., professor of physiology and biochemistry, University of Toronto; Walter C. Murray, LL.D., president, University of Saskatchewan; R. Hobson, president, Steel Company of Canada, Hamilton; R. A. Ross, consulting electrical engineer, Montreal; and Tancrede Bienvenu, general manager, Banque Provinciale, Montreal.

In the order-in-council providing for the appointment of the council it is recited that a similar scheme was adopted in Great Britain last year with the design of establishing a permanent organization for the promotion of scientific and industrial research. Representations were made that the British Advisory Council should be extended so as to embrace inter-Imperial effort and co-operation, but so far no definite action along this line has been taken.

The minister of trade and commerce points out the urgent necessity of organizing, mobilizing and encouraging the existing resources of industrial and scientific research in Canada with the purpose of utilizing waste products, discovering new processes—mechanical, chemical and metallurgical—and developing into useful adjuncts to industry and commerce the unused natural resources of Canada.

It is a pleasure to note among the names of the members comprising this council those of Messrs. R. A. Ross, of Montreal, and R. Hobson, of Hamilton, two men who have already rendered signal service to the engineering profession.

It may be taken for granted that in the days to come when the reports of the discussions and deliberations of this important body are made public, the contributions of the two gentlemen referred to will prove to be a very important and essential part of such records.

Probably there has never been an innovation which ever took so firm a hold of sanitary engineers and has engaged the attention of so many students of sewage disposal as the activated sludge process. A surprisingly large number of municipalities and industrial plants throughout the continent are either conducting experimental plants or are laying plans to do so. Out of all this the science of sanitary engineering should emerge the richer.

PERSONAL.

M. H. SULLIVAN, assistant superintendent of the Consolidated smelter, Trail, B.C., has resigned to accept the position of smelter superintendent for the Bunker Hill & Sullivan Co., Kellogg, Idaho.

G. N. HOUSTON, for the past three years a member of the Calgary Branch of the Canadian Society of Civil Engineers, has returned to Denver, Col., and reopened his office as consulting engineer.

WILLIAM PEARCE, president of the Calgary Branch Canadian Society of Civil Engineers, who has been in Ottawa for several months in connection with his duties on the Economic and Development Commission, has returned to Calgary.

Major HOWARD L. BODWELL, A.M.Can.Soc. C.E., who is a graduate of the Royal Military College, Kingston, and who is attached to the 2nd Canadian Pioneers, was on November 5th honored by the King at Buckingham Palace. He was invested with the D.S.O.

J. S. DENNIS, who will be the president of the Canadian Society of Civil Engineers for the year 1917, has been transferred from Calgary to Montreal by the C.P.R. and is now assistant to Baron Shaughnessy. Mr. Dennis states that after 44 years in the West, he has been brought east to assist in shaping a broad immigration policy to be pursued by the C.P.R. immediately the war is over.

S. G. PORTER, secretary-treasurer of the Calgary Branch, Canadian Society of Civil Engineers, has just returned from an extensive visit through the Western and Southern States. During the trip Mr. Porter addressed the Colorado Branch of the American Society of Civil Engineers at Denver, the International Irrigation Congress at El Paso, and the students of Baylor University, at Waco, Texas.

Lieut. R. LAWRENCE JUNKIN, of the 5th Field Company, Canadian Engineers, has been awarded the Military Cross, having distinguished himself on the field. Lieut. Junkin is 26 years old, and has been in the trenches fourteen months. He is a graduate of the School of Practical Science, Toronto, and was gazetted to an Ottawa Company of the Engineers.

F. A. DALLYN, C.E., A.M.Can.Soc.C.E., provincial sanitary engineer, has left for Europe, for the purpose of studying the utilization of sewage sludge, the treatment of trade waste problems, and matters of sanitation generally, in many of the leading cities of the British Isles, France and other European countries. The investigation will extend over two months and will be productive of a report to the Provincial Board of Health upon his return.

Captain W. G. MacKENDRICK, Toronto, has been appointed assistant deputy general director of roads with the Imperial Army in France. Capt. MacKendrick enlisted with the First Contingent and for some considerable time has been in charge of road construction work under the general headquarters staff of the British forces in France. Prior to enlisting he was for 20 years president of the Warren Bituminous Paving Company of Ontario, Limited, and was also an asphalt expert in the employ of the city.

OBITUARY.

J. W. SUTHERLAND, a director of the Dominion Power and Transmission Company, and treasurer of the National Natural Gas Company, died suddenly at Hamilton last week at the age of 65 years.

Private ALBERT BATES, a builder and contractor, who for some years carried on a successful business at Swift Current, Sask., has been killed in action at the front. When the war broke out he enlisted with the mounted police, later joining a battalion at Saskatoon.

Lieut. BRUCE HOSMER ACTON BURROWS, younger son of Mr. Acton Burrows, 120 Bedford Road, Toronto, is officially reported killed in action in France November 26. Lieut. Burrows was born in Winnipeg in 1893, and when two years old his family came to Toronto. He was educated at the Model School, Harbord Collegiate Institute and the Faculty of Applied Science, University of Toronto. He took a mechanical engineering course at the latter institution, graduating in 1913. In the fall of 1915 he was appointed lieutenant in the Canadian Engineers, and went overseas last March. While in England he took a two months' course at the Royal Engineering College. He went to France in August with the Engineers, 12th Field Company.

CANADIAN SOCIETY OF CIVIL ENGINEERS, MONTREAL.

Last Thursday, November 30th, the committee on "Standard Specifications for Highway Bridges," of which P. B. Motley is chairman, presented its report. The presentation of the report was followed by some discussion.

COMING MEETINGS.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Annual meeting, New York, N.Y., December 5-8. Secretary, Calvin W. Rice, 239 West 39th Street, New York.

NORTHWESTERN ROAD CONGRESS. Third annual meeting at Hotel Sherman, Chicago, December 7-8, 1916.

PORTLAND CEMENT ASSOCIATION. Annual meeting, New York, N.Y., December 11-13. Assistant to General Manager, A. H. Ogle, Chicago, Ill.

SOCIETY OF AMERICAN BACTERIOLOGISTS. Annual meeting, New Haven, Conn., December 26-28. Secretary, Dr. A. Parker Hitchens, Glenolden, Pa.

OKLAHOMA SOCIETY OF ENGINEERS. Annual meeting in Tulsa, December 27-28. Secretary, H. G. Hinckley, Oklahoma City.

AMERICAN STATISTICAL ASSOCIATION. Annual meeting, Columbus, O., December 27-30. Secretary, Carroll W. Doten, 491 Boylston Street, Boston, Mass.

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION. Convention at the Royal Connaught Hotel, Hamilton, Ont., January 23rd-25th, 1917.

VIRGINIA ROAD BUILDERS' ASSOCIATION. Sixth annual meeting, Norfolk, Va., January 16-18, 1917. Secretary, C. B. Scott, Richmond, Va.

WESTERN PAVING BRICK MANUFACTURERS' ASSOCIATION, Kansas City, Mo., January 20th, 1917. Secretary, G. W. Thurston, 416 Dwight Bldg., Kansas City, Mo.

AMERICAN WOOD PRESERVERS' ASSOCIATION. Annual meeting, New York City, January 23-25, 1917. Secretary, F. J. Angier, B. & O. Mt. Royal Sta., Baltimore, Md.