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Volume 29. Toronto, September 9, 1915. Contents of this issue on page 5.

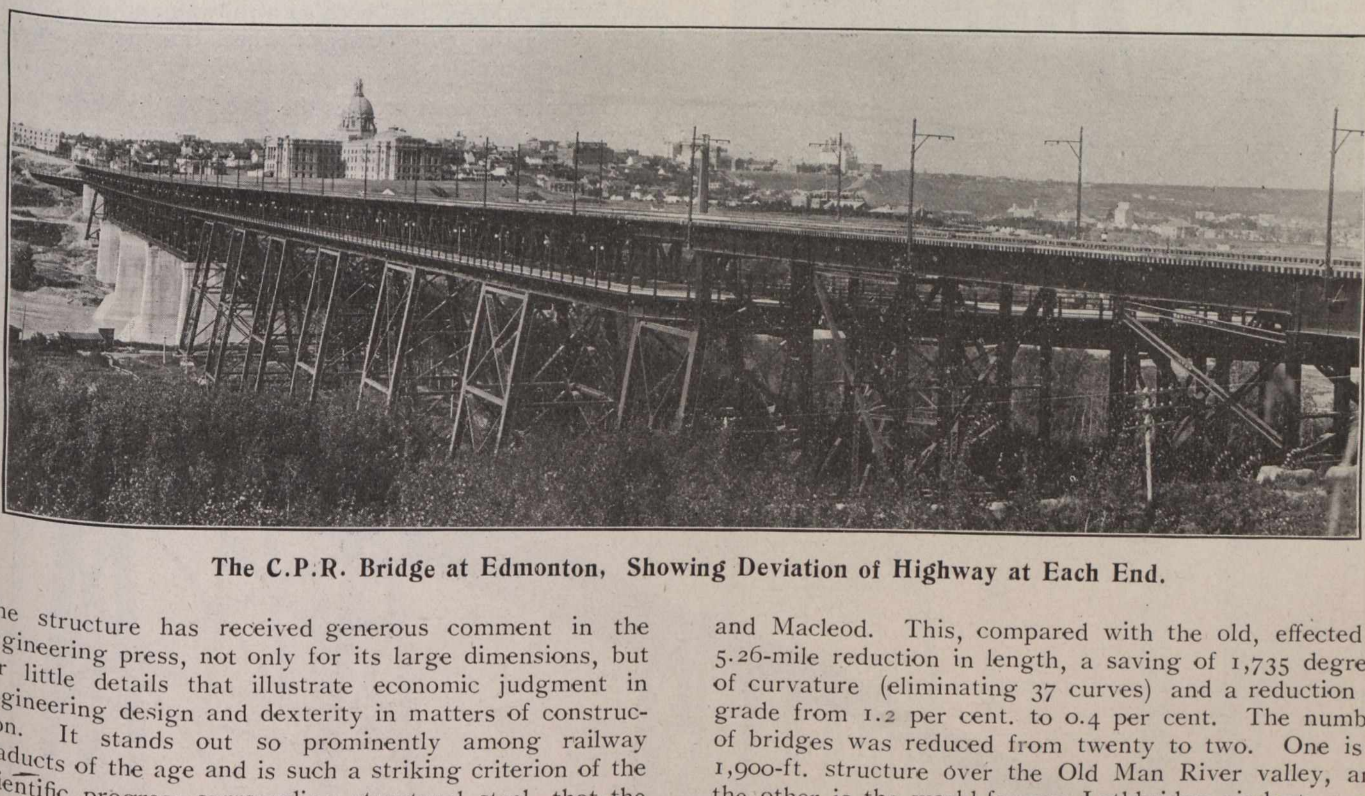
The Canadian Engineer

A weekly paper for engineers and engineering-contractors

SOME STEEL RAILWAY VIADUCTS IN WESTERN CANADA

THE CANADIAN PACIFIC RAILWAY VIADUCTS AT LETHBRIDGE, ALTA., EDMONTON, ALTA., AND OUTLOOK, SASK., BRIEFLY DESCRIBED AND ILLUSTRATED.

WHILE the opinions of bridge engineers may differ regarding the features of steel bridge design that bespeak distinctiveness and character, it is improbable that there may be readily called to mind a railway viaduct in Canada with more interesting points relating to its design and construction than the Canadian Pacific Railway viaduct which crosses the Belly River in the western part of the city of Lethbridge, Alta. The structure has received generous comment in the engineering press, not only for its large dimensions, but for little details that illustrate economic judgment in engineering design and dexterity in matters of construction. It stands out so prominently among railway viaducts of the age and is such a striking criterion of the scientific progress surrounding structural steel, that the following brief description of it, in conjunction with the more recently constructed C.P.R. bridges at Edmonton and Outlook, will doubtless atone for another reference to it, even after its six years of use.

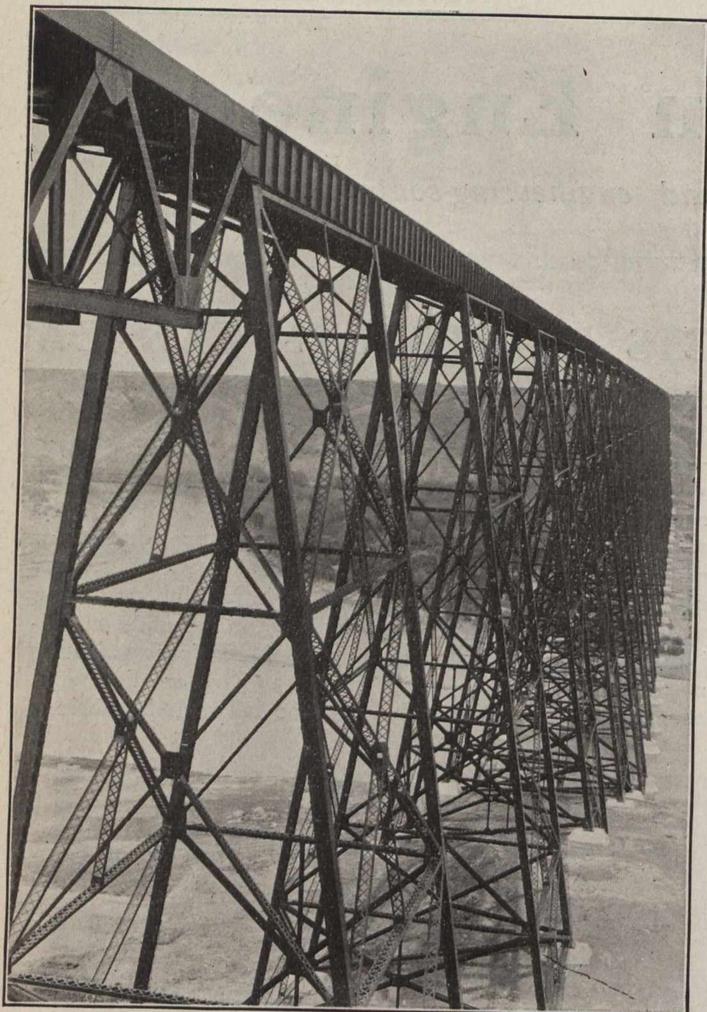


The C.P.R. Bridge at Edmonton, Showing Deviation of Highway at Each End.

The Lethbridge Viaduct.

Lethbridge, 759 miles west of Winnipeg, is a divisional point on the Crow's Nest Branch of the Canadian Pacific Railway. It is the centre of an important coal mining district as well as of a large irrigation tract on the eve of springing into greater prominence. The old Crow's Nest line, in its 38½-mile course from Lethbridge Junction to Macleod, had twenty bridges, aggregating nearly three miles of length, a number of them being over 100 ft. high. It had a curve, with no compensation, for every mile and to spare, and was burdened with a 1.2 per cent. grade (63.4 ft. per mile). The rapidly increasing traffic of ten years ago, coupled with the demands of rolling stock, for heavier structures, combined forces with the company's desire for lower grades and better alignment, and resulted in an entirely new line between Lethbridge and Macleod. This, compared with the old, effected a 5.26-mile reduction in length, a saving of 1,735 degrees of curvature (eliminating 37 curves) and a reduction of grade from 1.2 per cent. to 0.4 per cent. The number of bridges was reduced from twenty to two. One is a 1,900-ft. structure over the Old Man River valley, and the other is the world-famous Lethbridge viaduct, 5,327 ft. long with a maximum difference in elevation between river bed and base of rail of 314 ft.

The viaduct consists of 44 plate girder spans 67 ft. 1 in. long, 22 plate girder spans 98 ft. 10 in. long, and a riveted deck lattice truss span 167 ft. long. It is carried on 33 riveted steel towers, rigidly braced. Its general design is clearly illustrated in the accompanying views and elevation diagram. The substructure consists of concrete piles supporting concrete pedestals, the length of the piles under the land piers varying from 12 to 20 ft. The alignment is a tangent throughout. A 3-degree curve exists at the western approach and a 1-degree curve at the eastern approach. There is a grade of 0.4 per cent. rising towards the west for the entire length.



The River Section of the Lethbridge Viaduct.

The 33 high bents in the centre of the bridge have four anchor bolts, 2½ inches in diameter in the foot of each column; the remaining bents have two anchor bolts per column. The taper of the towers is 1:6. This, with the girders of the spans spaced at 16-ft. centres, gives ample spread at the base of the towers. The tower spans were made 67 ft. long in order to give longitudinal stiffness to the towers and to reduce the traction stress in the lower legs.

The diagonal bracings, both transverse and longitudinal, are stiff riveted members composed of angles and channels. Latticed and long members, as the illustrations show, are supported at the centre.

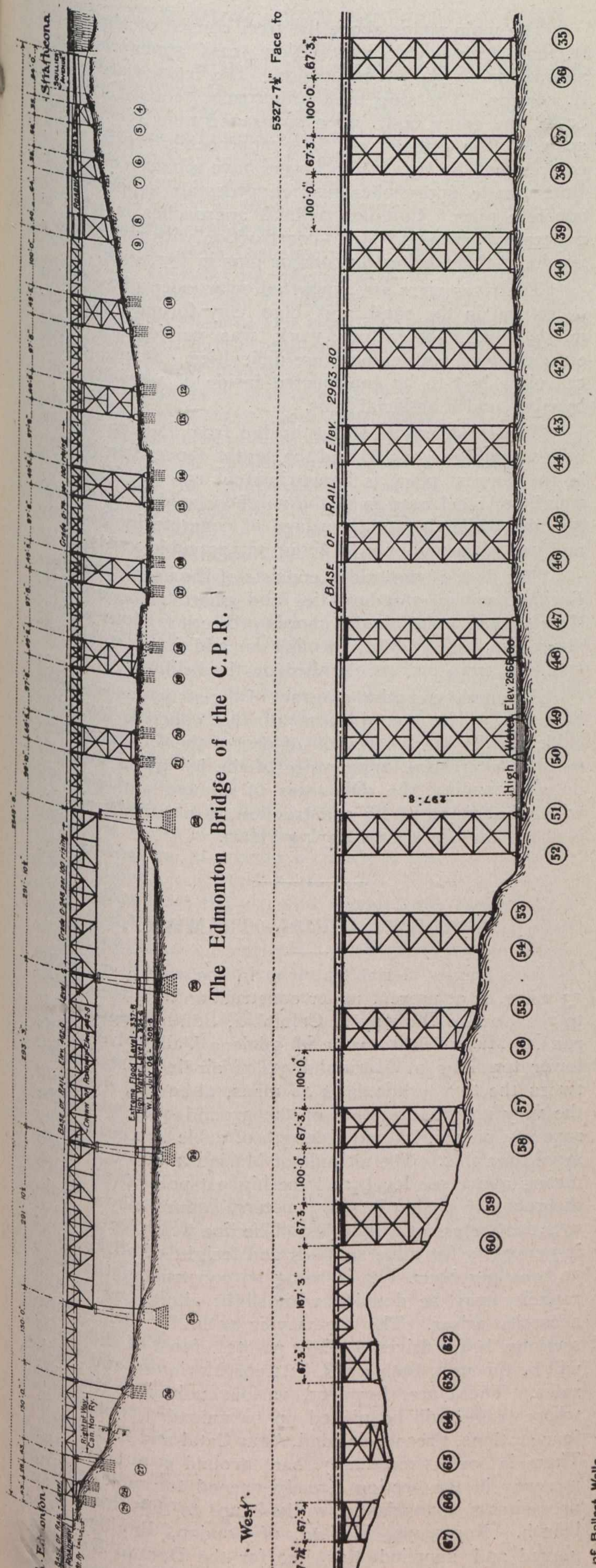
The Edmonton Viaduct.

The C.P.R. bridge across the North Saskatchewan River in Edmonton is a double deck structure about 2,687 ft. in length, providing a thoroughfare for vehicles, street cars and pedestrians in addition to railway traffic. The river divides the main part of the city from Edmonton South, which until a year or so ago existed as a separate town, Strathcona. As is characteristic of the rivers of the prairie west, the North Saskatchewan is a comparatively shallow stream, but of widely varying flow, traversing at Edmonton a valley upwards of a mile in width, this valley benching abruptly to the prairie level above.

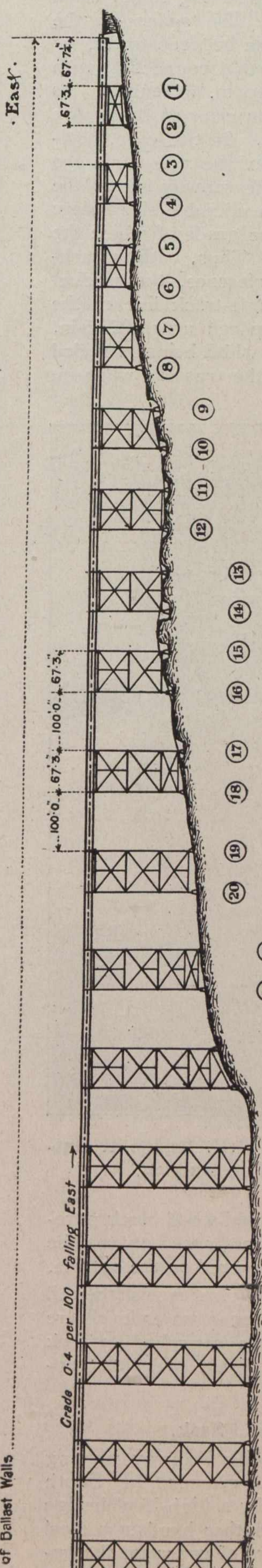
Prior to the erection of the present structure, a low-level swing bridge, used both as a railway and a highway bridge, was the only means of wheel transportation between the two cities.

The new viaduct crosses the river bed by three main double deck truss spans, one 293 ft. 3 inches long, and the other two 291 ft. 10½ inches long, with trusses 50 ft. deep and at 25-ft. centres. The approach on the Edmonton side includes two double deck truss spans, one 129 ft. 9 in. long, and the other 2 ft. longer, with trusses 19 ft. deep and spaced 25 ft. centre to centre. The balance of the approach on the north side consists of three short girder spans, by which the lower deck, for highway and pedestrian traffic, is diverted from under the rail deck, to escape the embankment which meets the latter.

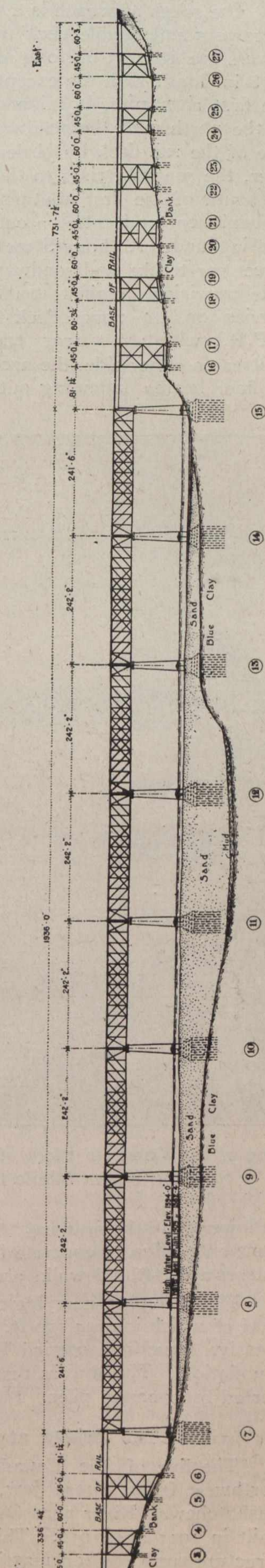
View of the River Section of the Outlook Bridge. At the Extreme Left is One of the Nine Land Towers.



The Edmonton Bridge of the C.P.R.

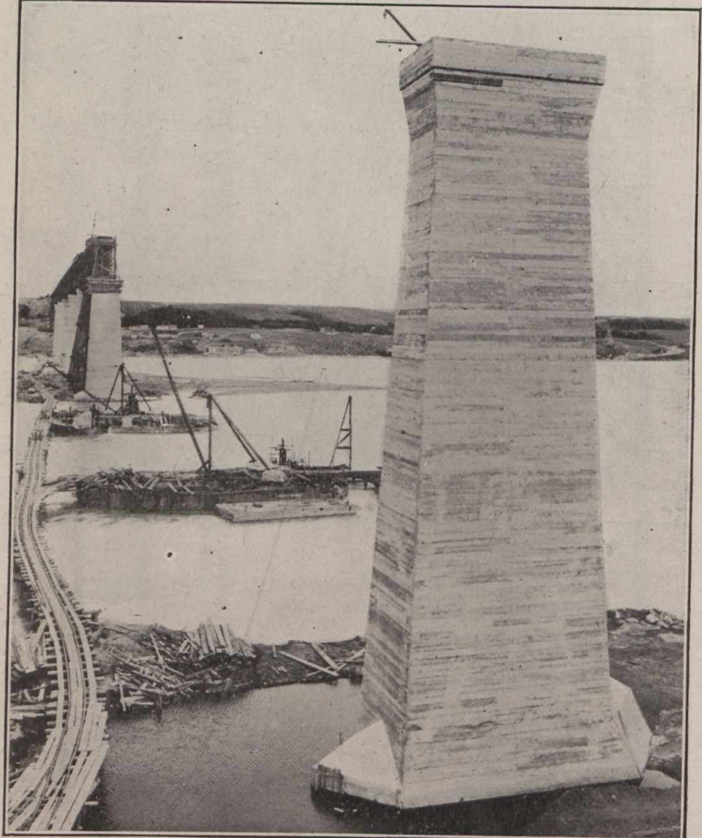


The Lethbridge Viaduct.



The C.P.R. Bridge at Outlook, Sask.

The south approach is a very interesting combination of towers and double deck trusses. The spans on the towers are 49 ft. 5 in. long and those between towers 97 ft. 8 in. long, with the exception of that connecting with the first river pier, it being 99 ft. 10 in. in length. As at the north end, the roadway is run clear of the centre line of the rail deck by girder spans. In this case, however, the roadway rises to the level of the rails some 250 ft. south of the first abutment. The railway leaves the embankment and enters a cut of considerable size before passing under Anthony Street, to the grade of which the street car tracks and roadway rise. Thus, with remarkable provision against traffic interference, the viaduct carries on its upper deck the single-track line of the C.P.R., with street car tracks spaced at 12-ft. 6-in. centres on either side, the necessary width being provided by floor beams extending out over the trusses; while on its lower deck the roadway, a creosoted wood block pavement on reinforced concrete foundation, runs between the trusses and 8-ft. sidewalks are cantilevered on the outside.



One of the Concrete Piers of the C.P.R. Bridge at Outlook, Sask., While Under Construction.

The four piers carrying the three river spans (the rail level of which is over 150 ft. above mean water level) are massive structures carried below the river bed to rock foundation. The towers rest on concrete pedestals supported by concrete piles.

The Bridge at Outlook, Sask.

The line of the Canadian Pacific Railway running northwest from Moose Jaw, Sask., crosses the South Saskatchewan River near Outlook by a high-level bridge built in 1911 and 1912. This is another handsome steel structure supported on massive piers of concrete, the approaches being in each case a steel trestle supported upon concrete pedestals.

The main spans above the river consist of eight 240-ft. long deck double intersection truss spans weighing approximately 4,052,000 pounds. The trusses are at 16-ft. centres. The steel trestle approaches consist of three 80-ft. and seven 60-ft. open spans and nine 45-ft. tower spans. The girders of these approaches are at 10-ft. centres and the legs of the towers have a batter of 1 in 6. Both trestle approaches rest on pedestals supported by concrete piles. Common to both approaches is what is generally known as "stiff" construction with riveted connections, there being no rods or pins in the work.

The river piers are supported on wooden piles driven to refusal in the sand and blue clay formation underneath. The substructure work was carried out under extreme flood and temperature difficulties. Several of the tall piers had to be constructed inside of specially built housing under artificial heat.

The total length of the bridge from face to face of ballast walls is 3,004 ft. and the height above river bottom in the deepest place is approximately 150 ft. The total weight of steel used is in the neighborhood of 6,000,000 pounds, while the total yardage of concrete in the piers and pedestals amounts to about 33,500 cubic yards.

The deck of the bridge consists of the usual Canadian Pacific Railway standard ties and guard rails, and the river spans have their top chords projecting about 16 ins. above the base of rail, forming an additional safeguard should a train become derailed on the bridge.

A general elevation diagram of the structure is shown herewith. The massiveness of the concrete piers is evidenced by the illustration of one of them, and the extremely interesting appearance of the bridge in general, notwithstanding the difficulties of climate and geology which handicapped its construction to a certain extent, is shown by the accompanying views.

LONGEST AERIAL TRAMWAY.

The longest aerial tramway in the world, by about 13 miles, is at present under construction as a feeder line to the Dorado Railway in Columbia, South America. It runs to Manizales from the Magdalena Valley, having its lower terminus at Mariquita. The air-line distance between the two terminals is 46 miles, although, owing to the very rough formation of the ground over which the ropeway passes, its actual length of cable is considerably more than this. The altitude of Mariquita is roughly 460 meters above sea level, and the highest point over which the ropeway passes is 3,675 meters, coming down again to 2,062 meters at Manizales. The line will have a carrying capacity for mine supplies and freight of all kinds of 10 tons per hour, but is being so constructed that this capacity may be doubled with slight alterations, if the necessity arises. The ropeway is naturally divided into sections, being driven at eight points. Most of the traffic will be through, both ways, between Mariquita and Manizales. There are, however, various points on the line where traffic will be picked up or unloaded, notably at four stations, Fresno, Soledad, Agua Catal and Esperanza. There is some exceedingly bad ground covered by the ropeway in the section already opened to traffic, which necessitates spans being worked up to 880 meters in length. Ropeways, Limited, of London, England, designed and supplied this line for the Dorado Railway Ropeway Extension, Limited, the consulting engineers being Sir Douglas Fox & Partners.

WATER PURIFICATION BY EXCESS LIME.

Dr. A. C. HOUSTON, the Director of Water Examination to the Metropolitan Water Board of London, Eng., issued recently his eleventh report on research work, in which he deals further with his investigations into the purification of raw water by the excess lime method. In his eighth report, reviewed in these columns in 1912, some results were given that tended to demonstrate the utility of this purification process, but his recent findings, under more nearly service conditions, indicate its effectiveness to a decidedly interesting extent. The "Engineer" of London publishes the following review of Dr. Houston's most recent work, beginning with a brief explanation of the principles involved in the experiments.

The hardness of water, as is well recognized, is of two kinds, "temporary" and "permanent." It is chiefly due to bicarbonate of lime (temporary) and sulphate of lime (permanent). When water is boiled carbonic acid is driven off, the comparatively insoluble carbonate of lime is precipitated, and the temporary hardness of the water is removed. In like manner, when lime is added to water it combines with the free and semi-combined carbonic acid and thus effects the same results. What takes place is represented in the following equation:—

Bicarbonate of lime		Quicklime		Carbonate of lime		Water
$CaCO_3, H_2CO_3$	+	CaO	=	$2\,CaCO_3$	+	H_2O

If only the exact quantity of lime be added to bring about this reaction the water remains non-bactericidal in character, though it has lost its temporary hardness and many of its impurities may also have been mechanically removed during the precipitation of the relatively insoluble carbonate of lime.

If, on the other hand, more than enough lime be added the water is rendered caustically alkaline owing to the presence of an excess of calcium hydrate $Ca(OH)_2$. Such a liquid is actively bactericidal. In the absence of carbonation from the air, and allowing for several days' contact, the excess of lime—CaO—required is exceedingly small—less than one part per 100,000, or 1 lb. per 10,000 gallons. With soft waters the process is cheap, but with those possessing a high degree of temporary hardness it is a good deal more expensive, as such waters cannot be sterilized until the lime has combined with the large amount of bicarbonates present in them. Moreover, it is necessary in such cases to have a greater excess of lime than is actually required for sterilization purposes, as a very small increase in the amount of temporary hardness would at once rob the water of the excess of lime on which sterilization depends.

Having satisfied himself that water could be sterilized by the lime method under laboratory conditions, Dr. Houston then went on to try the process on much larger volumes of water than were employed in his original experiments. Before describing what he himself did in this direction, Dr. Houston explains the results obtained on a large scale with Aberdeen water. It appears that the water used in that city is very soft and that the total supply is about 6¾ million gallons per day. It is abstracted from the River Dee at Cairnton and first passes through an aqueduct one mile long into Invercannie reservoir, which contains 9 million gallons. The lime was made into milk of lime and continuously added to the water just before it entered the reservoir. From the latter the water is conveyed by an aqueduct 18½ miles long to two service reservoirs at Mannofield, which contain 18 million gallons, and also to three small reservoirs for supplying the higher parts of the town. Excluding these small reservoirs, the duration of contact was nominally between four and five days, but actually it was found that some of the water was delivered to consumers within twenty-four hours.

The amount of lime added on the recommendation of Dr. Houston was equivalent to three parts of CaO per 100,000 parts, or 3 lb. per 10,000 gallons. The treatment was begun on February 26th, 1913, at 7 a.m. and finished on March 19th following at 10.30 p.m. The bacterial condition of the water as delivered from the Mannofield service reservoirs before, during, and after the treatment is set out in the following table:—

Date.	Typical B. coli found in
January 10th	50 c.c.
February 17th	5 c.c.
February 19th	5 c.c.
February 21st	10 c.c.
February 24th	100 c.c.
Treatment commenced February 26th, 7 a.m.	
February 26th	10 c.c.
February 27th	10 c.c.
February 28th	50 c.c.
March 1st to March 18th (inclusive)	*Not* in 100 c.c.
March 19th	50 *not* in 100 c.c.
Treatment stopped March 19th, 10.30 p.m.	
March 20th	*Not* in 100 c.c.
March 21st	*Not* in 100 c.c.
March 22nd	5 c.c.
March 23rd	1 c.c.
March 24th	1 c.c.
March 25th	10 c.c.

It will be observed that both before and after the treatment the water contained B. coli in 100, 50, 10, 5, or even 1 c.c., but that during the treatment the bacillus was practically always absent from 100 c.c. of water, which, as Dr. Houston says, is a remarkably good result.

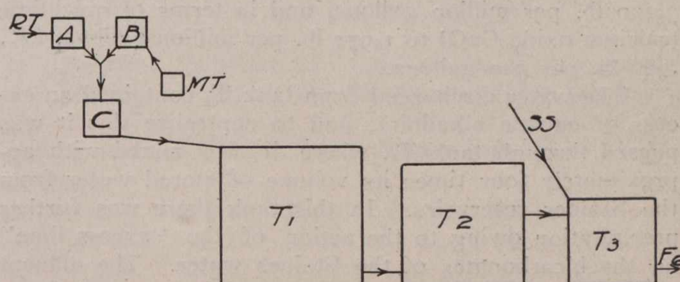


Fig. 1.—Diagram of Sunbury Experimental Plant for Treatment of Thames Water.

It was calculated that of the total amount of lime—3 parts per 100,000—added to the water, the consumer received 72 per cent., or 2.17 parts, as caustic alkali, and 15 per cent., or 0.45 parts, as carbonate of lime, the remaining 13 per cent.—0.39 part—of carbonate of lime having settled in the reservoirs. The presence of the carbonate of lime in suspension was, it is pointed out, of no importance from a health point of view, though it imparted a slight milkiness to the water, and had the treatment been continued might have resulted in the deposition of a gradually increasing coating in the pipes. Whether or not the caustic alkalinity would be injurious to health is another matter, and is open, as Dr. Houston remarks, to argument, though he himself does not think it would do any harm. He adds that the lime water of the British Pharmacopœia contains about half a grain of caustic alkalinity to the fluid ounce. The treated Aberdeen water was fifty times weaker than this. He concedes, however, that it would be undesirable to ask consumers to drink water containing even so innocuous a medicine as dilute lime water, even allowing for the fact that such a liquid is perfectly harmless to practically all persons and actually beneficial for not a few.

Dr. Houston then discusses the experiments which he carried out at Sunbury with Thames water. A diagrammatic sketch of the plant he used is given in the accompanying illustration, in which the various parts are referred to by letters. Raw Thames water was pumped into a tank A, which was arranged to tip periodically a definite volume of water into another tank C, which received with each tip a definite volume of milk of lime from tank B, which latter tank was supplied by hand pumping with milk of lime from tank M T. The mixture of raw water and milk of lime then passed on to the first sterilizing and settling tank T_1 and from thence to the second sterilizing and settling tank T_2. It is explained that the period of contact between the lime and the water cannot be stated with any certainty, as undoubtedly "short-circuiting" took place. Theoretically, however, it was about 1.8 days in tank T_1 and about 1.3 days in tank T_2. The volume of water treated varied considerably owing to certain causes over which there was no control, and the proportion of lime to water was kept nominally as constant as possible throughout the tests; but Dr. Houston states that it is evident from the detailed results that variations did occur. Approximately 167,985 gallons of water were treated per day.

The dose of milk of lime of known strength was such that nominally 1.4 lb. of lime were added to 500 gallons of the water. As a matter of fact, it was discovered at the end of the experiment that actually 1.7 lb. of lime had been used for every 500 gallons. This, stated in terms of slaked lime (calcium hydrate $Ca(OH)_2$), amounts to 3,400 lb. per million gallons, and in terms of quicklime (calcium oxide CaO) to 1,972 lb. per million gallons, *i.e.*, .986 lb. per 500 gallons.

The water discharged from tank T_2 contained an excess of caustic alkalinity, and to neutralize this it was passed through tank T_3, where it was mixed with approximately four times its volume of stored water from the Staines reservoirs. In this tank there was further precipitation owing to the action of the "excess lime" on the bicarbonates of the Staines water. The effluent from tank T_3 was led on to an ordinary sand filter. According to one investigation, the amount of carbonate of lime in suspension as the water went on to the filter was 1.9 parts per 100,000. As far as could be observed, this had no deleterious effect on the filter; but it is pointed out that perhaps the experiment was not continued long enough for the filter to get clogged, and that too much reliance must not be put on the apparent success of this part of the experiment.

The results of the investigation as a whole are set out in numerous detailed tables. With these we need not be concerned in the present instance, but can pass on to the conclusions at which Dr. Houston arrived. He remarks that, apart from questions of subsequent neutralization and filtration, the following results were achieved after sedimentation, as a consequence of the addition of 0.986 lb. of lime, calculated as CaO, to 500 gallons of raw Thames water:—

Chemical Results.—(1) The turbidity of the water was almost entirely removed, apart from slight cloudiness due to suspended particles of carbonate of lime.

(2) The brown color was reduced to a remarkable extent, especially when the river was in high flood.

(3) The ammoniacal nitrogen was increased, but for reasons explained in the report, Dr. Houston does not consider this fact as having any real hygienic importance.

(4) The albuminoid nitrogen was reduced on the average 38.6 per cent. in passing through the first tank.

(5) The oxygen absorbed from permanganate was reduced on the average 53.7 per cent. in passing through the first tank.

(6) The hardness of the water after neutralization of the excess lime by untreated water in the third tank was reduced by 22.7 per cent. (soap test) and the alkalinity by 32.9 per cent. Much more untreated water, however, was added than was necessary to effect exact neutralization. Under ideal conditions of exact neutralization and excluding questions of super-saturation the loss of hardness (soap test) would be over 71 per cent.

Bacteriological Results.—(7) The total number of bacteria was reduced over 99 per cent. in the first tank.

(8) The agar "count" was reduced over 91 per cent. in the same tank.

(9) The bile-salt-agar "count" in the raw water was 50 per 10 c.c., as compared with none per 10 c.c. in the outlet from the first tank.

(10) The B. coli results were remarkable. The raw water yielded the following results:—

Typical B. coli present in—

(*a*) 100 c.c.	(or less)	in	100	Per cent of samples examined.
(*b*) 10 c.c.	"	"	82.5	
(*c*) 1 c.c.	"	"	41.2	
(*d*) 0.1 c.c.	"	"	19.5	
(*e*) 0.01 c.c.	"	"	4.3	

None of the samples from the first and second tanks—ninety-two in all—contained B. coli even in 100 c.c.

Ten experiments were made on ten separate days with 10,000 c.c.—100,000 c.c. in the aggregate—of the water from tank T_2. The results were entirely negative as regards B. coli.

These results, Dr. Houston explains, imply on the (*a*, *b*, *c*, *d*, *e*) raw water basis an improvement of at least:

100	times	in all the samples				
1,000	"	"	82.5 per cent. of the samples			
10,000	"	"	41.2	"	"	"
100,000	"	"	19.5	"	"	"
1,000,000	"	"	4.3	"	"	"

Practically this means that B. coli was absolutely devitalized, a result which, apart from sterilization, cannot be achieved by any known process of water purification

(11) The effluent from the first tank could not conceivably have contained any of the microbes of epidemic water-borne disease—for example, typhoid fever.

General Results.—(12) Apart from its caustic alkalinity and slight turbidity due to calcium carbonate, the effluent from the first tank compared favorably—chemically—with the filtered water as supplied to London, and, bacteriologically, it was far purer, inasmuch as it was seemingly absolutely—not merely relatively—free from excremental microbes.

Of two works sand filtering (*a*) stored river water and (*b*) a mixture of stored river water and "lime-treated" river water, the latter would be likely to give, perhaps actually, and certainly relatively to the initial qualities of the water dealt with respectively, the better chemical and bacteriological results.

Dr. Houston sums up the results in the following words: "No hesitation is felt in expressing the opinion that river water, no matter how impure, may be brought into a condition of absolute safety bacteriologically and of great relative purity chemically by means of lime.

As regards the cost of the chemical, Dr. Houston explains that best Buxton lime calculated as CaO could be delivered at Sunbury Works at 21s. per ton. Enough to treat 1,000,000 gallons—*i.e.*, 1,972 lb.—would cost 18.48s. If 67 per cent. of the water were limed and 33 per cent. of stored Staines reservoir water used for neutralization the cost would be 12.38s., or, say, 12s. 6d. per million gallons. Sixty-seven per cent. of the total volume would then contain no excremental bacteria and the whole of the water would be softened to the extent of about 16 parts per 100,000 c.c.

THE COST OF RAILWAY TIES.

One of the formulas submitted by the tie committee of the American Railway Engineering Association last March gives the annual cost of maintaining a tie as follows:—

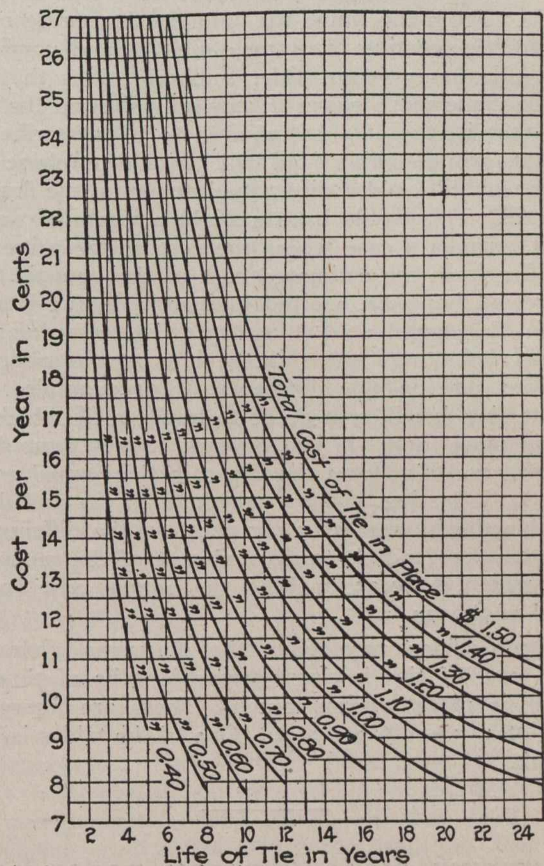
$$I + A = \frac{CR(1+R)^n}{(1+R)^n - 1} = \frac{C(1+R)^n}{\dfrac{(1+R)^n - 1}{R}}$$

or

$$I + A = \frac{\text{Amount of } C \text{ after } n \text{ years}}{\text{Amount of \$1 annuity for } n \text{ years}}$$

C = Final cost of tie in place;
R = Rate of interest;
I = Interest = CR;
n = Life of ties in years;
A = Annual contribution to sinking fund, which at compound interest will provide for renewal at end of life of tie.

Mr. J. G. Sullivan, chief engineer of western lines of the Canadian Pacific Railway, has had three diagrams



Cost per Tie per Year—for Ties Varying in Total Cost and in Length of Life, With Money at 5 per cent. Interest.

prepared to better facilitate the use of this complex appearing formula. The diagrams are for the use of the

Annual Cost of Ties Lasting Various Lengths of Time, Costing in Place Various Sums, Money Figured at 5% Interest.

Life in years.	Cost in Place. $0.40	$0.50	$0.60	$0.70	$0.80	$0.90	$1.00	$1.10	$1.20	$1.30	$1.40	$1.50
1	0.420	0.525	0.630	....	....	....	....	....	....	....	....	....
2	.215	.269	.322	0.376	0.430	0.484	0.538	....	....	....	....	....
3	.147	.184	.221	.257	.294	.331	.368	0.405	0.442	....	....	....
4	.113	.141	.169	.198	.226	.254	.282	.310	.338	0.367	0.396	0.423
5	.092	.115	.139	.162	.185	.208	.230	.254	.278	.301	.324	.345
6	....	.098	.118	.138	.157	.177	.196	.216	.236	.256	.276	.294
7	....	.086	.104	.121	.138	.155	.172	.190	.208	.225	.242	.258
8	....	.078	.093	.109	.124	.139	.156	.171	.186	.202	.218	.234
9	....	....	.084	.098	.112	.126	.141	.155	.168	.182	.196	.210
10	....	....	.077	.091	.104	.117	.129	.142	.154	.168	.182	.195
11	....	....	....	.084	.096	.108	.120	.132	.144	.156	.168	.180
12	....	....	....	.079	.090	.102	.113	.124	.136	.147	.158	.169
13	....	....	....	....	.085	.096	.107	.117	.128	.138	.149	.160
14	....	....	....	....	....	.090	.101	.111	.121	.131	.141	.151
15	....	....	....	....	....	.087	.096	.106	.116	.125	.135	.144
16	....	....	....	....	....	.083	.092	.101	.111	.120	.129	.138
17	....	....	....	....	....	....	.089	.098	.107	.115	.124	.133
18	....	....	....	....	....	....	.086	.094	.103	.111	.120	.129
19	....	....	....	....	....	....	.083	.091	.099	.108	.116	.124
20	....	....	....	....	....	....	.080	.088	.096	.105	.112	.120
21	....	....	....	....	....	....	.078	.086	.094	.101	.109	.117
22	....	....	....	....	....	....	....	.084	.091	.099	.106	.114
23	....	....	....	....	....	....	....	.082	.089	.096	.104	.111
24	....	....	....	....	....	....	....	.080	.087	.094	.102	.109
25	....	....	....	....	....	....	....	.078	.085	.092	.100	.107

engineers and the tie department of the C.P.R. One of them is shown in Fig. 1.

The diagrams show the value of *I* plus *A* in the formula. From this value the annual cost per tie can be taken for ties costing from 40c. to $1.50 and varying in life from 2 to 25 years. Mr. Sullivan states that they could be made much easier if they only showed the value of *A*—that is, the amount required to be subscribed annually to form a sinking fund which would purchase a tie. To this would be added direct the interest on the first cost of the tie. This would have a slight advantage over the present form in a case where the cost of the present tie will differ from the estimated cost of the new tie. The same result, however, can be obtained by taking from the diagram the annual cost, using the estimated value of the new tie, deducting from this the interest per annum at the given rate on this difference. For example, if we estimate that it will cost $0.80 to renew a tie which cost $0.75 in place, and will last 8 years, money figured at 5 per cent., we take from the diagram the annual cost of an $0.80 tie lasting 8 years, which is $0.124 and deduct from this the interest at 5 per cent. on the difference in the actual cost and the estimated cost of the renewal, 5 cents, which is $0.25, making the annual cost $0.1215 instead of $0.124.

Three tables accompany the diagrams giving the annual cost of ties lasting various lengths of time and costing (in place) various sums. These are figured for money at 4, 5 and 6 per cent. One of the tables is given herewith.

MOUNTING BIG GENERATOR ROTOR AND FIELD COILS ON SHAFT.

At the Seebe (Alberta) plant of the Calgary Power Company, two 12,000-volt, 4,200-kv.a. generators were erected with a remarkable saving of time in the following manner, according to Mr. H. F. Johnston, of Banff, writing in the Engineering Record of New York.

Instead of taking four days to put the 27-ton spider on a 15-in. shaft with a 100-ton hydraulic press the erection superintendent made a satisfactory mounting in less than four hours by heating the hub of the spider enough to expand it a little. The cost of mounting the spider in the press would have been $60, while the actual operation performed cost only $5. As time was a most important factor in the contract, the saving of over three and one-half days was of much more value than the small saving of labor.

This spider carried the rotor and field coils. It had to be keyed to a 15-in. vertical shaft directly connected through a coupling to the turbine shaft. The shaft was first mounted, and the coupling bolted up. The spider, on which the field coils had already been mounted, was blocked up about 9 in. off the power house floor. A ring of sand was then built around the outside of the hub, forming a pit under the hub in which a fire of dry pine chips was built. The top of the hub was covered with steel plates to help confine the heat. One man kept tending the fire, keeping it evenly hot all around the hub for three and one-half hours. The spider was then raised by the crane and easily fitted over the shaft. It was quickly turned to the proper position, the key driven home, and the mounting completed. The job proved entirely satisfactory, and the 100-ton press sent out by the contractor to comply with the specifications was returned unused.

A LARGE ELECTRIC HOIST.*

By Wilfred Sykes.

THE mining conditions in Butte, Mont., require the handling of large quantities of ore from depths of 2,000 to 4,000 ft., and eventually from 5,000 ft. In the past steam hoists were used, but the difficulty of getting good water supply, and the high cost of fuel, made their operation expensive. A few years ago an attempt was made to decrease the cost of operation and still utilize the greater portion of the existing hoists, by arranging them for compressed air operation. The air hoist has the same characteristics as the steam hoist, and is, therefore, not very satisfactory from the standpoint of manœuvering.

Recently the North Butte Mining Co. put into operation a new shaft and decided to use an electrically driven hoist instead of compressed air. The new shaft will be finally sunk to a depth of 5,000 ft., and the requirements of the hoist are representative of the conditions in the Butte field. The operating conditions are as follows:—

Depth of shaft—4,000 ft., eventually 5,000 ft.; net weight of load, 14,000 lb.; weight of skip and cage, 9,000 lb.; size of rope, 1⅝ in.—4.1 lb. per ft.; drums, 12 ft. in diameter. Maximum hoisting speed, 3,000 ft. per minute. Normal hoisting speed, 2,700 ft. per minute.

Owing to the fact that the power peaks are approximately 4,500 h.p., and, under the conditions that power is purchased in Butte, the cost would be excessive if a hoist operated by an induction motor were installed, it was decided to use a flywheel motor-generator set which would limit the input to the equipment, the peaks being carried by the flywheel. It was not attempted to install a flywheel of sufficient capacity to completely equalize the load, as this would have required a much larger wheel than the one installed and the continuous losses would have been very greatly increased. It was estimated that by the use of a 50-ton flywheel the input to the hoist could be limited to the following figures during normal operation:—

Depth—2,000 ft.	3,000 ft.	4,000 ft.
Input—1,250 h.p.	1,420 h.p.	1,850 h.p.

The efficiency of electric hoisting with this system is naturally lower than if the power were utilized more directly, due to the conversion and friction losses.

The hoist consists of two drums, each fitted with a clutch, post brake and band brake. The drums are mounted on a shaft supported by three bearings, the shaft having a flanged coupling to connect to the motor shaft. The clutches and post brakes are operated by oil cylinders, the pressure being supplied by an accumulator with an electrically operated triplex pump. The band brakes are operated by hand wheels. All of the operating levers are grouped on a large elevated platform with double stairways. The control and reverse levers are separate, but so interlocked that when the control lever is in the "on" position the reverse lever cannot be moved.

The safety devices include a mechanism for moving the control lever to the "off" position when the skip has

* From a paper to be presented at the Panama-Pacific Convention of the American Institute of Electrical Engineers, San Francisco, Cal., September 17, 1915.

reached a predetermined point, holding this lever in this position until the reverse lever has been moved to its opposite position, the operator being thereby prevented from starting the hoist in the wrong direction.

There are two solenoids which automatically apply the post brakes if the skip is carried too far after the current has been cut off.

An indicator with a large dial is provided for each drum, and for accurately spotting the skip or cage, the brake rings on the drums next to the middle bearing are extended 8 in., affording a large surface on which to paint marks.

On the platform there are mounted in front of the operator a panel holding a voltmeter and an ammeter, also a target, which is connected to the reverse lever, showing which drum is hoisting. Grouped around the sides of the platform are the signal gongs, lights and telephone.

The drums are 12 ft. in diameter by 9 ft. 4 in face, each with turned grooves to hold 5,000 ft. of 1⅝-in. rope in two layers. The drum shell, brake rings and spiders are made of cast steel, the latter being fitted with heavy bronze bushings, each bushing being provided with four large grease cups for lubrication.

The clutches are of the flat friction type, consisting of two heavily ribbed annular rims faced with wood, supported on a six-arm spider keyed to the shaft. These rings clamp a flat steel plate bolted to the drums. and are moved by six sets of toggle arms connected to a sliding sleeve and rock shaft and operated by an oil cylinder. All of the parts of the clutches are made of steel. The clutches are designed to take a load of 50,000 pounds on a 12-ft. diameter, and all of the parts are figured for a factor of safety of not less than eight. The clutches and the motor were subjected to a load of two and a half times their rated capacity and under this load developed no weakness.

The post brakes are made of plates and angles in the form of a box girder, and are lined with basswood blocks readily renewed. The post brakes are the parallel acting type applied by gravity and released by oil cylinders.

The band brakes are for emergency service and are operated by means of hand wheels and screws. Proper provision has been made for operating these by power later on if desired.

The bearings for the drum shaft are of the pedestal type, with quarter boxes adjusted both vertically and horizontally. They are lubricated by a continuous gravity feed oiling system, with the necessary tank, filters and pump, the latter being driven directly from the drum shaft, oil being supplied to the bearings whenever the hoist is in operation.

The drum shaft is of open-hearth forged steel, 22 in. in diameter by 40 ft. 5½ in. long, and has a flanged coupling forged at one end to be connected to the motor shaft. All of the operating connections and auxiliaries are placed on or above the floor level in full sight of the operator, so that any derangement of any of the working parts can be quickly observed.

The combined weight of the drum shaft with the two drums and two clutches is 300,000 pounds. The radius of gyration is 4.86 ft.

The hoist is driven by a direct-connected direct-current motor running at about 71 rev. per min. normal, which is mounted on sole plates built into the foundations. The motor is wound for 600 volts and has 16 poles. The armature is 10 ft. in diameter, the outside diameter of the frame being 14 ft. 1 in. The motor will develop 5,000 h.p. for short periods without injury, and particular care is taken to build a machine that would stand high temperatures without injury. The frequency of hoisting and the duration of the hoisting period is somewhat uncertain, and as a factor of safety, mica and asbestos insulation has been used throughout the machine. The armature coils are all mica insulated and the field coils are copper strap wound on edge, with asbestos insulation. The insulation is such that an ultimate temperature of 150 deg, cent. could be carried without injury. For hoists of this size it is important to guard against failures of insulation due to temperature, as the ventilation of the motor due to the periods of rest and the slow speed when running is not particularly good. The total weight of the rotating part of the motor is approximately 70,000 pounds and the radius of gyration is 4.1 ft. The motor is separately excited at 250 volts.

The motor generator set supplying power to the hoist motor is driven by a 1,400 h.p., 2,200-volt, 60-cycle induction motor, 14 poles, running at a maximum speed of about 505 rev. per min. The generator is designed to deliver about 6,000 amperes during period of acceleration at a maximum of 600 volts. It is connected solidly with the motor, the control of the speed and the direction of rotation being by means of the excitation on the generator. To enable the peak loads to be satisfactorily commutated, on account of the high speed, a commutating machine with interpoles was built. The armature has a diameter of 66 in., and the field has 10 poles, so that during acceleration peak period 1,200 amperes are collected by brush arm. The generator is arranged for separate excitation at 250 volts, from the direct-connected exciter. As the speed of the set varies during operation and it is desirable to maintain a constant exciter voltage, an automatic voltage regulator was installed for this purpose. Mounted between the motor and the generator is a steel plate flywheel having a diameter of 12 ft. and a weight of 100,000 pounds. The peripheral speed of the wheel is about 19,000 ft. per min., and it is built up of steel disks cut from solid plates, the disks being held together by rivets. The wheel is shrunk on the shaft and finished all over. It is protected by a case which completely encloses it. This case reduces the windage very appreciably, and also affords mechanical protection. The flywheel is carried by two water-cooled gravity-feed lubricated bearings, 18 in. in diameter by 46 in. long. In spite of the high bearing speed of about 40 ft. per sec., the bearings run quite cool. The flywheel and its shaft are built up as a unit, the shaft having a forged flanged coupling at each end to which motor and generator are coupled. In case any repairs are necessary to the motor or generator, the rotating parts can be removed without disturbing the flywheel. The whole of the set is mounted on a bedplate built into the foundation. The speed of the set during operation is controlled by an automatic slip regulator. This is also used for starting the set, and the input for which it is adjusted can be readily changed by varying the amount of the counterweight.

This hoist is noteworthy, as it is the largest electrically-operated hoist in the United States or Canada, and it marks a decided departure from previous practice in handling large quantities of ore in the metal mining fields.

HANDY APPROXIMATIONS IN HARNESSING THE SMALL STREAM.

By J. A. Macdonald, Ottawa, Ont.

IN the early days practically all manufacturing plants were located on the banks of streams. The grist mill, the carding mill, the tannery, the early established woollen mills, not to speak of the saw-mills; in fact, all primary industries depended upon the flow of water to drive their machinery. The coal became king and the advent of the steam engine made it possible to build factories away from the streams. Land values increased until territory within cities that was covered with water inpounded for power purposes was drained and used as building sites. Next the gas and oil engines made it possible for those using minimum powers to have the power close at hand at a fairly cheap rate. Thus we find many abandoned mill-sites throughout the country and a greater number that were never developed, simply because they were too small for commercial purposes. The ease with which electrical energy is now distributed, particularly in southwestern Ontario, and the demand for this remarkable agent by farmers and other small users of power, to run his light machinery, and to illuminate his buildings, is leading to the development of the small power plant. The small stream is coming to its own for this purpose. A comparatively small stream with a steady flow will do a surprisingly large amount of work if properly harnessed. There are thousands of small towns and villages in the country that could obtain the advantages of electric lighting if the near-by stream were but harnessed and turned into a hydro-electric plant, and that at the cheapest possible rate.

Determining the Capacity of the Stream.—The first thing to determine in examining a stream is the flow of water; that is, the amount of water passing a given point each minute. The amount of fall is secondary, for the success of the installation of a water wheel depends upon the water that is available to flow over it continuously. Often where the stream is small and pondage can be secured, enough of water can be stored in 24 hours to

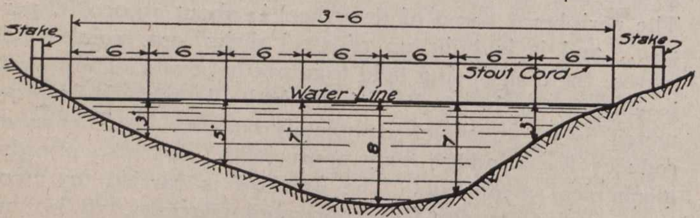


Fig. 1.—Measuring Cross-section of Stream.

supply the wheel for a few hours each day, running at full capacity.

If a power is desired the full year, only the minimum flow of the stream should be considered. The flow during the months of July and August usually represents the lowest stage of stream flow. The flow may be measured by two distinct methods, the first being the weir method, and the second by determining the velocity of flow of the stream and the cross-sectional areas at the place where the velocity is measured. The weir method is simple and practicable in many cases for the reason that a weir may be constructed with but little trouble. The chief requirement being watertightness, it is necessary to bed the planks well into the banks of the stream so that all the water passes over the notch. The notch must be level and must be sharp. In measuring the water it will be noted that the depth is measured a short distance up-stream from the weir in order that the true depth may be secured.

When the water is, say, six inches deep over the crest of the weir, each square inch represents close to one cubic foot of water per minute. For example, each inch in width of the weir would represent six cubic feet of water per minute, and if the weir were 15 inches in width, the total flow would be 6 x 15, or 90 cubic feet of water per minute. Below six inches in depth, the amount per square inch of section will be less than one cubic

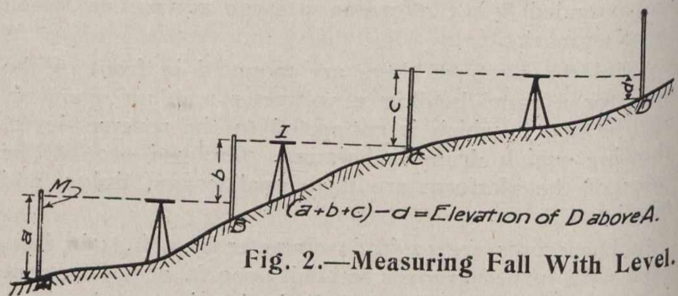


Fig. 2.—Measuring Fall With Level.

foot, and above six inches in depth, the amount will be more. For a rough average, it may be taken the same for all depths. When furnishing data for a manufacturing concern, it is necessary for the engineer to know the width of the notch and the depth of flow.

The second method of measuring stream flow is fairly accurate if some care is taken. Lay off a distance of, say, 100 feet in a straight line on the bank of the stream and parallel to it. Drive stakes at the points thus established. By dropping a small stick or cork in the stream and timing it between the two stakes, the velocity of flow in feet per minute may be determined. Many trials should be made and the average taken, this average being the surface velocity. The velocity beneath the surface is not quite as great, hence we multiply the average surface velocity by 0.8 to get the mean velocity.

Next determine the average depth, and multiply it by the average width. The cross-sectional area in square feet multiplied by the velocity of flow in feet per minute will give the stream flow in cubic feet per minute. Fig. 1 shows how to get the average depth which in this case is 4.71 feet, derived thus,

$$\frac{3+5+7+8+7+3 \text{ (vertical measurements)}}{7 \text{ (number of divisions)}}$$

An effective way to obtain the head or fall in feet of a stream is to sight across or through a level, (even a carpenter's level would answer). Measure the distance from the point sighted to the water surface and the result will be the difference in level between the two points, after the distance of the level above the surface of the water at the sighting point has been subtracted from it. A more accurate way is illustrated in Fig. 2. "M" representing the measuring pole, the staff of the level is pushed firmly into the ground and when the bubble is in the centre of the tube (transit answers best for this work), sight across towards the pole, the point sighted reading the distance or height. The method of obtaining the difference in elevation is apparent from the figure.

Horse-power.—The theoretical horse-power may now be determined by multiplying the head in feet, cubic feet of water per minute, and the weight of one cubic foot of water (62.5 pounds). Divide the product of these three by 33,000 and the quotient will be the theoretical horse-power. Counting the losses through friction and other causes, the power actually delivered by the water wheel will be about seven-tenths of the theoretical horse-power.

PURIFICATION OF WATER BY DISINFECTION.

THE establishment of practical methods of disinfection of water during the past few years has marked one of the most important epochs in the development of the art of water purification. At the present time disinfection of polluted municipal water supplies as the only method of treatment or as an adjunct to other methods of purification is practiced quite generally. The disinfection of water supplies which are temporarily used has also grown to be a customary procedure. Water supplies for private, military and construction camps, summer homes and resorts, hospitals, etc., are frequently polluted and in an attempt to render such supplies of safe sanitary quality disinfection has been adopted as the practical method. In view of the great development which has taken place in the art of purification of water by disinfection there is much of interest in a discussion of the methods which have been attempted and which are now in use. Mr. W. H. Dittoe, chief engineer of the Ohio State Board of Health, has written in the Journal of the Board a concise review, to which we are indebted for the following:—

A water supply is of perfect quality when its physical, chemical and hygienic characteristics are satisfactory. Rarely is such a water found, and to attain this standard, it is generally necessary to provide some form of treatment. The object in the treatment of the supply may be to improve its physical quality, chemical quality, or hygienic quality, but in most instances, especially if a surface source is used, the supply will be found faulty in more than one respect. To produce a water of entirely satisfactory quality in such cases, the treatment must provide for the correction of each deficiency.

The improvement of the physical quality of a water may require the removal of turbidity, odor and taste and the reduction of dissolved color. The improvement of the chemical quality of a water may include the removal of excessive amounts of iron, manganese, acidity, or hardness. The improvement of the hygienic quality of water involves the removal of bacteria, particularly those which are pathogenic.

Treatment of Water.

Purpose.	Content to be removed or reduced.	Methods of Improvement.
Improvement of Physical Quality.	Turbidity. Odor. Taste. Color.	Plain Sedimentation and Storage. Coagulation and Sedimentation. Softening. Filtration. Aeration. Disinfection.
Improvement of Chemical Quality.	Iron. Manganese. Hardness. Acidity.	
Improvement of Hygienic Quality.	Bacteria.	

A number of methods of improvement of the quality of water supplies has been developed. The improvement of physical characteristics of water received first attention, but since development of the germ theory of disease particular attention has been given to the improvement of hygienic quality. Of more recent occurrence has been the development of methods of the improvement of the chemical quality of water supplies. In a general way it may be stated that water supplies are improved by the following methods: Plain sedimentation and storage, coagulation and sedimentation, softening, filtration, aeration, disinfection.

The above methods are practiced individually as listed, or in various combinations to secure the improvement of the water supply desired. In fact, all of the above methods may be used in the treatment of a single water supply to improve a water which is deficient in physical, chemical and hygienic quality.

For the purposes of this discussion we are particularly interested in the last mentioned method, disinfection. This method is practised in the treatment of public water supplies alone or in combination with other methods of treatment and is also extensively used for quasi-public and private water supplies.

Extensive studies have been conducted by various investigators in this country and abroad to determine the efficiency and practicability of numerous agencies of disinfection. Clark and Gage conducted a research of disinfectants for water and sewage in 1907, 1908 and 1909, trying permanganate of potash, bleaching powder, formaldehyde, hydrogen peroxide, boric acid, benzoic acid and sodium benzoate, phenols, corrosive sublimate, copper salts and many others. Rideal mentions citric acid, iodine and cuprous chloride among other available disinfectants. Parkes and Rideal have recommended sodium bisulphate as a practical disinfectant for water. Many other chemicals and agencies of disinfection have been proposed and used to a limited extent and with varying results.

During the last ten years much careful study and attention to this important subject has been given with the result that we have now available practical methods for disinfecting water on a large scale for municipal supplies as well as on a small scale for individual use.

In this discussion a number of disinfectants which have been studied and used to a limited extent will be omitted and only the following agents will be considered: Heat, copper and its salts, permanganates, ozone, hypochlorites and chlorine, lime. the ultra violet ray.

Heat.—By boiling or distillation water may be rendered safe for domestic use. This fact has been recognized for many years and the method has been used extensively to render polluted water supplies safe for drinking. It has rarely been employed for the purification of public water supplies, although at Troon, Scotland, at Perim and Kossier on the Red Sea and in several South American cities, quite extensive plants for the distillation of water are in use to convert salt water into a potable supply. The method is also employed generally on seagoing vessels to furnish a water supply for all purposes. Distillation of water renders it free from bacteria and practically pure from a chemical standpoint. Distilled water has an unsatisfactory flat taste, but by aeration this defect is partially corrected.

Claims have been made occasionally that distilled water is too pure and hence not adapted for drinking purposes. It appears, however, that these statements are not based upon physiological principles or clinical experience.

Boiling of water renders it satisfactory from a hygienic standpoint. It is known that pathogenic bacteria are killed by a temperature of 60° C. maintained for 20 minutes and only the most resistant organisms can exist at the temperature of boiling. No diminishment of the organic content of the water results. The dissolved gases, including carbon-dioxide, are expelled, bringing about a partial softening of the water due to the precipitation of carbonates. By boiling and sedimentation a degree of clarification of turbid water may be brought about.

In cities having polluted water supplies, boiling of water for drinking purposes by the individual consumers is a safe procedure generally recommended by health authorities and waterworks officials. The method can also be practiced by travellers and campers at slight expense and inconvenience. It is generally conceded that the disinfection of municipal water supplies by boiling is impracticable due to the expense involved.

Several types of devices have been developed for the sterilization of water by heat. These are adapted to individual use and also to the purification of large quantities of water to serve in case of epidemics. Recently a French manufacturer has marketed an apparatus for use in households, schools, hospitals, etc., which produces sterilization by heating water under pressure to a temperature of 115° C. without causing boiling.

During the World's Fair at Chicago in 1893, sterilized drinking water was used by 15,000 employees. The sterilization was effected by passing the water through boiler feed water heaters where it was raised to a temperature of boiling and held at this point for a short time. No typhoid fever occurred while this water was being used, but intestinal disorders arose during interruptions of operation of the sterilizer.

Copper.—In 1904 copper as an algicide and disinfectant for water supplies was studied by Moore and Kellerman of the U.S. Department of Agriculture. The results of these studies led to the conclusion that copper and its salts were active algicides and also effective as agencies for disinfection. The report of the studies indicated that metallic copper placed in water was effective in bringing about complete sterilization in from 3 to 48 hours. Subsequent studies, however, demonstrated that the efficiency of copper and its salts as a germicide was much less than as an algicide and that its action was easily inhibited by the presence of both organic and inorganic substances. The use of copper does not prevent or even materially reduce putrefaction and tastes and odors resulting from it. At the present time it is not generally accepted as an efficient disinfectant for water, although it has been used with favorable results in connection with ferrous sulphate in water treatment.

Permanganates.—Sodium, potassium and calcium permanganates have been used at various times to disinfect water. The permanganates are powerful oxidizing agents to which is attributed the bactericidal action. Permanganate of potash has been used extensively in India for the disinfection of private wells during cholera epidemics and has been efficient in checking the spread of the disease. It was also used during the Boer war to disinfect drinking water for the British troops in the field and is employed in the treatment of the public water supply of Bloemfontein, South Africa. It has been studied by the Massachusetts State Board of Health, at the Lawrence Experiment Station, the results of which study indicated that the application of 5 parts per million effected a satisfactory reduction of total bacteria, but was inefficient in reducing bacteria incubated at body temperature.

In its use the potassium permanganate is dissolved in the water to be treated in an amount to produce a faint pink color, which indicates that an excess of oxygen is present. The organic matter present in the water is oxidized before the bacteria are affected and for this reason many authorities do not favor the use of permanganates for the treatment of polluted water supplies. It appears that permanganate may have some value in purifying relatively small quantities of drinking water, but due to its doubtful efficiency and high cost, its use for disinfection of municipal water supplies will always be limited.

Ozone.—The utility of ozone as a germicide has been known since 1886, although its application in water treatment has been of recent occurrence. In Europe several large installations have been made for the treatment of municipal water supplies in conjunction with filtration, notably at Paris and at Petrograd. Plants have also been installed at Lindsay, Ontario, and Ann Arbor, Michigan, but the process has not been extensively employed on the American Continent. The use of ozone as a method of disinfection of the water supply of Montreal was considered, but discarded in favor of cheaper and more satisfactory methods of disinfection. A small ozone plant as an adjunct to a rapid sand filter plant for the office building of the Chicago, Burlington & Quincy Railroad of Chicago was installed in 1914 to disinfect the drinking water supply for some 3,000 persons.

Ozone is a modified form of oxygen produced by the passage of an electric current through air. It is a powerful oxidizing agent and an active disinfectant. The ozone is conducted into the water to receive treatment with which it mixes and causes the death of the bacteria contained. A number of ozonators have been developed in Europe and have been used with varying degrees of success. Considerable difficulty has resulted in securing constancy of production of ozone, and a proper mixture of the ozone with the water, which are necessary to produce a satisfactory efficiency. The cost of the treatment is reported to be excessive, being estimated by the city engineer of Paris at $6 to $7 per million gallons. In the face of more efficient and less costly methods of disinfection, it does not appear that ozone will be extensively used in the future. It is not generally considered as an available means for disinfection of the water supply in the household. A small household ozonator has been developed, but has not been extensively employed for water treatment.

Chlorine.—The use of chlorine as a disinfectant has developed entirely during the 19th century and has followed closely the commercial production of bleaching powder. It is available in the form of calcium hypochlorite, sodium hypochlorite and liquid chlorine. The efficiency of chlorine as a disinfectant was recognized as early as 1854 by the Royal Commission on Sewage disposal of the British Government. Experiments in the disinfection of sewage by hypochlorites were conducted in Germany, England and the United States from 1897 to 1907 and its first use in water disinfection was in 1897 at Maidstone, England. Previous to 1908 chlorine in its various forms had been used for intermittent treatment of water supplies and disinfection of distributing systems, but had not been adopted as a continuous method of treatment. Following extensive studies at Chicago and Boonton, New Jersey, in 1908, the use of hypochlorite of lime as an agency for continuous treatment of a public water supply was adopted. Since that time the method has been introduced in over 300 cities in this country. It is employed extensively as the only method of treatment of the supply and in numerous cases as an adjunct to other purifying processes. In Ohio 19 water supplies serving a total population of 1,800,000 receive treatment by chlorine in the form of calcium hypochlorite, or as the liquid. Of these, 10 are filtered supplies.

Calcium hypochlorite bleach, bleaching powder, or chloride of lime, as it is variously known, is a soluble white powder which in solution and in the presence of carbonic acid gas forms an unstable hypochlorous acid which acts upon organic matter and bacteria, destroying the latter by oxidation. The only compound which remains in the water as a result of the treatment is a small quantity of calcium chlorine which is inert and harmless. The nascent oxygen formed by the breaking down of hypochlorous acid is the active agency of disinfection. Sodium hypochlorite is formed by the action of an electric current on a salt solution. The hypochlorite in solution acts in a manner similar to calcium hypochlorite as previously described. Liquid chlorine is marketed in steel cylinders holding about 100 to 125 pounds of the liquid under a pressure of about 100 pounds per square inch. Various types of apparatus have been developed for applying liquid chlorine to the water to be treated. In general, these involve permitting the discharge of the chlorine from the cylinder under control and applying it in a measured amount to the water. The action of chlorine is similar to that of the hypochlorites with the exception that in the formation of hypochlorous acid no calcium or sodium salts are introduced.

In the use of chlorine and chlorine compounds for the disinfection of water it is customary to express the degree of treatment in terms of available chlorine. Commercial bleaching powder contains about 35% available chlorine, while the liquid form is practically 100% available chlorine. Five-tenths part per million, more or less, is used in the treatment of water. The amount required depends upon the pollution and physical quality of the water. The amounts used in this country vary from about two-tenths part per million to two parts per million, the latter being used in the treatment of the turbid Missouri River water. For clear waters it is generally found that one-half part per million is sufficient.

It is important to observe that the disinfection action is one of oxidation and not chlorination, as it is frequently expressed. While the chlorine is the important agent necessary to effect oxidation, the oxygen itself is the agency which destroys the bacteria.

In the use of bleaching powder it is customary to dissolve the chemical in a proportion to give a solution of about 1% strength, that is, 1 lb. of bleaching powder to 100 pounds of the solution. This solution is stored and applied to the water through various types of measuring and controlling devices.

The efficiency of chlorine in its various forms as an agency of disinfection of water has been firmly established by analytical results and by typhoid fever statistics in communities in which it has been used. It does not, however, take the place of filtration as a method of purification of water supplies. The treatment does not affect the appearance of the water and has no beneficial effect upon chemical quality. The province of its use is limited and it is not to be considered a universal remedy for all polluted water supplies. It is the consensus of opinion among water supply experts that it is most properly adapted as an adjunct to filtration and as an emergency method of rendering a polluted water safe for use. Several state boards of health, including those of Minnesota and Kansas, have devised portable outfits for the emergency treatment of polluted water supplies. These outfits are transported and used temporarily to check typhoid fever outbreaks. This method of disinfection is also available as a means of purifying private and camp water supplies. It has been proposed to use capsules of hypochlorite for the disinfection of small quantities of water used for drinking purposes in the household, by travellers and in temporary camps. It should be observed that the use of capsules for rendering a polluted water supply safe for drinking purposes is subject to considerable uncertainty depending upon the application of proper amounts of the chemical and upon the characteristics of the water treated.

Lime.—Quick lime, CaO, has been used in the treatment of water for a number of years. For excessively hard waters it has been used for softening purposes and for very soft waters of high acidity it has been employed to correct corrosive action. In the treatment of the water supply of London it became apparent that the use of lime was of assistance in securing bacterial efficiency. In 1911 extensive studies were carried on by Dr. A. C. Houston, Director of Water Examination of the Metropolitan Water Board, which led to the conclusion that treatment of the water by quick lime in an amount sufficient to cause an excess of CaO of .007% resulted in the destruction of B. coli in from 5 to 24 hours. Dr. Houston attributed this disinfection action to the toxic effect of the lime and therefore advanced a method of treatment of water which had previously not been recognized. He proposed that about 75% of the water supply should receive the excess lime treatment, the caustic alkalinity being neutralized by the addition of 25% of the total supply comprising water previously purified by storage or disinfection by some other agent. At the water softening plant in Columbus lime treatment has been employed continuously. The same efficient bacterial results reported by Houston have been noted by Mr. C. P. Hoover, chemist in charge of the Columbus plant. These results have been attributed not necessarily to the toxic effect of the excess lime or caustic alkalinity, but to the natural death of the organisms following the depletion of free carbonic acid resulting from the lime treatment. It is stated that the excess lime treatment is unnecessary and that equally efficient results are secured by treatment with lime sufficient to neutralize the free and half-bound carbonic acid in the water.

While this method of disinfection of water has been carefully studied, several important features of the treatment remain to be demonstrated. Its bacterial efficiency has been shown, but its universal applicability has not been proven. The principal objection which has been advanced relates to the cost of the treatment necessary to secure disinfection. In this connection, however, due credit should be given to the beneficial softening effect also produced by the treatment. Its use as an available method for purification of water supplies for private use has not been demonstrated.

The Ultra Violet Ray.—The application of artificial light as a method of water disinfection was studied as early as 1878. The use of the ultra violet ray for this purpose has, however, been a development of recent years. About 1908, following extensive studies at the Sorbonne, Paris, a mercury vapor arc inclosed in a fused quartz lamp was developed. This lamp permits the passage of the ultra violet ray into the water which is passed within a few inches of the arc. By the action of the ultra violet ray it is claimed that bacterial organisms are killed. The method has been used for several public water supplies and in numerous hospitals, clubs, railway stations and private residences abroad. Data have been presented to show the efficiency of the treatment when a clear sparkling water is handled. It is important to observe that the efficiency depends upon the freedom of the water from turbidity or dissolved color. The Austrian army uses a special field apparatus for pumping, filtering and sterilizing by means of the ultra violet ray the drinking water for troops. In this country the ultra violet ray, as an agency for disinfection of water, has not been extensively adopted. A water company in Chicago filters and disinfects by the ultra violet ray, water obtained from the municipal supply markets the same as a drinking water of satisfactory hygienic quality.

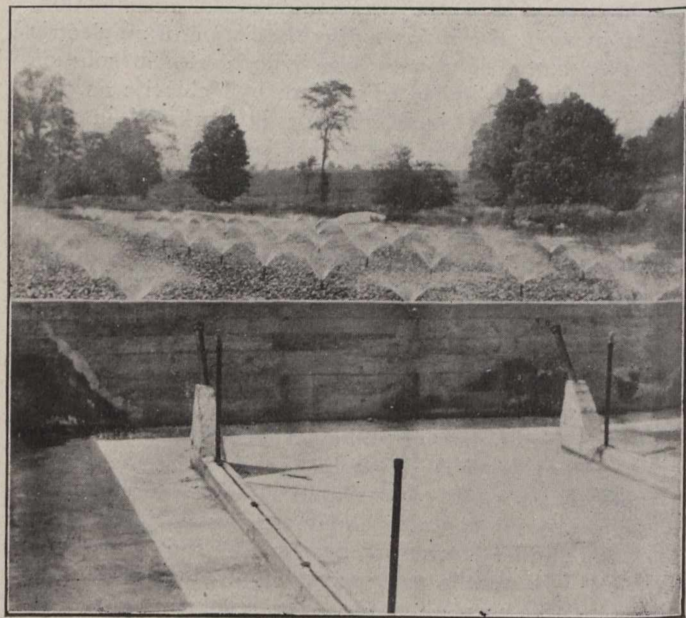
An installation is now being made at Corning, New York, for the treatment of the municipal supply and it is to be hoped that accurate data on the efficiency and cost of the process will soon be available. The advantages claimed for this method of disinfection are that it is efficient and easily operated, and that no chemical is introduced into the water supply. The principal objection to its use has been the excessive cost involved, which has apparently made it an impracticable method in comparison with other agents of disinfection.

STRATFORD (ONT.) SEWAGE DISPOSAL PLANT.

The problem of sewage disposal in Stratford has always been a vexed question, primarily on account of the small flow in the Avon River during the summer months, thus requiring as fine a purification as may be obtained. From time to time additions and alterations have been made in the plant until now sewage is treated by screening and removing detritus, by the use of the double chamber sedimentation tank and by continuous filters. All of the sewage is pumped before distribution on the filtering beds.

The latest addition to the plant is the screening and grit chambers and the sedimentation tank. This work was let by contract in July, 1914, and completed in July, 1915, being executed by Mr. Geo. B. Moogk, Weston, Ont., the contract price being $16,000.

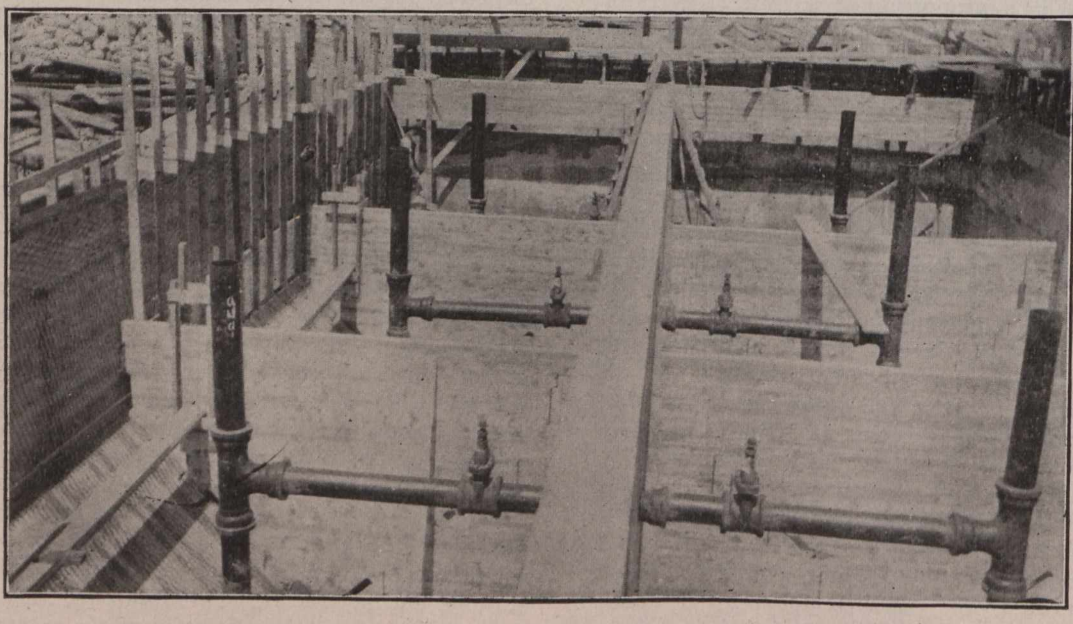
The tank is 86 ft. 8 in. long by 43 ft. 4 in. wide over all and 24 ft. 8 in. deep. It is divided in the centre by a wall, making, if need be, two separate tanks, each tank in turn being divided into four compartments. Each tank is divided throughout by aprons running lengthwise and sloping to the centre forming a double chamber, being so arranged to allow sludge to pass below but not the reverse. Each compartment is made with a hopper-shaped bottom to collect the sludge, and is divided from the next by a four-inch reinforced partition wall. The sewage is carried by means of channels from the screens and discharged over submerged weirs set in the tank ends and drawn off in a similar manner at the opposite end. By means of a system of gates the flow in the channels can be reversed, thus reversing also the flow through the tanks and giving a more evenly distributed sludge content.



Sprinklers in Operation at the Stratford Sewage Disposal Works.

The digested sludge is removed by means of cast iron water pipes from each compartment, collecting to a main pipe in the centre wall which in turn leads to the sludge beds.

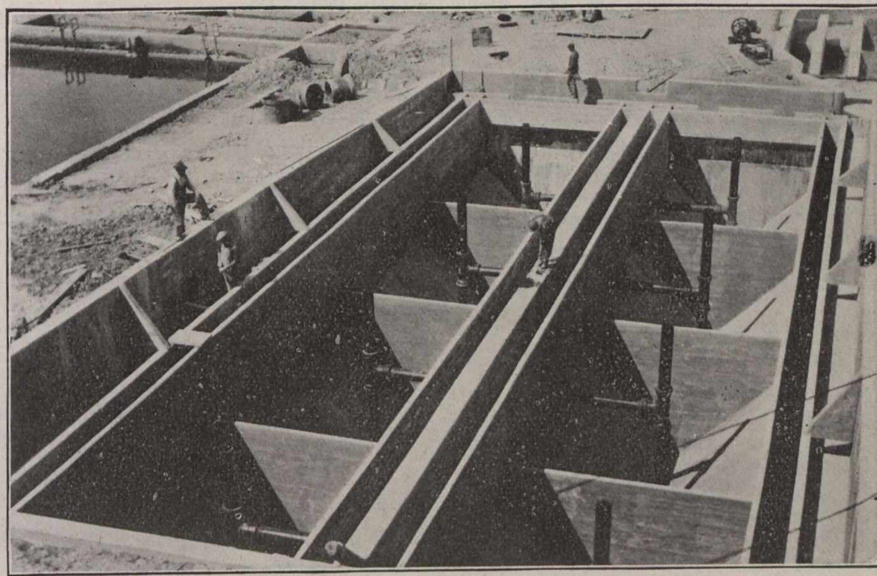
The tank's walls and floors are constructed of a



Tank Under Construction, Showing Form Work and Reinforcement.

1:2:4 mix of concrete. The interior walls being reinforced vertically with ¾ round iron spaced 9-inch centres inside and out, and horizontally spaced 2 feet centres. The aprons, partition, walls and channels are built of a 1:1:2 concrete and reinforced with No. 10 mesh expanded metal.

The upper or sedimentation portion of the tank has a capacity of 132,000 gallons and a flow through a period of approximately one hour. The lower or sludge-receiving chambers have a capacity of 85,000 gallons and will be drawn off four times a year.



Sedimentation Tank Newly Added to Sewage Disposal Works.

From the sedimentation tank the sewage is run to a low-level storage tank, from which it is raised some sixteen feet by an electrically driven centrifugal pump aided by a gasoline-driven auxiliary pump each of an 850 Imperial gallons per minute capacity, to a high-level storage tank. From this tank the sewage is delivered by gravity over filter beds of graded crushed stone 4½ feet deep. The sprinklers are of the Columbus type and are spaced at 15-foot centres. The beds are so arranged that any one or all may be in operation at once. By means of underdrains the effluent is collected and carried to the river. The general design of the tanks is clearly shown in the illustrations.

We are indebted to Mr. A. B. Manson, B.A.Sc., city engineer, for the information and views of the plant.

PENNSYLVANIA RAIL SPECIFICATIONS.

The following are the sections relating to chemical composition of the revised specifications for 100-lb. carbon steel rails of the Pennsylvania Railroad:—

Chemical Composition of Rail Steel.—4. The chemical composition of the rails rolled from each melt of steel, shall be within the following limits.

Elements.	Bessemer Process.	Openhearth Process.
Carbon	0.45 to 0.55%	0.60 to 0.75%
Phosphorus...	not to exceed 0.10%	not to exceed 0.04%
Manganese ...	0.80 to 1.10%	0.60 to 0.90%
Silicon	0.05 to 0.20%	0.10 to 0.30%

Note 1—In the event of nickel and chromium being present to the extent of 1% and 0.35% respectively, these elements will be considered as the equivalent of 0.07% of carbon in the above requirements.

Note 2—When the analyses for carbon by the mill chemists and by the railroad chemists do not agree, a tolerance of two points below the minimum or two points above the maximum will be allowed to cover such variation before condemnation.

5. It is desired that the percentage of carbon in an entire order of rails shall average as high as the mean percentage between the upper and lower limits specified.

Analyses of Rail Steel.—6. In order to ascertain whether the chemical composition is in accordance with the requirements, analyses shall be furnished as follows:

(*a*) For Bessemer process, the manufacturer shall furnish to the inspector, daily, carbon determination for each melt before the rails are shipped, and two chemical analyses every 24 hours, representing the average of the elements, carbon, manganese, silicon, phosphorus and sulphur, contained in the steel, one for each day and night turn respectively. The analyses shall be made on drillings taken from the ladle test ingot not less than ⅛ in. beneath the surface.

(*b*) For openhearth process, the makers shall furnish the inspectors with a chemical analysis of the elements, carbon, manganese, silicon, phosphorus and sulphur, for each melt.

(*c*) For openhearth process, a check analysis will be made by the purchaser of a piece of rail representing a melt, after the rails from that melt have passed the physical requirements. On request of the inspector, and in his presence, the manufacturer shall furnish from one of the drop-test pieces representing the melt, drillings satisfactory to the inspector, taken with a ⅝-in. flat drill, parallel to the axis of the rail, at a point one-third of the distance from the upper corner to the centre of the head (designated as point "O"). The analysis from these drillings shall conform to the chemical requirements specified in Section 4, and failure to meet these requirements shall be sufficient cause for the rejection of the entire melt.

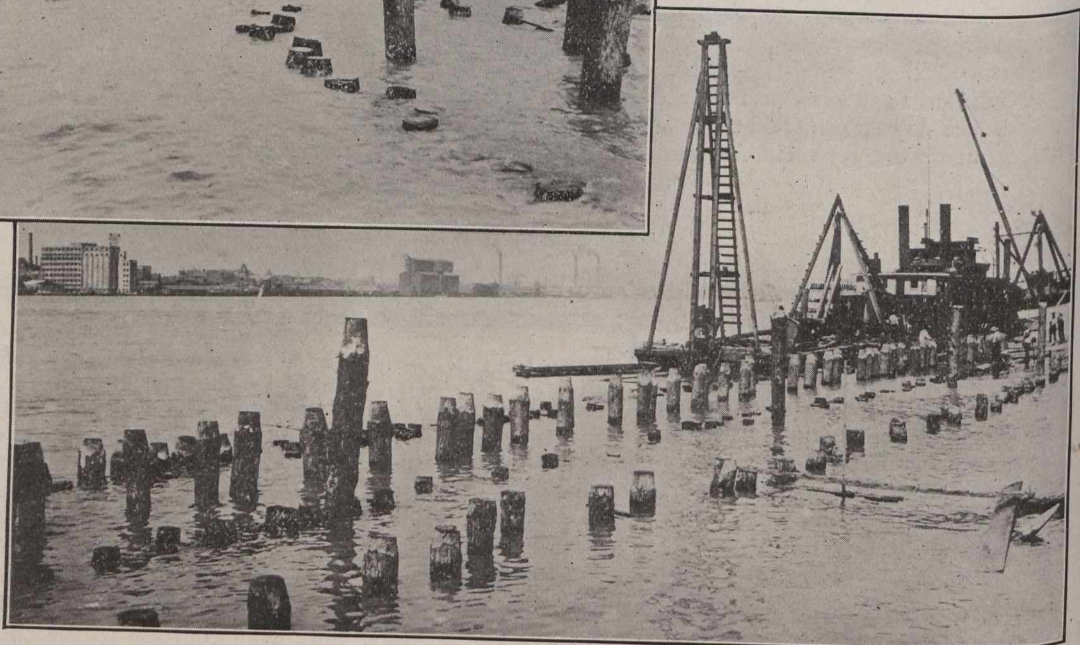
(*d*) For openhearth process, after the rail has passed the physical requirements, additional drillings will be taken from the same rail, and in the same manner as specified in Section 6 (*c*), at the junction of the head and web (designated as point "M"). The carbon determination from these drillings (Note 2, Sec. 4) shall be within 12 per cent. of the amount found at location "O." If the test from the top rail fails to meet this requirement, all the top rails from the melt shall be rejected, and a similar determination shall be made from location "M" of a second rail. If this test fails, all the second rail from the melt shall be rejected, and a similar determination shall be made from location "M" of a third rail. If this test fails, all the remaining rails shall be rejected.

(*e*) If, however, the segregation found at location "M" in any rail in a rolling exceeds 25 per cent., when determined as provided for in 6 (*d*), the progressive testing of the second and third rails will not be permitted on any subsequent melts; but on such melts the failure of the top rail to pass the requirements provided for in 6 (*d*) will cause the rejection of the entire heat.

PILE FOUNDATIONS OF WINDSOR WHARF.

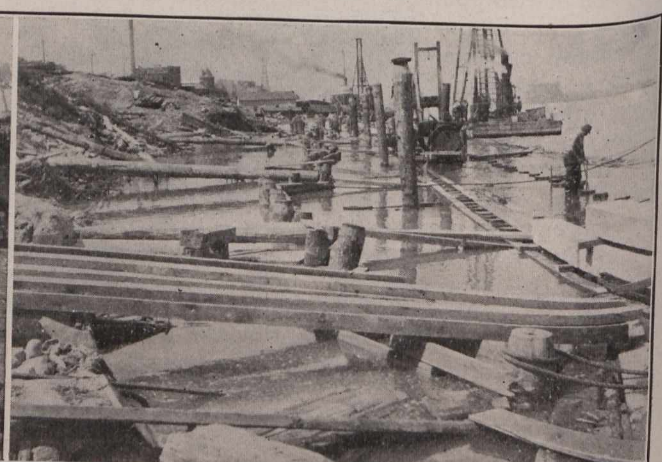
In *The Canadian Engineer* for July 8th, 1915, a description was given of a new landing wharf constructed at Windsor, Ont., for the Department of Public Works of Canada. The article, written by Mr. H. B. R. Craig, district engineer for the Department, dealt with its general design and also with the design of the warehouse which it supports. The accompanying illustrations, for which we are again indebted to the writer of the article, relate to the pile foundations upon which the reinforced concrete superstructure is built. These piles are of white oak, braced longitudinally and vertically by oak waling. There are five rows of piling, not including the sets of six 55-foot fender piles protecting the wharf. As may be noted, there is a double row under the front wall, placed at 2-foot centres; a row at 4-foot centres along the centre line; a rear row at 2-foot centres, and a row of anchor piles about 15 feet back from the wharf. The fender piles are, as stated, 55 feet long, those in the front row are 40 feet and the remainder 35 feet in length.

The piling was placed by Mr. A. E. Ponsford, of St. Thomas, Ont., under the direction of Mr. H. B. R. Craig, who was assistant to the district engineer, Lieut.-Col. H. J. Lamb, at the time, and who is now district engineer at Fort William for the Public Works Department.



Rows of Driven Piling Before Framing; City of Detroit in Background of Lower View.

Anchor Piles Sheeted and Rotary Saw at Work on Rear Row of Bearing Piles.



Bearing Piles Framed With Waling and at Required Elevation.

PROTECTIVE COATINGS FOR METAL.

MR. H. B. C. ALLISON, of the Research Laboratory, General Electric Company, Schenectady, N.Y., has compiled a very valuable resumé of the most effective processes of forming protective coatings for metals. This review is confined to two types: firstly, that in which the metal itself is made more resistant, usually by some chemical treatment; and secondly, that in which another metal is used as a surface coating.

In the first instance a coating is formed which must possess the following properties, if it is to be successful: It must be homogeneous, continuous, resistant to attack by acids or alkali, firmly attached to the base metal and must have a similar expansion coefficient. The ideal metal coating should also be homogeneous and continuous, but should be strongly electropositive to the base metal and should form electropositive alloys with it, so that in case of oxidation the coating will be attacked and the base metal protected.

Extracting Old Piling With Dredge at Windsor, Ont. Submerged Cribwork on Site of New Government Wharf Prior to Its Construction.

As iron is the metal most commonly used as the base, the processes which Mr. Allison has chosen are those used for its protection, although some may be applicable to other metals.

Oxide Coatings.—It was known for a considerable time before any process was devised that the black or magnetic oxide formed on iron, under certain conditions, was a very fair protective coating. Attempts to control and improve this coating have led to a number of patented processes, of which two may be taken as typical.

Bower-Barff Process.—The pieces to be treated are heated to a temperature of 900 deg. C. in a closed retort. When this temperature has been reached, superheated steam is admitted for 20 minutes and a coating consisting of a mixture of red and black oxides is formed. Producer gas is then substituted for the steam and allowed to act for the same length of time. After cooling somewhat, the pieces are oiled and a smooth, green-back coating is produced, which affords efficient protection from sea water, acid fumes, etc., and will stand a wide variation in temperature.

Gesner Process.—This is a further development of the above process. The pieces to be treated are maintained at 600 deg. C. for 20 minutes, after which steam at low pressure is let in at intervals for 30 minutes. The steam, on entering, passes through a red hot pipe at the base of the retort, and is thus partially decomposed into hydrogen and oxygen. After this treatment a small quantity of naphtha or hydrocarbon oil is introduced and allowed to act for 15 minutes to reduce any red oxide, and also to carbonize the surface. The coating is said to be a compound of iron, hydrogen and carbon, and analyses have shown that a minimum of 2 per cent. hydrogen is present.

It is an improvement on the Bower-Barff process in that the danger of warping, due to high temperature, is removed, the size of the piece is practically unaltered, and the tendency to scale is much less.

Both of these processes are quite expensive, but users have usually found the protection afforded of sufficient benefit to warrant the added expense.

Protection by Chemical Means.—There is one process which may be of interest in this connection, known after its inventor as "Coslettizing."

The pieces to be coated are first cleaned as usual, either by pickling or sand blasting, and are then placed in a boiling water solution of phosphoric acid, in which iron or zinc filings are always present. The period of treatment is from one-half to three hours, depending on the thickness of the coating desired. After drying, the pieces are usually oiled. By this treatment a very slight amount of the surface of the article is converted into certain phosphates of iron, but most of the coating comes from the solution itself.

This coating has been found to be particularly useful in the tropics, and is used in one instance for typewriters. It is not a complicated process or an expensive one and the finish is very durable. It is, however, subject to patent restrictions.

Protection by Another Metal.—The agent used in the majority of cases for protecting iron is the metal zinc. Zinc is strongly electropositive to iron and so are its alloys, if free from impurities. It is also readily available and may be applied by a number of processes.

Hot Galvanizing.—The oldest process is that of hot galvanizing, which consists simply of cleaning the piece, coating with a suitable flux and then dipping in the molten zinc. The piece is usually wiped after this to improve the coating. This process has the disadvantages of limiting the thickness of the coat, of plugging any small holes, of the composition of the coating being variable, and the possibility of including injurious and corrosive substances in the coating, which may cause early failure.

Lohman Process.—A modification of this process is known as the Lohman process. After cleaning, the article to be coated is dipped in the Lohman bath, which is a solution of hydrochloric acid, mercuric chloride and ammonium chloride; it is then dried before immersing in the molten metal, which may be any one or a mixture of a number of metals such as lead, zinc, and tin. The chief point in its favor seems to be that the junction between the iron and the protective alloy is kept free from all oxide, and, therefore, the alloy will fill all the pores and no corroding agent can be included.

It is claimed by its backers that a graduated alloy is formed so that the protective coating cannot be completely broken through except by breaking the sheet itself.

Cold Galvanizing.—Another process which is being used more and more as it is improved is that of wet galvanizing or electroplating. In this case the article to be coated is suspended as a cathode in a suitable bath and is subject to easy control. It provides a coating of high purity and uniform thickness in general, but recesses and corners cause some trouble. It is liable to be more or less porous and may contain acid which will eventually cause failure. In both of these processes, hot or cold, the coating does not become intimately connected with the base metal through deep alloying.

Sherardizing.—The latest process of this type is sherardizing, and it is undoubtedly the most perfect as a protection. The object to be sherardized is placed in an iron drum which is filled with a mixture of finely powdered zinc and zinc oxide, in varying proportions, and is heated in a reducing or inert atmosphere for a period of time, the length of which depends on the thickness of coating desired. The coating so obtained consists of four protective layers. Next to the pure iron is an alloy "C," rich in iron, upon which is another definite alloy "B," containing more zinc. Then there is a layer containing a number of more or less unknown alloys, and finally a layer of pure zinc. This makes a coating which is not easily broken down and which is continuous. The principal objections to its use are the high temperature to which the piece must be subjected and the increase in size which may be caused.

The theory which has been advanced to explain this process is interesting in that it may be considered as a distillation process. The zinc dust which is obtained from the zinc smelters is said to be in a state of unstable equilibrium, so that in contact with the hot iron it undergoes a change tending to restore it to the normal condition. During this change some of it alloys with the iron, thereby lowering the vapor pressure for zinc in that region. A slow distillation then begins from the zinc nearest the object to the object itself. As the alloy becomes richer in zinc the difference in vapor pressure becomes less and less and then finally becomes zero. This is found to be the case in practice. The deposition becomes slower as the time is extended.

Calorizing.—This recently developed process makes use of aluminum as the protective metal and is of particular advantage in preventing oxidation at high temperatures. The protective action is due to the oxide formed by the action of heat on the protecting metal, rather than to any electrolytic relations between the aluminum and the base.

It has been found very useful in the case of iron utensils subject to direct contact with flames at temperatures up to 1,000 deg. C. and also in the case of boiler tubes, for the life is increased many times by this treatment and the saving in the cost of replacements is much greater than the additional initial cost of calorizing.

Schoop Process.—One of the most recent processes, and one of the most promising, is the Schoop process. This is applicable to the deposition of metals or alloys on any sort of an object. The apparatus consists of a pistol into which the coating metal is fed as a wire. It passes through a straightening and centering device into the nozzle, where it is fed through a burner whose temperature may be regulated from 700 deg. to 2,000 deg. F. The molten metal is carried a short distance by the gas current and is suddenly caught by a powerful blast of compressed air which shoots it out of the nozzle with a velocity of 3,000 feet per second, directly on the object to be coated, which is held a short distance away. The coating is homogeneous, continuous, and of any desired depth, and is also exceedingly intimate.

The following explanation of the theory is given by the inventor:

"The theory is that the gaseous medium used is much larger in volume at any moment than the drop it has pulverized and is carrying, and the gas is expanding so rapidly that its temperature is far lower than that of the spray. A rapid exchange of heat, therefore, takes place between them, which consolidates the molten particles and gives them a temperature far below the melting point. If the particles arrived in a liquid state at the base with the observed velocity of 3,000 feet per second, they would simply splash on the surface and largely rebound. As a matter of fact they impact and inter-penetrate freely, and the later bombarding particles unite with the earlier ones to form homogeneous compact bodies. In accounting for the observed action of the Schoop spray at the receiving base, it is supposed that the cooled particles of the metal, just before impinging with great velocity on a hard surface, are in an abnormal physical condition. Due to the heat of collision they pass directly into a vapor which condenses and solidifies on the relatively cold receiving body, penetrating by osmotic pressure the superficial pores of the base when an affinity for the latter exists, and otherwise driven in by the pressure behind it. In either case it condenses and solidifies after penetration, and is effectively dovetailed into the base. The hammering and bombardment of the solidified first coat by the minute succeeding particles is practically a process of cold working. The entrained particles liquidify and solidify so rapidly that the metal has not time to return to its natural crystallized state."

In conclusion Mr. Allison states that there are many other processes in use which could not be mentioned in a brief review of this type. Those processes outlined were chosen as representative of the various different means used to obtain the desired protection because of their prominence, or of some new feature which they contain.

GAS FROM REFUSE WOOD.

Leaves, loppings, roots, chips and sawdust, and any kind of combustible refuse will make gas for working gas engines and supplying retorts and furnaces. According to the Timber Trades Journal, 2½ to 3 pounds of such refuse will develop 1 b. h. p., which means that a ton will supply 100 b. h. p. a day. As no skilled attention is needed for such wood-waste gas-producing plants, the working costs are low. Sawdust and wood-waste show good financial results when used for distillation purposes, and it also pays to use sawdust for the manufacture of oxalic acid, which at the present time commands a high price. It is found that the distillation of one ton of waste wood (common soft woods) yields 15 gallons of boiled tar, 4 gallons of wood oils, 6 cwt. of charcoal, 5 gallons of wood naphtha, and 1¼ cwt. of lime. With wood-waste at 10s. a ton it is calculated the working expenses of a complete distillatioin plant to deal with 100 tons a week would be about 23s. a ton, and a quantity so small as 25 tons can be treated weekly on a commercial basis.

The firm of Keuffel and Esser Company of Hoboken, N.J., has been awarded three grand prizes at the Panama Pacific International Exposition at San Francisco. One was for drawing materials and slide rules; another for surveying instruments, and a third for telescopic sights and periscopes.

Editorial

EDUCATIONAL VALUE OF EXHIBITIONS.

Exhibitions have now become so numerous that they are more or less commonplace, and it is natural to enquire whether they are accomplishing the work for which they were originally established. Prince Consort's idea in organizing the first great exhibition of 1851 was to show what Great Britain was producing and to show the world her enormous resources. Since then exhibitions have multiplied and are now held in all parts of the world.

They are certainly a great source of attraction to any city, and that accounts for the huge sums of money that are spent. Each great exposition is made to surpass its predecessor, until the Panama Exposition is claimed to be the greatest yet held. But while most of them are successful in the point of number of visitors, it is open to serious discussion whether the principal object has been attained in many instances. This was probably the reason why Great Britain and Germany declined to send exhibits to the Panama Exposition. The exhibitors who have incurred great expense and trouble expect something more tangible than the fact that thousands have enjoyed themselves. The tendency of these great periodical institutions is to fail to make the fullest use of the educational features of exhibitions.

Exhibitions are highly essential, especially in a new and developing country. The older countries appreciate their value, and devote great efforts to utilize the opportunities of showing the public what can be or is done. One of the important functions of an exhibition is to display goods, machinery, local products, works of art, and other things which will indicate what progress is being made and of what value they are to the country. If the exhibit is an agricultural implement or machine it would be a source of education if some of the primitive makes were preserved and shown in the same building. The contrast would make a lasting impression. Suppose in the great transportation building of the Toronto Exhibition there were some of the earliest makes of automobiles to be seen on pedestals, so that the visitors could themselves judge of the wonderful advancements which have been made. Would the exhibit produce a lively interest? Would it have any influence on the thoughts of the people as to what is being done in this country? Would the visitors discuss the developments, compare details, contrast the designs, and so on? When there are scores of magnificent cars on view it requires the ability of an expert to judge of their individual merits, but when a contrast is possible, then any novice can discern the enormous improvement from the old to the new.

Each exhibition must necessarily have its own local color. It would manifestly be useless exhibiting mining machinery in an agricultural community. It must, and will, cater to the needs of the people, and, therefore, to have its full educational value it should have exhibits which will kindle the interest of those who have not previously seen the machinery or things that were used in former days, and to revive the memory of those who have. The farmer, builder, merchant, engineer have each their requirements to be satisfied and their thoughts directed to improvements. The engineer, for example, finds that in the rush of daily work many changes take place which have escaped his observation, and at the Exhibition hopes to replenish his knowledge of new things and to familiarize himself in the details of improvements, which he may, sooner or later, have to use; at any rate, he desires to be *au fait* in everything that concerns his profession.

It would be useful to him if it were possible for the exhibitors to hold meetings at which they could describe any particular quality or capacity which they claim for their goods. By this means the maker and the client would meet and mutually discuss matters, and both be benefited. The engineers also might hold meetings for the purpose of discussing subjects of interest, perhaps associated with something shown in the exhibition, and also of having social intercourse. These suggestions will, of course, apply to other professions and trades as well. The point to be made is that an exhibition should be made to have as powerful an educational influence as possible, and also be made attractive in other respects.

It is not contended that these features are absent at present, for that would be absurd. Exhibitions, to those who seek for information, always have a great value. New ideas and contrivances, improved materials and better methods of application are to be seen, whereas it would otherwise entail great trouble and expense for the visitor to obtain the same information by any other means. And while this is the case, it is well that the visitors should reap the advantages to the full, and the exhibitors be assisted to benefit in his enterprise.

EXPERIMENTS WITH OIL-MIXED PORTLAND CEMENT CONCRETE.

Concrete, as a constructional material, possesses many virtues. No other material has been favored with such universal adoption. The enormous growth of the cement industry is a striking evidence of its widespread use.

But it is not without its faults. Under certain conditions it exhibits a consistent tendency to crack. This is attributed to several causes, such as external temperature changes, rise and subsequent fall of internal temperature during the hardening process, and shrinkage during the drying-out of the mass. Concrete, also, as ordinarily made, is more or less porous and absorbent of moisture.

To increase the impermeability of concrete has been the hope behind many an experiment, and there are not a few waterproofing compounds on the market. Dr. Logan Waller Page, director of the U.S. Office of Public Roads at Washington, while experimenting with concrete mixtures, a few years ago, found that when a heavy mineral residual oil was mixed with Portland cement it entirely disappeared in the mixture and did not separate from the other ingredients after the cement had become hard. He immediately began laboratory tests to determine the physical properties of concrete and mortar containing various quantities of oil admixtures. These tests have demonstrated very definitely the value of oil-mixed concrete in damp-proof and waterproof structures. They have shown, according to recent report, that the admixture of oil is not detrimental to the tensile strength of mortar composed of 1 part cement and 3 parts sand when the oil added does not exceed 10 per cent. of the weight of the cement used. The compressive strength of mortar and of concrete suffers slightly with the addition of oil, although when not to exceed 10 per cent. of oil is added the decrease in strength is not serious. Concrete mixed with oil requires a period of time from 50 to 100 per cent. longer to set hard than does plain concrete, but the increase in strength is nearly as rapid in the oil-mixed material as in the plain concrete.

Concrete and mortar containing oil admixtures are almost perfectly non-absorbent of water. The addition of oil, however, does not appear to increase to any great extent the impermeability of concrete subjected to heavy water pressure, and this method alone will probably not make the concrete proof against the actual percolation of water through the mass. It has been found that strict attention to the details of proportioning, mixing, and placing concrete accomplishes more toward making it waterproof or impermeable than the addition of any extraneous material. On the other hand, no amount of care in connection with the preparation of concrete prevents the absorption of water into the mass. The addition of some water-repellent compound appears absolutely necessary to insure this result, and for this purpose laboratory tests have shown these oils to be at least equal to any other substance that has been used. Laboratory tests show that oil-mixed concrete is just as tough and stiff as plain concrete, and, furthermore, its elastic behavior within working limits of stress is identical with that of plain concrete.

The bond between concrete and plain-bar reinforcement is decreased by the use of oil in the concrete, but when deformed bars, wire mesh, or expanded metal is used there is no apparent decrease in the bond.

OPENING FOR STEEL ROLLING MILL MACHINERY.

The Department of Trade and Commerce, Ottawa, advises that a firm in Buenos Aires desires to install, as soon as possible, the necessary machinery for steel rolling mills, to produce about 30,000 tons per year of double T from 0.080 to 0.300 N.P. and several other sections as angles, rounds, squares, flats, etc. Plans are therefore requested with details of trains of rolling mills and the corresponding auxiliaries, with all the improved means, up-to-date, to save time and manual labor, and besides a complete specification with weight and prices. Account must be taken of the fact that trains of three high rolling mills, the moving tables, guides and small rolls, travelling cranes and auxiliary motors shall move by electricity, produced by crude oil engines of the Diesel type or any other similar prime mover. It would be a fixed condition that, instead of a single oil motor, the power is to be divided in two or three oil motors, to help for repairs. There will be a three high blooming train to prepare steel ingots for two three high rolling mills. One three high rolling train will work from 0.80 cts. up to 0.22 cts., and shall have for it 30 rolls weighing 201.300 kilos. more or less.

The other three high rolling train shall laminate from 0.24 to 0.30 cts., and shall have for it 18 rolls weighing 125,000 kilos, more or less. Preference is expressed for only a single rolling train for all the profiles. The necessary rolls for angles, flats, rounds, etc., are to be taken into account. Besides the plans and specifications for the rolling mills, two travelling overhead electrical cranes are wanted for the steel foundry, and of 30 tons power each, with 15 metres span, and a third oil motor of 200 h.p. to give light for the workshop and power for pumps, tools, etc. Prices are requested for the total of the machinery, and separately, and the prices for the laminating rolls per piece or per kilos.

The name and address of the firm in question may be obtained on application to the Department.

FACTORS GOVERNING SUCCESS IN WELL-DRILLING.

In a paper read before the Connecticut Society of Civil Engineers by R. E. Horton, a hydraulic engineer, of Albany, N.Y., the subject of well-drilling is dealt with at considerable length. The author points out that a great deal of light can ordinarily be obtained in advance on the question whether a well at a given location will be successful or not. Still more certain answers to this question could be obtained if more effort were made by well-drillers, engineers and geologists to obtain accurate logs of the strata and materials passed through in drilling wells. The sand pumpings from an ordinary churn drill taken alone form a very unsatisfactory basis of determination of the character of the material passed through. In the first place, material from different beds is very often mixed; second, it all comes to the surface finely pulverized, and, especially in the case of sandstone or shale, it is sometimes impossible to tell from the drillings whether the natural material was in the form of earth or was cemented and consolidated into rock. The drillings from sandstone are frequently identical with those from sand, and those from shale are the same as those from clay containing shale fragments or gravel. Additional information can be obtained: First, from the rate of drilling; second, a well-driller can form judgment of the character of the material from the "feel" of the drill as the work is going on.

It is not always true that when the drill passes through material of a certain thickness, a bed of that thickness actually exists. Of course, if the bed happens to be inclined, its actual thickness may be very much less than the thickness drilled through. Whether or not the strata or beds penetrated by the drill are probably horizontal or inclined, and if so, about how much, can generally be determined from observations on the surface or in nearby railroad cuts or other deep excavations. This valuable source of information, always sought after by geologists, seems to be generally overlooked by well-drillers.

Other conditions affecting the probable success attainable by drillings are the presence or absence of faults in the locality, the presence of nonconformity in the strata, and in the case of materials other than firm rocks, the presence of local beds or pockets of impermeable material mixed in with materials capable of storing a water supply. Lenses of clay and pockets of nearly impervious conglomerate are both common in water-bearing beds of sand or sand and gravel.

There is one set of conditions where wells will always fail, and that is obviously where there is no ground-water supply. This may result from five principal causes:—

1. The available rainfall is deficient or is entirely lost by surface run-off and evaporation, leaving nothing for percolation beyond the reach of plant roots.

2. Lack of absorption capacity of the soil or surface. This may be due to the existence of impervious rocks or clay at the surface.

3. Lack of adequate transmission capacity. Owing to sparseness of fissures in rock or fineness of soil materials, it may be impossible for the soil to transmit enough water to deep-seated water-beds to furnish a permanent adequate supply for wells.

4. Lack of storage capacity. The infiltration or supply to the water-beds being intermittent, the yield of the wells will also fail unless the water-beds have enough storage capacity to provide water supply during periods of insufficient infiltration.

5. Inability of the water-bearing material to yield its supply to the well. This is a common cause of difficulty in securing adequate water supply from very fine sands and clays. These materials commonly contain from 25 to 40 per cent. of voids which are filled with water, but only a little of which will flow into a well because a large portion of the water is permanently held in the fine pores by capillary attraction and the artesian flow or transmission of water through such materials is exceedingly slight. It is evidence that none of these causes exists to prevent obtaining a satisfactory well in a given locality when it is known that there are several successful wells, all obtaining satisfactory water supplies under the same conditions as those which apparently exist where the new well is to be drilled. If, now, most of the wells in a certain locality are successful, and it is known that there is a water horizon generally existing in the place where a new well is desired, the presumption is very strong that a successful well will be obtained at about the same depth as in the other wells in the vicinity.

Failures not infrequently occur under just these conditions. It is also the existence of such failures and the existence of marked success where failure is the general rule which have created in a marked degree the popular feeling that there is great mystery, if not something supernatural, about the occurrence of underground water.

It seems certain that failures to secure water supply in wells drilled under the conditions described, i.e., where there are other successful wells in the vicinity and where there is known to be a generally diffused ground-water horizon, are due to only a few causes, and can readily be explained in most cases from evidence either existing on the surface, in railroad cuts or other excavations, or obtainable directly from the records of wells drilled.

In analyzing the causes of such failures, it is convenient to consider three cases:—

1. Where ground-water is generally diffused through the pores of the water-bearing medium, usually sand or sandstone.

2. Where the ground-water is contained in fissures in more or less fractured rock, such as granite, trap rock, or shale.

3. Where the only underground water available generally is that contained in solution channels or other definite open passages, such as often occur along fault lines.

Discussing these cases in their inverse order, it may be said that where water is only contained in solution channels or definite passages along fault lines, the chances of success in any given bore made at random are very small. The presence of solution channels in limestone may, however, sometimes be detected at the surface by the presence of sink holes, and their presence would naturally be expected from the existence of caves, and from brooks or springs issuing from limestone strata and in general where limestone is prevalent throughout the region. The existence of fault lines is often apparent at the surface, where they may be traced by anyone, and where not so apparent, they can often be traced by geologists. We are here presuming that wells have been generally successful in the locality. This could be true where the source of water supply is in solution channels or along fault lines only when the existing wells are located along such lines. The natural location for new wells would be in line with existing wells. They will fail where, as is often the case, the direction of the fault line or solution channel suddenly changes or comes to an abrupt end.

In the first two cases mentioned, where wells are generally successful, it may be said that there are five, and only five, principal reasons why a new well in the same locality put down to the depth at which ground-water is supposed to exist should be a failure:—

1. The existence of a pocket or included mass of non-water-bearing materials.

2. Local pinching out of the water beds or water-bearing strata by thickening or interfoliation by overlying and underlying non-water-bearing beds.

3. Termination of the water beds by nonconformity.

4. Termination of the water-bearing beds by faults or trap dykes.

5. The failure of the well to strike a fissure in cases where the water is contained in rock fissures.

OPERATING AND TEST DATA FOR FUEL-OIL ENGINE AND GENERATOR.

The great economy that is possible to effect by the employment of the fuel-oil engine in electric light and power service is strikingly shown in the report on the performance of such an engine in the plant of the Goodland (Kan.) Light and Power Company, as outlined by R. B. White in the Electrical World, Vol. 65, No. 26. The oil engine is 60-horse-power, of the two-stroke semi-Diesel type for crude or fuel-oil, belted from the fly-wheel to a 75-kilowatt, three-phase, 2300-volt, sixty-cycle generator, operating single-phase at 2200 volts. This unit operates in parallel with a 100-kilowatt, single-phase generator driven by a 105-horse-power single-cylinder engine. The steam is generated from coal costing $3.25 per ton delivered. The oil engine uses Kansas fuel-oil costing 2.3 cents per gallon. Before installing the oil engine the coal bill was $600 per month, whereas the present coal and oil bill does not exceed $300 per month.

A test section of the pure water conduit, which is to run from Lake Erie to St. Catharines, has been built at Port Colborne, Ont. It is 300 feet long and four feet in diameter.

Last month there were five large factories under construction in Hamilton, Ont., for the following owners: Proctor-Gamble Company, Dominion Sheet Metal Company, Canadian Horseshoe Company, the Canadian Cartridge Company, and the T. Eaton Company.

EDMONTON DEMONSTRATION PAVEMENT—WITH CANADIAN ASPHALT.

The accompanying photographs relate to some experimental work that should be closely followed by engineers, contractors and particularly paving men. They are views of the first pavement laid with material from the extensive deposits of bituminous sand which occur in the McMurray district of Northern Alberta. This demonstration pavement is now being laid in the city of Edmonton under the direction of Mr. S. C. Ells, of the Mines Branch, Department of Mines, Ottawa. In *The Canadian Engineer* for April 22nd, there appeared a synopsis of a report prepared by Mr. Ells for his Department on the bituminous deposits of the province. This report described their general character and variation in bituminous content, the grading of the mineral aggregate and the thickness and nature of over burden. The author was later detailed to carry out more complete investigations, and the result is the present attempt to demonstrate the material on a commercial scale.

Laying the First Pavement With Canadian Asphalt, Edmonton, August, 1915.

It may be stated that cities in Western Canada are intensely interested in the work that is under way. The City Commissioners of Calgary, for instance, when they learned of the progress that was being made, sent Mr. F. C. Field, who is recognized west of the Great Lakes as a leading authority on asphalt work, to prepare a report for their consideration; and, as indications point to the successful use of these bituminous deposits in paving work, it is quite probable that other cities will shortly be trying it out. This will mark the establishment of a new industry in Alberta.

COAST TO COAST

Toronto, Ont.—The corner-stone for the new Canadian Pacific Railway station in North Toronto was laid by Mayor Church on September 9th.

St. Vital, Man.—About 6½ miles of paving is to be laid on St. Mary's Road, and 1½ miles in St. Vital. Work started two weeks ago. The estimated cost is $102,000.

Fredericton, N.B.—The tenth annual convention of the Union of New Brunswick Municipalities was held during the week of August 23rd, Mr. J. K. Kelley, of St. John, presiding.

Yorkton, Sask.—Work has commenced on the Thunder Hill branch of the C.N.R. and it is expected that steel will soon be completed from its present terminus at Preeceville to section 4.36, a distance of 25 miles.

South Vancouver, B.C.—The sewerage construction work undertaken by this municipality to connect with the trunk sewers laid by the Vancouver and District Joint Sewerage and Drainage Board, was commenced on August 25th.

Fort William, Ont.—The terminal elevators at Port Arthur and Fort William are ready to handle the rush of Western grain. Combined, they have a capacity of 42,000,000 bushels, a grain handling capacity of 3,000 cars per day, or 100,000,000 bushels per month. This year's shipments will in all probability make a new record and surpass the existing 1913 record of 203,377,000 bushels through the elevators.

Toronto, Ont.—The Woodville Avenue trunk sewer, 5,780 ft. in length, has been completed. Its construction covered a period of nearly two years. With the exception of a short trench excavation, the sewer was tunnelled, compressed air having been used throughout, the men working under a 21-pound pressure. The sewer is circular in shape and 8 ft. in diameter. About 6,000,000 brick were used. A great deal of it is in quicksand at a depth of 45 ft. below street level.

Winnipeg, Man.—The Manitoba government elevator commission has completed the annual work of repairing the 168 elevators leased by the government to the Grain Growers' Grain Company. The exact cost of this year's repairs is not yet obtainable as the returns have not all been tabulated. In other years the cost of repair has averaged from $10,000 to $12,000, and it is said that this year will be normal in this regard. The bulk of the repairs is in connection with the breaking down of engines and the loosening of tin sheeting on the outside walls.

Vancouver, B.C.—The big grain elevator to be established on the government dock on Burrard Inlet has been started, excavation having been completed and the concrete footings placed for the lower piers of the main building. The sea wall, 800 ft. long and 300 ft. in width, has been practically completed. It is expected that the dock will be finished early in November. A description of it was published in *The Canadian Engineer* for April 15th, 1915, while the elevator, which is being constructed by the Barnett-McQueen Co., of Fort William, Ont., was described in our issues of November 19th and December 17th, 1914.

Winnipeg, Man.—The Manitoba Exploration Syndicate offers to pipe 20,000,000 cubic feet per day into Winnipeg from gas fields distant 90 miles west. The Syndicate proposes to lay two 8-inch mains at a cost of about $3,000,000, and to supply gas at a cost of 25c. per thousand feet. It states that a single well on its property is producing 2,000,000 cubic feet per day. The company has natural gas field holdings in Saskatchewan also, about 150 miles from Saskatoon, and similar holdings near Medicine Hat and Calgary in Alberta. Mr. L. S. Kempher is manager and chief engineer of the Syndicate.

Saskatoon, Sask.—The reinforced concrete bridge at 25th Street is progressing rapidly. A number of the arches have been completed and the concrete for the floor system is in place for over half its length. Concrete is being poured in two of the 150-ft. span arches, while the formwork is in place for two others. Mr. Fred. Saynor is resident engineer for the Provincial Government, and expects the bridge to be finished by the middle of October, with the exception of its lower deck, which will carry sewerage and water pipes, and electric conduits. The bridge provides a thoroughfare for street car, vehicle and pedestrian traffic.

Cape Tormentine, N.B.—The last crib in connection with the Cape Tormentine terminal of the Prince Edward Island ferry was set in position a week ago, and it is stated that the terminal may be completed before the end of the year. Besides crib work, two dredges are operating in the harbor on an approach to the ferry landing, and a stone breakwater is in the course of construction. The crib work is 800 ft. in length on the north side, and 270 ft. on the south, being an extension of about half a mile of breakwater. The other terminal, at Carleton Point, P.E.I., was described in *The Canadian Engineer* for February 25th, 1915. Tenders are now pending for the erection of various terminal facilities at this point.

Montreal, Que.—According to a statement issued last week by Mr. S. P. Brown, chief engineer of the Mount Royal Tunnel and Terminal Co., the excavation for the Mount Royal tunnel has been practically completed from end to end, and the concrete block lining, the blocks of which have been constructed at the Dorchester Street terminal yard, are in position for about half a mile from the eastern terminal. The remaining part will be solid masonry with the exception of the separation wall between the double tracks. This will be of steel and concrete. A section of it has already been completed from the eastern portal. It is believed that trains may be running through the tunnel in the early spring.

Ottawa, Ont.—The Billings Bridge over the Rideau Canal, described in *The Canadian Engineer* for January 29th, 1914, and March 4th, 1915, was formally opened last week. The bridge is about 600 ft. long and 60 ft. in width. The superstructure is of heavy through-plate girder construction, with five spans, each 78 ft. long, resting on reinforced concrete piers and abutments. It carries two street railway tracks, two 15-ft. roadways, paved with creosoted wood block on a 4-inch reinforced concrete slab foundation, and two 6-ft. cantilever sidewalks. The abutments, one of them resting on piles and the other constructed with wing walls, are of very interesting construction. The bridge has cost about $80,000.

Toronto, Ont.—Hon. G. H. Ferguson, minister of lands, forests and mines, has made an important arrangement with the Abitibi Pulp and Power Co., whose new plant at Iroquois Falls is now nearing full operation, whereby the company will purchase all pulpwood taken out by the settlers within a wide radius of the plant. This extensive power development was described in *The Canadian Engineer* for July 1st, 1915, at which time the large paper machines were just being installed. At the present time two of these are in operation, turning out over 90 tons of paper per day. In a few weeks the complete battery of four will turn out about 240 tons a day. All the newsprint manufactured is being exported and the company has a large market for its increased output.

PERSONAL

J. H. MOIR has been appointed traffic manager of the Edmonton Radial Railway.

P. J. FLYNN, manager of the Winnipeg joint terminals, has been appointed superintendent of the C.N.R. at Winnipeg.

J. COOK, of Weston, Ont., has been appointed superintendent of the Mimico and New Toronto Hydro-Electric Commission.

H. J. WHITE has been appointed supervisor of car work for the C.N.R. on all lines east of Port Arthur, with headquarters at Toronto.

A. H. EAGER, superintendent of shops for the C.N.R., has been appointed assistant superintendent of rolling stock, with headquarters at Winnipeg.

C. BOVARD has been appointed assistant superintendent of the New Brunswick division of the National Transcontinental Railway, with headquarters at Edmundston.

ROBERT KING, formerly superintendent at London for the Canadian Pacific Railway, has been appointed superintendent of the National Transcontinental Railway with headquarters at Winnipeg.

E. S. M. MACNAB, until recently electrical foreman of the car department at the Angus shops, Montreal, has been appointed engineer of electric car lighting for the Canadian Pacific Railway.

C. E. AUSTIN, formerly of Moose Jaw, has been appointed manager of the government system of terminal elevators situated at Port Arthur, Moose Jaw, Saskatoon, Calgary and Vancouver.

JOSEPH DAW, an architect of St. Catharines, Ont., has been granted a commission with the Royal Canadian Engineers, and has secured an appointment on the Director-General's staff at Ottawa.

A. M. WEST, formerly city engineer of North Vancouver, has been taking a course in military training at Esquimalt, B.C. Pending an appointment, he has again resumed his duties as city engineer.

J. L. BOOMER, formerly superintendent of the Canadian Northern Railway, at Calgary, has been transferred to Brandon, Man., where he succeeds Mr. W. E.

Roberts. Mr. Boomer is succeeded at Calgary by Mr. W. B. Murphy.

R. O. WYNNE-ROBERTS has opened an office as consulting engineer at 310 Temple Building, Toronto. He comes to the city from Regina, Sask., where he has acted for several years as consulting engineer to that city in establishing its water supply and also to the Saskatchewan government in the matter of lignite coal resources. In his 30 years' experience in municipal engineering he has attained prominence chiefly in water supply and sewage treatment problems, his published work on the latter in 1897, while he was engaged in installing plants in Great Britain, having been recognized at the time as a most complete synopsis of every process then known. For a number of years he was city and water engineer of Cape Town, S.A. Mr. Wynne-Roberts has been an authoritative contributor to the engineering press, his recent observations on the activated sludge process, investigated by himself and others, adding materially to the limited amount of valuable information as yet available regarding the subject. He is a member of the Canadian Society of Civil Engineers, The American Society of Civil Engineers and the Institution of Civil Engineers of Great Britain.

OBITUARY.

The death occurred in Hamilton last week of W. T. McAndrew, superintendent of the Hamilton waterworks system.

The death occurred in Toronto last week of R. A. Lackey, contractor.

On September 2nd the death took place in Montreal of Mr. Frederick M. Spaidal, general superintendent of the Canadian Northern Quebec Railway. He had been with the C.N.R. for about eight years, and was previously connected with the Canadian Pacific Railway.

Mr. James Carson, of the contracting firm of Carson and Whan, Edmonton, who have large contracts for grading near Smoky River on the Edmonton, Dunvegan and British Columbia Railway, was killed last week while manipulating a large grader.

We announce the death, at the age of 62, of Mr. Giles S. Ransom, for the past twenty-seven years president of the Toronto Furnace and Crematory Co., Limited.

The death occurred in Mount Royal, Que., last week of Mr. A. C. Cooke, of the town engineering staff. The deceased was 28 years of age.

Mr. John Knox, treasurer of the Dominion Power and Transmission Co., Hamilton, died on August 31st. He was also treasurer of the National Natural Gas Co., and president of the Western Counties Electric Co., of Brantford, Ont.

With respect to the much muted question of spacing of expansion joints in concrete roads, Mr. A. R. Hirst, State highway enigneer of Wisconsin, states that he has used fifty foot spaces between joints both in 1914 and 1915. He began to discontinue the use of metal plates at expansion joints in 1914, and had almost entirely discontinued the practice in 1915. The joints are now filled with an expansion strip furnished in sheets and without the metal protecting device, Mr. Hirst seriously doubts whether they will ever increase the distance between expansion joints to more than 50 feet. The elimination of metal plates at expansion joints at a spacing of 50 feet has meant an average saving of about 2 cts. per sq. yd.

ONTARIO MUNICIPAL ASSOCIATION.

The newly elected officers of the Ontario Municipal Association, in convention in Toronto last week, are: President, Mr. A. K. Bunnell, city treasurer, Brantford; first vice-president, W. C. Caughell, township clerk, Yarmouth; second vice-president, Alderman Menzies, Niagara Falls; third vice-president, A. M. Chapman, county clerk, Belleville; fourth vice-president, A. Ferland, reeve of Coleman, Cobalt; fifth vice-president, S. H. Kent, city clerk, Hamilton; secretary-treasurer, F. S. Spence, Toronto.

ENGINEERS' CONVENTION IN CALGARY.

The annual convention of the Western Association of Mechanical and Electrical Engineers was held in Calgary last week. At the first session an address was delivered by Mr. Theodore Kipp, consulting mechanical engineer of Winnipeg, who described a new invention of his for softening feed water for boiler use.

COMING MEETINGS.

AMERICAN ROAD BUILDERS' ASSOCIATION and AMERICAN HIGHWAY ASSOCIATION.—Pan American Road Congress to be held in Oakland, Cal., September 13th to 17th, 1915. Secretary, American Road Builders' Association, E. L. Powers, 150 Nassau Street, New York, N.Y. Executive Secretary, American Highway Association, I. S. Pennybacker, Colorado Building, Washington, D.C.

AMERICAN ELECTRO-CHEMICAL SOCIETY.—Twenty-eighth annual general meeting to be held in San Francisco, Cal., September 16th to 18th, 1915. J. M. Muir, 239 West 39th Street, New York City, Chairman of Transportation Committee.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, Calvin W. Rice, 29 West 39th Street, New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—Convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, F. L. Hutchinson, 29 West 39th Street, New York City.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—Annual convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, Charles Warren Hunt, 220 West 57th Street, New York.

INTERNATIONAL ENGINEERING CONGRESS.—To be held in San Francisco, Cal., September 20th to 25th, 1915. Secretary, W. A. Catell, Foxcroft Building, San Francisco, Cal.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—Annual convention to be held in San Francisco, Cal., October 4th to 8th, 1915. Secretary, E. B. Burritt, 29 West 39th Street, New York.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Annual convention to be held in Dayton, O., October 11th and 12th, 1915. Secretary, Will P. Blair, B. of L. E. Building, Cleveland, O.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Annual convention to be held in Dayton, O., October 12th to 14th, 1915. Secretary, Charles Carroll Brown, 702 Wulsin Building, Indianapolis, Ind.

SHRINKAGE AND TIME EFFECTS IN REINFORCED CONCRETE.

IN the extensive investigations of the properties and behavior of reinforced concrete that have been made in recent years very little has been done in establishing the effects of loads sustained for long periods of time. This seems the more remarkable in view of the fact that a progressive sagging or cracking has been often noticed.

In a recent issue of Studies in Engineering, of the University of Minnesota, Mr. F. R. McMillan describes a series of tests in which it has been found that certain changes do take place that are chargeable neither to poor construction nor inadequate design, but rather to the nature of the material itself—its tendency to shrink and yield under load. While no attempt is made even to suggest a solution to the problems presented by these shrinkage and time effects, the facts which the author has presented are of sufficient importance to warrant careful attention. With materials and mixtures used in these tests it was deemed safe to predict a shrinkage of from three-fourths to one inch or more in 100 feet when exposed to the ordinary dry air of a heated building. The yielding of the concrete under compressive stress with time, a phenomenon similar to the yielding of ductile metals when stressed beyond the yield point, is greater as the unit stress is greater and seems to go on indefinitely. In these tests the deformation due to yielding was found to be from three to five times that produced immediately upon the application of the load.

A few of the possible results that may be looked for where these twin changes are in progress are suggested. The production of cracks in floors, ceilings, and partitions, even though in no sense indicating a structural weakness, is an undesirable feature. And in certain places with some types of structures or details cracks might leave the reinforcement accessible to moisture and thus prove a source of danger. Sagging of the structural framework may cause the bending of doors in positions, a feature that is both expensive and annoying. The tilting of columns by the unequal shrinkage in the different floors might be a source of high bending moments and column stress. But of far more importance than these may be mentioned the two following possible effects, both of which might in certain instances be of serious consequence:

(1) The continued yielding of the upper fibres of a beam, coupled with the gradual breaking down of the concrete in tension, may result in a progressive destruction of the bond from the centre toward the supports, similar to that occurring with the progressive loading of a beam, as shown by Mr. D. A. Abrams in Bulletin 71, University of Illinois. Also the drying out incident to the large shrinkage movement may assist in this destruction of the bond.

(2) The possibility of high stresses in the longitudinal steel of compression members seems to be the most important conclusion to be drawn from these tests. The time yielding of the concrete under stress, combined with the excessive shortening due to shrinkage, may result in deformations from five to fifteen times those expected from the ordinary calculations. In columns of the ordinary ratio of vertical steel in which no allowance has been made for spirals the resulting steel stress is probably well within the elastic limit, but in those columns designed on the assumption of large loads being carried by the hooping the steel stresses may approach dangerously near the yield point.

VANADIUM.*

SINCE vanadium has been introduced as a purifying agent in the manufacture of steel, great interest has been evidenced in prospecting for, and in the location of, deposits of vanadiferous ores of commercial value. The main uses of vanadium are for the making of alloys of ferro, cupro, and aluminium vanadium, etc., as well as for the preparation of dyes and a number of chemical products. Vanadium oxides are used to a limited extent for coloring pottery and glass, while the pentoxide provides a useful substitute for gold bronze as an ornamental surface-covering. Numerous applications of the metal depend upon the ease with which its less-oxidized compounds take up oxygen and the higher oxides, and their salts are reduced.

There are few substances which are so widely distributed as vanadium ores, though they are not often found in such quantity as to be of economic importance, and capable of being profitably worked. Important deposits occur in which the metal is present as a sulphide. It is occasionally found as silicates, but the ores most commonly met with are the vanadates. The more important ores are carnotite, patronite, roscoclite, vanadinite, magnetite, and certain iron ores. The best-known mineral is vanadinite, containing theoretically about 19 per cent. of vanadium pentoxide, equivalent to 10.9 per cent. of metallic vanadium. The most important producing districts are Spain, Peru, Colorado, and New Mexico. Of these, Spain produces vanadinite—that is, a vanadate of lead, with an inferior portion of lead chloride. In France and Italy it occurs in bauxite and clay, and may therefore be looked for where igneous rocks kaolize, or break up. In Great Britain deposits occur in the Warlock Head Mine, in Dumfries, and at Harmer Hill, in Shropshire; also in Cheshire at Alderley Edge, 14 miles south-east of Manchester, among the large copper mines there, now closed down. The mineral found there has been given the local name of mottramite. Other vanadium-producing countries are Portugal, Baden, Bavaria, and Sweden.

In America the main output comes from Peru; the ore found there is patronite, a sulphide; also vanadiferous asphalite. In 1912 it was asserted that nearly 90 per cent. of the world's supply came from Peru; the ore carries 15 per cent. of vanadium. The Peruvian mines are at Minasragra, 23 miles northwest of Cerro de Pasco, also at Casapalca. The Colorado ore is a carnotite, a uranyl-potassium vanadate. The New Mexico product is mainly vanadinite.

During 1914 there was a very large output of vanadium ores in the United States, the total quantity of vanadium from carnotite and other ores being approximately 430 tons. Vanadium-bearing ores have been found in Utah, Western Colorado and Michigan. South Australia produces a sulpho-vanadate of copper. In New South Wales vanadium occurs in bauxite and clay. Ores also occur in Rhodesia and South-West Africa.

The developments which have taken place during the last two decades in connection with the making of ferro-vanadium alloys in a direct way, by the treatment of ferrous-vanadium ores, are the outcome of the knowledge acquired through experiments on the Taberg iron ores and products therefrom.

It has been known that the iron produced from the treatment of the Taberg ores at the Eckersholm works

*Engineering (London).

was possessed of an extraordinary degree of softness and tenacity. The analytical investigations made to ascertain the cause producing these properties demonstrated the presence of vanadium in the iron ore, cast iron, wrought iron, as well as in the slags obtained at the second stages of the metallurgical operation. When the important facts relating to the high physical properties imparted to all the varieties of iron by alloying them with vanadium became known, the discovery did not impress iron-makers, or induce them to utilize vanadium. It is remarkable that industrially, and in relation to its metallurgical uses, this discovery should not have been productive of immediate results. More recently it became known that vanadium, as well as titanium, were frequently found in a number of iron ores, mainly in magnetites and in bog iron. During the reduction process these two metals passed into iron products, forming multiple alloys. At first a difficulty occurred in the direct treatment of vanadiferous iron ores, owing to the peculiar properties of vanadium, the greater portion passing into the slag, forming silicated compounds, whilst another portion was separated as carbon-nitrogen compounds, which also mixed with the slags or found their way to other parts of the reduction apparatus. These difficulties have been overcome, and both cast-iron and steel alloys with vanadium are produced in a direct way from the treatment of iron ores, in which that element is present, almost the whole of the vanadium occurring in the ore being recovered. The Norwegian magnetites and iron ores with fairly high vanadium contents are almost inexhaustible.

In the preparation of vanadium steel, the addition of only ¼ per cent. of vanadium gives a high tensile strength and range of elasticity. Whereas the tensile strength of ordinary steel may be taken at 27 tons per inch, that of steel containing only 0.25 per cent. of vanadium is nearly 35 tons. The limit of elasticity is also increased by this small admixture, from 16 to 28.5 tons per sq. in. The addition of vanadium also rids the steel of traces of oxygen, and promotes a homogeneous distribution of the carbon contents. By the addition of chromium as well as vanadium, still better results are obtained. The malleability of vanadium steel can be considerably increased by annealing. A steel containing 12 per cent. of nickel and 0.5 per cent. of vanadium is stated to have a much higher breaking stress and limit of elasticity than good chromium steel. The addition of vanadium to aluminium bronze and brass also appears to promise well; other alloys have been experimented on. The main difficulties are the limited supply and high price.

In the United States, where vanadium is both produced and imported, the consumption during 1911 was about 300,000 lb. As it was then estimated that 5 lb. of metallic vanadium were required to treat a ton of steel, it followed that 60,000 tons of finished vanadium steel was the output for that year. It has been steadily increasing. The output of vanadium during 1912 in the United States was just under 300 tons. (There are no details at hand for comparison of the output of vanadium steel in Great Britain.) During that year the United States industries produced about 100,000 tons of vanadium steel, containing 7 lb. of metal vanadium per ton of steel, which is equivalent to 350 tons of metallic vanadium, obtained by treating 4,000 tons, or more, of vanadium ores, with an average of 10 per cent. of vanadium metal. The main part of these ores came from Peru, and the remainder from Colorado and Utah. If the method of extracting the oxide and preparing the alloys were less wasteful and more economical, the price of vanadium metal could be lowered and the output of vanadium steel could be increased tenfold. The actual high cost of making ferro-vanadium alloys limits their employment to the manufacture of high-speed steel for many special uses. Through the employment of improved methods of dealing with low-grade ores of a better roasting, lixiviating, and precipitation of the solutions, and of careful fluxing and reducing of the mixed oxides, a high rate of extraction ought to be secured and a large portion of the loss by volatilization avoided. By an adequate adjustment of these operations vanadium products should be made at a cost approximating to that of copper, but certainly not higher than that of nickel.

Where vanadium is to be utilized in the manufacture of vanadium steel, an alloy of iron and vanadium, containing from 25 to 52 per cent. of the latter is the product which is usually placed on the market. One method of treating the vanadate ores is to fuse them with bisulphate of soda. A quantity of the latter equal to twice the weight of the ore to be treated is melted in a closed crucible, and the pulverized ore is added. The melt cools to a citron-yellow mass, which absorbs water, and becomes greenish in color. It is broken up into fragments less than an inch in diameter, and dissolved in hot water. By means of sulphuretted hydrogen and ammonia other metals are precipitated, and a red solution of sulphovanadate of sodium is obtained, which slowly precipitates sulphite of vanadium. Space will obviously not permit an exhaustive list of the uses to which vanadium can be put in connection with vanadium steel, but enough has been stated to indicate its value and importance. Some useful applications of vanadium steel may be added.

In two new types of compressors problems as to the proper valve material have recently been solved by the adoption of heat-treated vanadium steel for these parts. One of the types in question is a compressor designed for the extraction of gasoline from natural gas. Owing to the high temperatures resulting from the compression of gas, but also to the presence of gasoline in the gas entering the cylinder, the proper lubrication of the cylinders and valves of this type of compressor presented a number of difficulties. Formerly the valves were made of steel, with bronze seats and guides; but these valves soon failed, because the material was not adapted to meet the requirements. Better results have been obtained from valves with seat and guides made of heat-treated vanadium steel, cut from the solid bar. Such valves have now been in service for fifteen months in continuous operation at 200 revolutions per minute, compressing gas to 250 lb. per sq. in. As a result of endurance tests carried out in the United States on plate-valves for air-compressors, heat-treated vanadium steel has been adopted for the suction and the discharge valves of high-speed air-compressors. Such valves are of the plate-valve type cut from a steel sheet, and consist of two concentric rings with a device for centering the valves on the seats. The selection of suitable steel for such valves is considered of the greatest importance; to test the efficiency of vanadium-steel valves under the most unfavorable conditions, valves of this material have been installed in a small experimental machine running at 500 revolutions per minute. The lift to the valves was increased to ⅛ in., which is double that ordinarily used. The severe conditions under which these valves were tested are never met with in modern practice. This compressor, after registering 6,000,000 revolutions, had the valve still intact. Owing to its strength, toughness, high wearing qualities, and the fact that it withstands much

higher temperatures than other steels without deterioration, heat-treated vanadium steel is particularly adapted for compressor valves.

Public attention has been called recently to the more economical production of armor-plates. Tests made on armor-plates in which 0.24 per cent. of vanadium was present showed a resistance to perforation by projectiles and to splintering not equalled by any other composition of the steel alloys used in armor-plate making.

The high cost of vanadium contained in ferro-alloys has prevented its use in this important application. Cast iron treated with a vanadium addition of 0.1 per cent. has its tensile strength raised from 6 to 13 tons per sq. in., whilst the resistance to crushing is proportionately increased. The making of a high quality of cast iron will open a wide field to the use of vanadium. Cast iron thus alloyed is an excellent metal for making crushing-rolls and many other cast-iron articles. This vanadium cast iron is very compact and free from blow-holes, and it has a very fine-grained texture. An enormous demand for vanadium will result as soon as the ferro-alloy can be placed on the market at a reasonable price.

REINFORCED CONCRETE TROLLEY POLES FOR MUNICIPAL RAILWAYS.

According to "Electric Traction," the city of San Francisco is using reinforced concrete trolley poles on all of the municipally owned street railways, the total length of which lines is about nine miles. Two types of poles are used: those without cross arms, used in connection with a system of underground conduits carrying the feeders; and those with cross arms, used in some districts of the city in which aerial feeders are allowed.

Table I. gives the principal features of the design of poles of both types.

Reinforcement.—All standard poles have six longitudinal bars, ¾-in. square, of which four extend the full length of the poles and two from the bottom to about 6 ft. from the top. All strain poles and riser poles have six longitudinal bars, ⅞-in. square, of which four extend the full length of the poles and two from the bottom to about 6 ft. from the top. All poles have stirrups of ¼-in. round steel wire, with spacing varying from 8 in. to 12 in.

Materials, Construction, Etc.—A machine mixture of one part Portland cement, two parts sand and four parts crushed rock was used. The specifications called for rock "of varying sizes, from that which will pass a screen of 1-in. mesh down to that which will be rejected by a screen of ¼-in. mesh, and not less than 50% shall pass a screen of ½-in. mesh."

The specifications called for square deformed bars or round mechanical bond bars of equivalent net cross-section. Twisted square bars were used.

The forms were of wood and were leveled up in a horizontal position. The only unusual feature of their construction was that the flat octagonal pyramid at the top of the pole was formed by a plaster of paris mold.

The concrete mixture was made of such consistency as to allow it to flow freely into place in the forms and around the reinforcement, with the assistance of some tapping of the bars and spading. The upper side of the pole was given a sidewalk finish, and was then covered with sand, which was wet down twice daily for seven days. The specifications permitted the removal of the side forms two weeks after pouring, but required that the poles should not be moved until 30 days after pouring. Out of a total of over 700 poles poured, only 11 were rejected by the inspector. These were found to be honeycombed, due to insufficient tamping around the reinforcing bars.

No soaping or oiling of the forms was permitted.

After stripping, the exposed concrete surfaces were washed with water and any rough surfaces found were finished with cement mortar consisting of one part cement, one part "Keystone" sand (a coarse white beach sand) and two parts ordinary bank sand. If the poles were sufficiently smooth, with true planes, straight and plumb, and free from pronounced form marks, a coat of cement grout, applied with a brush, was accepted as an adequate finish before painting. The poles are painted after erection with two coats of an approved concrete paint.

The poles were hauled from the yards in which they were manufactured to their places in the streets by lumber trucks, and erected by means of a derrick mounted on a truck. Standard poles were set 6 ft. 6 in. in the ground and strain poles 7 ft. The rake is ¼ in. per ft. of height, measured on the street face of the pole, the rake of the centre line being less by the amount of the taper. The hole in which the pole was set was made large enough to give the concrete backfill around the pole base a minimum thickness of about 6 in.

	Prices, each. Poles with provision for cross arms.	Prices, each. Poles without provision for cross arms.
Standard poles	$33.55	$32.90
Standard poles with one conduit	......	39.00
Strain poles	38.10	35.75
Strain poles with one conduit	......	41.85
Riser poles with one conduit	43.23	......
Riser poles with two conduits	48.07	......

The additional price for hauling and erecting poles is $17.60.

TABLE I.

	Poles with cross arms. Standard poles.	Poles with cross arms. Strain poles.	Poles with cross arms. Riser poles.	Poles without cross arms. Standard poles.	Poles without cross arms. Strain poles.
Dimensions at base (square)	12 in.	16 in.	14 in.	12 in.	16 in.
Dimensions at top (square)	9 in.	10 in.	10 in.	19 in.	10 in.
Length over all, for P-1	32 ft. 7½ in.	33 ft. 1½ in.	32 ft. 7½ in.	30 ft. 2½ in.	30 ft. 8½ in.
Length over all, for P-2	33 ft. 7½ in.	34 ft. 1½ in.	....	31 ft. 2½ in.	31 ft. 8½ in.
Length in ground	6 ft. 6 in.	7 ft.	6 ft. 6 in.	6 ft. 6 in.	7 ft.
Height of span wire eyebolt above ground, for P-1	22 ft.	22 ft.	22 ft.	22 ft.	22 ft.
Height of span wire eyebolt above ground, for P-2	23 ft.	23 ft.	....	23 ft.	23 ft.

(P-1 and P-2 designate poles of different lengths: P-1 is used on streets of ordinary width, with a span of about 50 ft., and P-2, which is one foot longer than P-1, is used on the wider streets.)