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THE SELECTION AND PROPORTION OF AGGREGATES FOR CONCRETE.

In proportioning the ingredients for aggregates of large size it is first necessary to measure the voids existing in any given quantity of the largest particles, so as to determine the quantity of mortar necessary to fill these voids. After selecting the best stone or gravel economically obtained in the particular locality in which the work is to be done, the next thought is the grading of this material so as to obtain maximum density, thus reducing the voids and consequently the amount of mortar required to furnish the bond.

As the value of broken stone depends on several conditions, the following classification, read in the order in which they are stated, must be taken merely as a guide: Trap, quartz, gravel, limestone (hard), granite, marble, limestone (soft), slag, sandstone, slate, shale, and cinders. The importance of toughness and hardness, as related to strength, increases with the age of the concrete. For all classes of concrete, stone breaking in cubical form is far better than one breaking in flat layers, such as shale or slate, it being almost impossible to ram or tamp such stone into as dense and compact a mass as that breaking in cubical fracture.

The size of the stone aggregates depends on the purpose for which the concrete is used. For large masses of concrete 2½-inch stone is usually considered the maximum size, but for 12-inch walls and the ordinary cases of concrete construction ¾-inch stone will give satisfaction. In considering the selection of broken stone, Mr. Albert Moyer, in a publication dealing with this subject, written for the Vulcanite Portland Cement Company, states that he has found the use of screenings, quarry tailings, etc., a decided advantage when used with crushed stone, for the reason that voids are thus reduced, giving greater density and strength. When screenings are used as a proportion of the larger aggregates in concrete, the 1/100 in. or less dust, should not exceed 10% of the volume of screenings, which will pass a ¼ inch mesh, as the dust is apt to coat the stone so that the mortar does not come as readily in direct contact with the larger pieces of stone. If, through careful mixing, the mortar does happen to reach every portion of the surface of the larger aggregates, it is from necessity made less rich by the dust; therefore, dust and other particles which pass through a ¼ or ⅛ inch mesh should be screened out and used as part of the mortar.

Material which is foreign to the stone, such as vegetable mold, scale, or loam, which cling to the surface, will reduce the strength of the concrete. This again is largely a question of careful and thorough mixing. Numerous tests conducted during the last several years by competent engineers have shown that clay in small proportions, not over 15 per cent., when well mixed in the mortar, does not reduce the strength of the concrete; in fact, tests have shown that the strength has been increased. This applies particularly to the leaner mixtures. If carefully mixed, therefore, the clay will not cling to the stone, but will become part of the mortar.

Good sand cannot be easily defined, or an inflexible specification written, as sands of various properties may make equally good concrete. All things being equal, a coarse sand containing a large percentage of coarse particles is far superior to a fine sand in which few coarse particles are present.
The full strength of any cement cannot be developed with a sand, all the particles of which are fine, or so fine as to all pass through a 30 mesh sieve.

For field work the best test to determine the sand which will produce the greatest density is by means of the water void test properly applied and read.

The void test by use of water should be done in a graduated glass tube. Supply two glass tubes 1½ inches to 2½ inches in diameter, containing 200 cubic centimeters or over and marked by a graduated scale divided into cubic centimeters.

Dry the samples of sand to be tested by spreading a thin layer in a pan or over a piece of tin and heating same to a temperature of over 212° F. The reason for drying the sand is to arrive as nearly as possible at an accurate unit of measurement, so that the proportion of cement to sand, which will be described later, may be ascertained. When this sand is cool measure out in the graduated glass tube 100 c.c. of this dry sand; be careful to pour slowly into the tube, jarring the tube while pouring. Level off the top with a flat end stick so as to accurately read the measurement.

In the other glass tube, measure out 100 c.c. of water. Pour the dry sand slowly into the glass tube containing the water and note the height to which the water rises. Also note the number of c.c. of the sand. The sand will not always measure when wet exactly the number of c.c. as when dry, namely 100, as some sands, as previously stated, due to peculiar characteristics, swell in volume when moist or wet.

If 100 c.c. of solid matter had been placed in the glass tube the water would have risen to 200. Therefore, to ascertain the voids, deduct the number of c.c. to which the water has risen from 200. Sand as it comes from the bank or is measured by contractors is always damp or wet; it is assumed that it has swelled to its maximum volume.

If it is found that the sand has swelled in volume then the number of c.c. to which it has swelled over and above 100 must be considered.

As an illustration: 100 c.c. of Cheshire white quartzite, medium, was placed in 100 c.c. of water. It was found that white quartzite then measured 114 c.c., showing that it had increased in volume by 14 c.c., thus under working conditions increasing the voids. Therefore, if 114 c.c. of solid matter had been added to 100 c.c. of water, the latter would have risen to 214 c.c. It was found, however, that the water only rose 156 c.c., therefore there is 58 c.c. of voids in the 114 c.c. of sand; divide 58 by 114 and the result is 50 8/10% of voids.

Table 1 is a table giving the calculations for void percentages.

In making field tests by the above described method of different samples of sand, use that which shows the least percentage of voids.

Wash 100 c.c. of the sand in 100 c.c. of water by shaking together in a bottle, decant water into a graduated glass tube; again wash sample as before and decant water into the glass tube, stand until settled and read amount of clay or loam.

Table 1.

100 C. C. Dry Sand Added to 100 C. C. Water.
(C.C. Stands for Cubic Centimeter.)

Water rose to	Sand Swelled in Volume to Following c.c.														
	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114
	Percentage of Working Voids.														
150	50	50^{5}	50^{9}	51^{4}	51^{9}	52^{4}	52^{8}	53^{3}	53^{7}	54^{1}	54^{5}	55	55^{3}	55^{7}	56^{1}
151	49	49^{5}	50	50^{5}	51	51^{4}	51^{9}	52^{3}	52^{8}	53^{2}	53^{6}	54	54^{4}	54^{8}	55^{2}
152	48	48^{5}	49	49^{5}	50	50^{5}	50^{9}	51^{4}	51^{9}	52^{3}	52^{7}	53^{1}	53^{6}	53^{9}	54^{3}
153	47	47^{5}	48	48^{5}	49	49^{5}	50	50^{5}	50^{9}	51^{4}	51^{8}	52^{3}	52^{6}	53	53^{5}
154	46	46^{5}	47^{1}	47^{6}	48	48^{6}	49^{1}	49^{5}	50	50^{5}	50^{9}	51^{4}	51^{7}	52^{2}	52^{6}
155	45	45^{5}	46^{1}	46^{6}	47^{1}	47^{6}	48^{1}	48^{6}	49^{1}	49^{5}	50	50^{4}	50^{8}	51^{3}	51^{7}
156	44	44^{5}	45^{1}	45^{6}	46^{1}	46^{7}	47^{2}	47^{7}	48^{1}	48^{6}	49^{1}	49^{5}	50	50^{4}	50^{8}
157	43	43^{5}	44^{1}	44^{6}	45^{1}	45^{7}	46^{2}	46^{7}	47^{2}	47^{7}	48^{2}	48^{6}	49^{1}	49^{5}	50
158	42	42^{5}	43^{1}	43^{7}	44^{2}	44^{7}	45^{3}	45^{8}	46^{3}	46^{8}	47^{3}	47^{7}	48^{2}	48^{6}	49^{1}
159	41	41^{5}	42^{1}	42^{7}	43^{3}	43^{8}	44^{3}	44^{9}	45^{4}	45^{9}	46^{4}	46^{8}	47^{3}	47^{7}	48^{2}
160	40	40^{6}	41^{2}	41^{7}	42^{3}	42^{8}	43^{4}	43^{9}	44^{4}	44^{9}	45^{5}	45^{9}	46^{4}	46^{9}	47^{3}
161	39	39^{6}	40^{2}	40^{8}	41^{3}	41^{9}	42^{4}	43	43^{5}	44	44^{5}	45	45^{5}	46	46^{4}
162	38	38^{6}	39^{2}	39^{8}	40^{4}	40^{9}	41^{5}	42^{1}	42^{5}	43^{1}	43^{6}	44^{1}	44^{6}	45^{1}	45^{6}
163	37	37^{6}	38^{2}	38^{8}	39^{4}	40	40^{6}	41^{1}	41^{6}	42^{2}	42^{7}	43^{2}	43^{7}	44^{2}	44^{7}
164	36	36^{6}	37^{3}	37^{9}	38^{5}	39	39^{6}	40^{2}	40^{7}	41^{3}	41^{8}	42^{3}	42^{8}	43^{3}	43^{8}
165	35	35^{6}	36^{3}	36^{9}	37^{5}	38	38^{7}	39^{2}	39^{8}	40^{4}	40^{9}	41^{4}	41^{9}	42^{4}	42^{9}
166	34	34^{6}	35^{3}	35^{9}	36^{5}	37^{1}	37^{7}	38^{3}	38^{9}	39^{4}	40	40^{5}	41	41^{5}	42^{1}
167	33	33^{6}	34^{3}	34^{9}	35^{6}	36^{1}	36^{8}	37^{4}	38	38^{5}	39^{1}	39^{6}	40^{1}	40^{7}	41^{2}
168	32	32^{7}	33^{3}	34	34^{6}	35^{2}	35^{8}	36^{4}	37	37^{6}	38^{2}	38^{6}	39^{2}	39^{6}	40^{3}
169	31	31^{7}	32^{4}	33	33^{7}	34^{2}	34^{9}	35^{5}	36^{1}	36^{7}	37^{3}	37^{8}	38^{3}	38^{9}	39^{4}
170	30	30^{7}	31^{4}	32	32^{7}	33^{2}	33^{9}	34^{6}	35^{2}	35^{8}	36^{4}	36^{9}	37	38	38^{6}

That the reader may have confidence in the methods above described in ascertaining the characteristics of sand which will produce maximum density, some of the experiments made by Mr. Moyer and published in the pamphlet heretofore referred to, will be described.

The use of a graduated glass tube of 1½ inches to 2½ inches in diameter containing 200 to 250 c.c. might appear to some engineers as being unreliable on account of the small quantities tested and the probable variation of volume. Also the theory of capillary attraction prying apart the grains of sand of certain characteristics might seem to be unsound, but numerous tests seem to bear out this theory. At any rate

Table 2.

Proportion	100 c.c. Sand gave a Volume of Mortar of	Average 5 Briquettes Tensile Strength 7 days	28 days	Collected on Sieve.	%
1:1½	125 c.c	407	524	10	.003
1:1¾	120 c.c.	335	445	20	.004
1:2	120 c.c.	275	396	30	.01
1:2¼	115 c.c.	277	367	50	$.31^{4}$
1:2½	110 c.c.	255	334	Through	$.66^{9}$
1:2¾	110 c.c.	211	282		
1:3	110 c.c.	181	255		

5$\frac{5}{16}$ oz. Cement figured as = to 100 c.c. which is in same proportion as 94 lbs. = one cu. ft.

such peculiar characteristics have been noted by a number of engineers, but the writer has not yet run across any other theory which cannot be explained away. Some say that the head of the water used has different effects, that if a larger amount of water was used instead of 100 c.c., the results would be different. The writer, however, has not found this to be a fact and furthermore it would then be difficult to account for the sand which did not swell at all in volume.

Water must be clear, odorless and tasteless. If there is taste or odor, the water must be analyzed, the chemist to advise if there is sufficient percentage of any elements present to be injurious to Portland cement.

The most important ingredient in concrete is Portland cement, as it is this material which forms the bond. The other aggregates being usually stronger, upon the uniform strength of the cement depends the strength of the concrete.

Table 3.

% Voids in Sand.	PROPORTIONS. Figuring actual volume of 1 bbl. cement as packed by Mfgrs. to =3.8 cu. ft. and assuming 1 bag=1 cu. ft.	Proportions to use figuring 1 Bag cement=to 1 cu. ft. Figures are nearest the ¼.	% Voids in Sand.	PROPORTIONS. Figuring actual volume of 1 bbl. cement as packed by Mfgrs. to=3.8 cu. ft. and assuming 1 bag=1 cu. ft.	Proportions to use figuring 1 Bag cement=to 1 cu. ft. Figures are nearest the ¼.
	cu. ft.			cu. ft.	
25	1:3.76	1:3¾	38	1:2.47	1:2½
26	1:3.61	1:3½	39	1:2.41	1:2½
27	1:3.48	1:3½	40	1:2.35	1:2¼
28	1:3.35	1:3¼	41	1:2.29	1:2¼
29	1:3.24	1:3¼	42	1:2.23	1:2¼
30	1:3.13	1:3¼	43	1:2.18	1:2¼
31	1:3.03	1:3	44	1:2.13	1:2¼
32	1:2.93	1:3	45	1:2.09	1:2
33	1:2.85	1:2¾	46	1:2.04	1:2
34	1:2.76	1:2¾	47	1:2	1:2
35	1:2.66	1:2¾	48	1:1.96	1:2
36	1:2.61	1:2½	49	1:1.91	1:2
37	1:2.54	1:2½	50	1:1.88	1:1¾

The selection of stone, screenings, slag, cinders, sand or other ingredients can be determined often by sight or touch, or at least by simple tests. Portland cement tests require experts of some years' experience; the results of known laboratory tests are merely a guide from which deductions may be made only by the best scientific understanding available. Owing to the variable conditions surrounding such tests, the results cannot be absolute.

Each manufacturer exploits his particular brand as the best cement, some claiming extraordinary fine grinding the criterion, others larger bulk per barrel, others low lime content, others high lime content and hard burned clinkers, etc., etc., and all of them claim the strongest by test, which claims they support by various published test sheets.

Table 4.

Weight per Cubic Foot-lbs	Gravel (Pebbles) without Sand	Sandstone	Limestone medium soft	Limestone medium hard; Sandstone hard	Granite Blue stone Limestone hard	Granite hard Trap medium	Trap hard
75	54	50	52	54	—	—	—
80	51	47	49	51	52	—	—
85	48	43	45	48	50	51	—
90	45	40	42	45	47	48	50
95	42	37	39	41	44	46	47
100	39	33	36	38	41	43	45
105	36	30	33	35	38	40	42
110	33	26	29	32	35	37	39
115	30	—	26	29	32	34	36
120	27	—	—	26	29	31	34
125	—	—	—	—	26	28	31
130	—	—	—	—	—	26	28
135	—	—	—	—	—	—	25

There have been carried on a large number of experiments based largely on laboratory methods, which experiments tend to show that 3.8 cu. ft. to the barrel of Portland cement weighing 376 lbs. net, is approximately correct.

If 3.8 cu. ft. weigh 376 lbs., then 100 c.c. will weigh 5 19-32 oz., so if it is assumed that 1 bag of Portland cement, 94 lbs., is a cu. ft., then 100 c.c. would = 5 5-16 oz.

Using the calculated voids as per the water test above referred to, and the proportion of cement accordingly, using as a unit of measurement 94 lbs. as assumed to be equivalent to 1 cu. ft., or 100 c.c. as equivalent to 6 5-16 oz., it was found that the volume of mortar was entirely dense, economical and in every instance greater than the volume of sand used to the extent of from 10 to 15%; therefore irregularities in mixing and placing are automatically cared for.

To arrive at correct proportions obtain the voids in sand by means of the graduated glass tube water test described above. Use Table 2.

Apply preceding table, No. 3, using the proportions as shown in last column opposite the % of voids as ascertained above.

Proportions of cement and sand resulting in maximum density for water-tight mortar.

(Voids to be determined by method described above). Proportions figured on 4 bags = 3.8 cu. ft. Proportions stated, 1 bag = 1 cu. ft.

To ascertain the percentage of voids in the larger aggregates, the following table will be a simple means of furnishing this information.

Make a box of such dimensions as will contain 3 cu. ft., box to be 1′ x 1½′ x 2′. Dry the stone or gravel, heating to over 212° F. Throw the stone into the box loose, level off the top with a straight edge, and having first weighed the box, weigh the box when full. Deduct the weight of the empty box from the gross weight and divide the net weight by 3, which will give the actual weight of 1 cu. ft. Apply Table 4.

Table 5.

Voids in Stone	Proportions of Stone expressed in cubic feet											
	PROPORTIONS OF MORTAR											
%	1:1	1:1¾	1:2	1:2¼	1:2½	1:2¾	1:3	1:3¼	1;3½	1:3¾	1:4	1:4½
25	4	7	8	9	10	11	12	13	14	15	16	18
26	3¾	6¾	7¾	8½	9½	10½	11½	12½	13½	14½	15½	17¼
27	3½	6½	7½	8¼	9¼	10	11	12	13	14	14¾	16¾
28	3½	6¼	7¼	8	9	9¾	10¾	11½	12½	13½	14¼	16
29	3½	6	7	7¾	8½	9½	10½	11¼	12	13	13¾	15½
30	3¼	5¾	6¾	7½	8¼	9¼	10	10¾	11¾	12½	13¼	15
31	3¼	5¾	6½	7¼	8	9	9¾	10½	11¼	12	13	14½
32	3	5½	6¼	7	7¾	8½	9¼	10	11	11¾	12½	14
33	3	5¼	6	6¾	7½	8¼	9	9¾	10¾	11½	12	13¾
34	3	5¼	6	6½	7¼	8	8¾	9½	10¼	11	11¾	13¼
35	2¾	5	5¾	6½	7¼	7¾	8½	9¼	10	10¾	11½	12¾
36	2¾	5	5½	6¼	7	7¾	8	9	9¾	10½	11	12½
37	2¾	4¾	5¼	6	6¾	7½	8	8¾	9½	10¼	10¾	12¼
38	2¾	4¾	5¼	6	6½	7¼	8¼	8½	9¼	10	10½	11¾
39	2½	4½	5	5¾	6¼	7	7¾	8¼	9	9¾	10¼	11½
40	2½	4½	5	5¾	6¼	7	7½	8	8¾	9½	10	11¼
41	2½	4¼	4¾	5½	6	6¾	7¼	8	8½	9¼	9¾	11
42	2¼	4¼	4¾	5½	6	6½	7¼	7¾	8¼	9	9¼	10¾
43	2¼	4	4¾	5¼	5¾	6½	7	7½	8¼	8¾	9¼	10½
44	2¼	4	4½	5¼	5¾	6¼	6¾	7½	8	8½	9	10¼
45	2¼	4	4½	5	5½	6	6¾	7¼	7¾	8¼	8¾	10
46	2¼	3¾	4¼	5	5½	6	6½	7	7¾	8¼	8¾	9¾
47	2¼	3¾	4¼	4¾	5¼	5¾	6¼	7	7½	8	8½	9½
48	2	3¾	4	4¾	5¼	5¾	6¼	6¾	7¼	7¾	8¼	9¼
49	2	3½	4	4½	5	5½	6¼	6¾	7	7¾	8¼	9¼
50	2	3½	4	4½	5	5½	6	6½	7	7½	8	9
51	2	3½	3¾	4½	5	5½	6	6½	6¾	7¼	7¾	8¾
52	2	3¼	3¾	4¼	4¾	5¼	5¾	6¼	6¾	7¼	7¾	8¾
53	2	3¼	3¾	4¼	4¾	5¼	5¾	6¼	6¾	7	7½	8½
54	2	3¼	3¾	4¼	4¾	5	5½	6	6½	7	7¼	8½

Before ascertaining the voids in stone containing screenings or gravel containing sand, dry by heating, screen out all particles which will pass through a ¼ inch mesh sieve; such particles should be figured as a portion of the mortar. Having obtained the percentage of voids in the larger aggregates, the proportion of mortar necessary to fill these voids is thus known.

You are now in possession of the proportions of cement to sand or stone screenings in forming the mortar and the number of voids in the larger aggregates which will be filled with this mortar. The preceding table, No. 5, will be a ready means for obtaining the proportions for concrete.

ELECTRIC POWER FROM WIND.

By H. E. M. Kensit, M.I.E.E.

The Canadian Engineer of November 2nd contains a note on "Electric Power from Wind," which suggests considerable possibilities in the way of isolated wind driven electric plants.

The convenience, advantages, and economy of such installations for electric light and power to ranchers and others all over Canada are too obvious to need comment. The point is, are they practical and reasonable in cost?

As a matter of fact they are. Very practical results have been obtained for some time past in this direction in European countries, and a few examples of actual instances showing the amount of power developed and the cost, may be of general interest.

The main difficulty is, of course, the irregularity of the wind, but this has been efficiently overcome by several different methods as shown below.

Considerable attention has been given to this subject by the Danish government, and at the beginning of 1906 there were some 40 windmills driving generators in operation in Denmark.

The experiments are mainly carried out for the government by Prof. La Cour, and their success led to the formation of the Danish Wind Electricity Co., who put in most of the above mentioned installations.

The La Cour method of obtaining approximately regular voltage is as follows: The main pulley actuated by the windmill shaft drives a pulley whose shaft is mounted on a weighted and adjustable lever. A larger pully on this same shaft drives the dynamo by belt. The difference of tension between the tight and slack sides of the main belt can be regulated by adjusting the weight on the lever, and when the speed exceeds a pre-determined rate the belt slips proportionately and the apparatus becomes self-regulating. An automatic switch prevents the battery discharging through the dynamo when the battery voltage is higher than that of the dynamo.

It has been found that for the particular type of windmill used a blade area of 514 square feet gives 8 h.p. with a wind velocity of 13.4 miles per hour and 16 h.p. with a wind velocity of 17.8 miles per hour.

At Askov a windmill drives two dynamos of 12 h.p. each Part of the power is used to charge a battery supplying 705 incandescent lamps, 4 arc lamps, and 8 motors, a total of 21 h.p., the balance being used for electrolytic purposes.

At another installation at Valle Kilde the area of the blades is 240 square feet, and this gives 8.6 h.p. at 24 r.p.m. with a wind velocity of 15.6 miles per hour. The capacity of the dynamo is 8 kw. and of the battery 600 ampere hours. The plant drives a grinding mill, circular saw and other machines. In this case a petrol motor was put in as a standby. The total cost of the installation, including this petrol motor and buildings, was $3,600.

A fairly complete description of these plants, with diagrams, is given in the Electrical Review, (Eng.) No. 5162, Vol. 61.

A similar installation, also equipped with a standby petrol motor, has been used in Denmark for the public supply of electricity, the charge being equivalent to 11½ cents per kw. hour for lighting and 3½ cents for power.

The capital cost was $4,300, and the balance of revenue over expenditure for the year's working was $538, which shows 12½% on the investment to meet interest, sinking fund and depreciation.

This is an expenditure and result which would make the supply of electric light possible in many small villages where the cost of continuous attendance on steam or gasoline engines is almost prohibitive.

An example of a small plant is that manufactured by J. C. Child's & Co., of Willesden Green, England.

This consists of a wind-turbine mounted on a steel tower 50 feet high and complete with dynamo and battery. The dynamo is of 2 kw. capacity at 130 volts, and comes into operation automatically between the speeds of 800 and 1,600 r.p.m. The voltage is kept constant by varying the field excitation by a system of 6 graded relays. The batteries are automatically cut in or out, as necessary, and the plant requires but little attention.

The cost of this plant in England would be equivalent to about $1,215, and under London conditions, where the mean velocity of the wind is stated to be 8 miles per hour, it would supply about 1,500 kw. hours per annum. Allowing 10% interest, etc., on the investment, this represents an annual cost of $122, or just over 8 cents per kw. hour.

To give an idea of what this 1,500 kw. hours would do, let us assume a ranch with ten 25 c.p. tungsten lamps and one 2 h.p. motor. Then assuming the average use of the lamps over the whole year in a ranch house to be 3½ hours each per day, these 10 lamps would consume 400 kw. hours per year, and the remaining 1,100 kw. hours would operate the 2 h.p. motor at times when light was not required for over 2 hours every week day in the year.

This, however, is by no means the limit of what could be got out of such a plant. London is far from being a windy place, and in a very large proportion of places the wind is both more frequent and of higher velocity, increasing the output of the plant more than proportionately.

Another plant by the same makers consists of a wind-turbine on a 75-foot steel tower connected to a 4 kw. dynamo and battery. This plant is entirely automatic in operation and bearings and gears are so designed that it is claimed they could be left for 12 months without attention. With an average wind of 9 miles per hour the plant would supply about 5,000 kw. hours per year.

In addition to supplying 100 lamps it operates a motor which drives as required either a chaff cutter, circular saw, or root pulping machine.

In a German plant two batteries are used, each capable of supplying one evening's load. In the daytime the batteries are charged in parallel. At night one battery is used in parallel with the dynamo to maintain constant voltage at the lamps, any surplus power being used to charge the other battery, and the following night the functions of the batteries are reversed. When there is no wind both batteries are put in parallel on the load.

An interesting application of the wind driven electric generating set was that installed on the S.S. Discovery for the expedition to the Antarctic regions, with a view to economizing fuel. This was designed by Mr. Arthur Bergtheil, of Bergtheil & Young, London, England. In this case constant voltage is maintained, irrespective of the wind, by using two generators opposed to one another, mounted on the same shaft, and varying in speed from 500 to 2,000 r.p.m.

The tower is 20 feet high and the windmill 12 feet in diameter, developing about 3 h.p. in a 15-mile wind.

GRAVEL AS BALLAST.

The following excerpts are taken from an article by C. Brauning, appearing in Zeitschrift für Bauwesen, and translated for the American Railway Engineering Association. The full article appears in Bulletin No. 136 of that association.

Owing to its high cost, hard stone, crushed, can only be afforded for ballast in roadbeds which are heavily taxed with traffic, while stretches taxed to a less extent must resort, at least for some time to come, to material near at hand, mostly river or mountain gravel. The greater carrying capacity of crushed stone is principally due to the many sharp edges of the individual pieces. This gives it the high resistance when used as ballast, which is not greatly reduced under shock. On the other hand, the gravel pieces give way easily under pressure and lose still further in resistance when subjected to shock. The object of this article is to determine to what extent gravel makes possible a uniform and permanent roadbed.

The observations direct themselves first to the conditions to be met. It was desirable to follow out the changes in different individual roadbed stretches and note their greater or lesser durability in comparison with the peculiar characteristics of the ballast of each stretch. The ballast of the observed stretches consisted of a mixture of coarse and fine gravel with a sand content of 25 to 33 per cent., consisting of grains under 1 mm. greatest diameter. The cross-ties were spaced 750 to 840 mm. The traffic over the roadbed yearly amounted to about 1.2 million tons. Among the daily trains which covered these stretches were several which had a velocity of 75 kilometers per hour and more. The observations were continued two years, the elevation of the rails was taken every two months, and during affecting weather conditions more often. It was determined that the most important observations come just previous to the occurrence of, during the time of the heaviest, and just after the complete disappearance of frost.

It was to be noted from the observations that close relations exist between the different elevations of the rails and the nature of the soil upon which the roadbed rests. Every clay and clay-bearing soil drove the track upward, and as other observations indicated, also towards the sides. The more uniform such soil is, and the more uniformly it is distributed, the more uniform the tendency to lift the track seems to be, and to lower it again after the disappearance of frost. Irregular mixtures of sand and clay, as occur in earthen embankments such as are formed by dumping led to very unfavorable action in spots, owing to the fact that the earth, due to the action of the frost, was unevenly forced upward and outward and did not regain its original position after frost had disappeared. Clean and evenly fine grained sand proved to be quite constant under the action of frost, and a similar absence of the expansive force of frost was noted in the gravel ballast itself, though it was not entirely free from earthy constituents.

During the seasons of no frost such apparent influences of the soil underneath the ballast were not noted. The effect of the deposits, which came principally into consideration here, changed itself according to the water-absorbing capacity of the clay-bearing sub-soil, but the contour of the sub-grade varied within such narrow limits that it was impossible to observe individual changes. In the summer time the sinking of the rails was generally very small and hardly measureable. Several times notice was taken of the rising of the rails up to 2 mm.—however, only at the hottest time of the year.

A comparison of wooden cross-tie construction was also made with longitudinal stringer construction made up of

Haarmann's stringer rails, which, owing to their unfavorable position in the roadbed, are more sensitive to the changes in the ballast and sub-soil than the wooden cross-ties.

The nature of the ballast, whether crushed stone or gravel, does not assist in remedying the influences of the soil upon which the ballast rests. In order, therefore, that the sub-soil have no influence on the roadbed, it is necessary that it consist of a material which is constant under the action of frost, and extends below the frost line. In North Germany frost extending to a depth of 70 cm. in loose sand and gravel, or a depth of approximately 55 cm. underneath the wooden ties, should be taken into consideration. Any bed of clean sand will serve as a frostproof sub-soil, even when the sand is of fine grains.

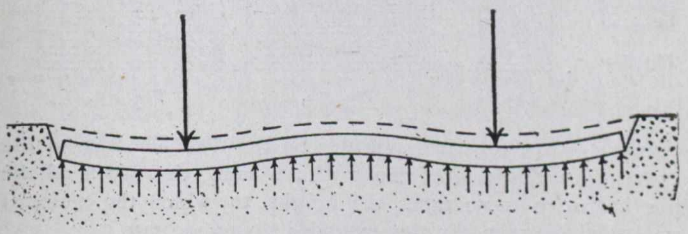


Fig. 1.

The investigations were continued along the line of determining the effects of these different properties. In purely scientific treatment of the roadbed it is commonly taken that the ballast is uniformly elastic, and this feature only is taken into consideration. As a matter of fact, the different portions of the ballast which act as individual supports are not uniformly elastic. Each load occurring in the operation over the railroad causes, with the temporary depression, also a permanent change, however slight. This permanent set has a definite relation to the unit pressure imposed. If, therefore, the loads are unequal which are transmitted to the ballast through the ties, then the set underneath the more heavily loaded ties is more serious than in the case of the others. Consequently, owing to this tendency, the original conditions of loading of the ballast are gradually changed, principally in that the pressures under the more heavily loaded ties gradually diminish and the pressures under the lightly loaded ties gradually increase, until the condition of loading becomes quite uniform. In order to observe these phenomena, a section of roadbed was purposely unevenly tamped so that a portion of the ties rested solidly on the ballast, while the other portion was without any support. By repeated observations it was found that the spaces between the ballast and the ties gradually diminished, and after six months disappeared entirely. Hence, ballast supporting cross-ties not uniformly loaded tends to change tiself into a uniformly loaded mass. Of course, this equalization of the loading does not occur through a uniform sinking of the rail and ties, but is due rather to more or less prominent local depressing, and thus amounts to a deterioration of the condition of the roadbed.

An equal change is experienced by the ballast underneath each tie. And here, too, the tendency is for the tie to take such a form that the unit pressures of it in the ballast are equal in all places. Hence, the tie itself becomes a beam with uniform loading, and the surface of the ballast underneath the tie assumes, therefore, the shape of the elastic curve of the tie under this particular condition of loading. This shape of the surface is present whether the tie is loaded or not (Fig. 1).

If the bed upon which the tie is imposed is confined between two rigid walls, the resistance of the bed with these walls strongly opposes the tendency of the bed material to become displaced upwards. But if the confinement of the bed arises from the neighboring ties, simultaneously loaded, as is the case in track, moving particles which meet between the ties oppose one another, and, not finding any confining resistances, drive themselves upward. Fig. 2 illustrates an experiment with two equally loaded ties on a confined bed. The distances between the ties chosen were such that the amounts of material between the ties and between the walls and the ties were equal, and thus also making the resistance in the two directions equal. This was approximately the case when $a/2:c = 1:1:3$. (Fig. 2). The distance between ties when the bed material ceased to rise up between them appeared to be when $a = 1.5b$. Even with a pressure as great as 40 kilograms per square centimeter no rising of the bed material was noted when the ties were brought closer together than $a = 1.5b$.

After these observations of the nature of the movements taking place in a gravel bed, it became desirable to learn more about the resistances which the gravel opposes to these movements. The heavy pressures required in these experiments do not occur in the ordinary roadbed, so it became necessary to depend upon special arrangements on a smaller scale. The results herefrom cannot be applied directly to ordinary roadbed practices, since enlarged conditions, such as occur in practice, would alter the shapes of the material under load; and, further, since the varying nature of ballast material itself and peculiarities of the loading in actual roadbed practice cannot be taken into consideration sufficiently. Hence the object of these particular experiments was to determine certain relations of the different properties of the ballast material which it is assumed would obtain in actual practice. More particularly speaking, it was the object of these investigations to determine the influence of tie-spacing, the width of ties, the height to which material was packed between the ties, and of the nature of the ballast itself. For the purpose of these experiments iron cases with adjustable walls were used. They were of such a depth that the movements of the materials in the bed would not extend to the bottom. A press consisting of a screw and a heavy spiral spring, which transmitted the pressure imposed upon the spring to an indicating pointer, was used to load the tie (Fig. 3). The scale of the indicating device was determined by means of actual weights. The press was arranged for a

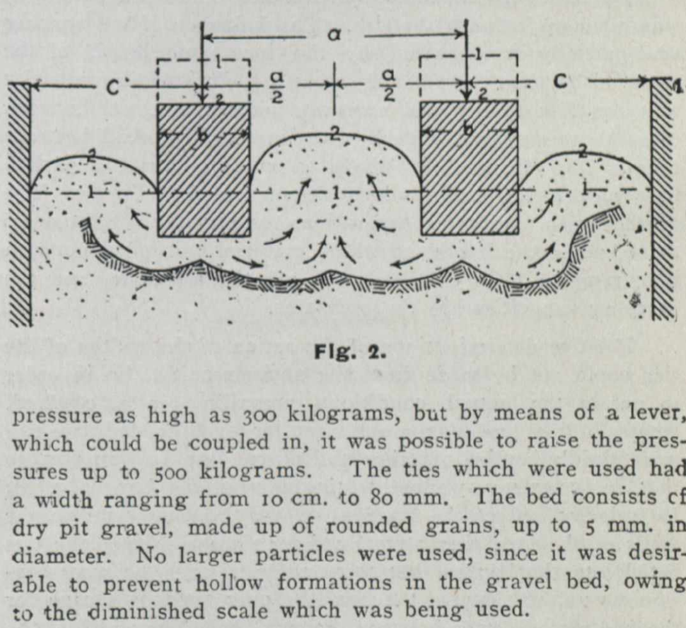
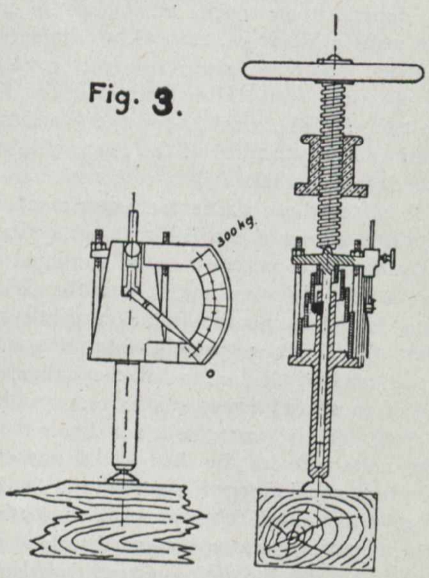


Fig. 2.

pressure as high as 300 kilograms, but by means of a lever, which could be coupled in, it was possible to raise the pressures up to 500 kilograms. The ties which were used had a width ranging from 10 cm. to 80 mm. The bed consists of dry pit gravel, made up of rounded grains, up to 5 mm. in diameter. No larger particles were used, since it was desirable to prevent hollow formations in the gravel bed, owing to the diminished scale which was being used.

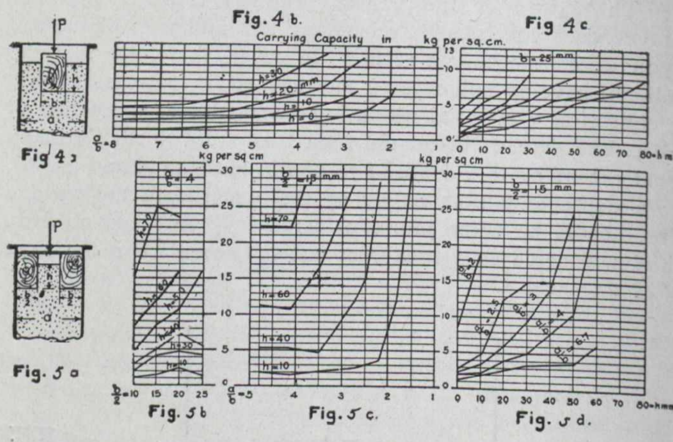
The first experiments were made on single ties ranging in width from 20 to 60 mm., resting on a bed of fine grained sand, no particles of which exceeded 1 mm. in diameter. The pressure was increased until clearly defined movements were discernible in the bed. As a rule, a sudden collapsing or release occurred when the pressure reached a certain point temporarily relieving the pressure imposed. The resistance of the bed depends upon its width "a" (Fig. 4), the width of the tie "b," and the height to which the bed material rises along the side of the tie "h." The influence of the width of the bed "a" bears a particular relation to the width of the tie "b." Hence, this influence may be designated by the relation a/b, through which may be determined the proper tie spacing. The results of the experiments are demonstrated in Figs. 4a to 4c. In Fig. 4b the distances between ties are plotted along the abscissa, while the carrying capacities of the bed in kg. per sq. cm. are plotted along the corresponding ordinates, giving curves for different heights of "h" ranging from 0 to 30 mm. When h was 0 and the relation between a/b was greater than 7, the carrying capacity remained practically constant. As the distance between ties decreased the carrying capacity increased, first slowly and then more rapidly, so that when a/b = 2 it was twice as great as when a/b = 3.

Fig. 3.



The carrying capacity was further increased as gravel was piled up between the ties. The influence of the spacing was partially compensated by the increasing height of the material between them to the extent that the carrying capacity was equal in ties spaced narrowly without material between them to ties spaced widely with material packed between them. The effect of the height to which material is packed between the ties is particularly demonstrated in Fig 4c. The several lines are for tie separations ranging for a/b from 2.6 to 20, while the height to which material was piled between ties, ranging from 0 to 80 mm., are the abscissæ, and the carrying capacities are the ordinates.

Positive determinations of the action of the widths of the ties could not be made from the above results. So in order to get at the actual conditions prevailing in a roadbed, where the ties are equally and simultaneously loaded, two ties were rigidly bonded together and placed into an iron box, so that each came very close to the sides of the box (Fig. 6). In order to reduce the friction of the bed material on the walls of the box, they were lined with glass. Since the ties fitted into the box so that three sides of each tie were contiguous to the sides of the box, the only possible escape for the bed material was between the two ties. The width of the ties in reality, therefore, corresponds to ½ the width of a tie in actual practice, and, consequently, is indicated by b/2. At this time it was observed that a wedge with its apex pointing upward appeared underneath each tie when the material between the ties had reached a certain height and the material of the bed tended to glide off the sides of this wedge, exer-



cising a heavy pressure sidewise on the tie. The size of the gravel particles ranged from 1 to 2 mm., the width of the ties b/2 = 10 to 50 mm., the height to which the material was piled between the ties extended up to 130 mm.

The results illustrated in Fig. 5-a to 5-d are similar to the ones reached in previous experiments; however, the effect of tie spacing was felt at lower values of a/b, approximately when same equalled 4 (Fig. 5-c). As this ratio decreased its influence was still greater than in the previous case, so that the carrying capacity with a ratio of a/b = 2 was four times as great as when a/b = 3. The limit was reached for a sidewise displacement of the bed material when a/b = 1.5 and h = 10 mm. As the height h increased, the carrying capacity of the bed, it seems, grew at an increasing rate (Fig. 5-d). These relations were the more apparent and more effective as the distance between ties decreased. Here, also, a distinct influence of the width of the ties was noticeable on the carrying capacity of the bed, as is demonstrated in Fig. 5-b for different values of h, height of material between ties. As the widths of ties increased the unit pressure increased according to the laws of a straight line, maintaining a relation quite constant.

The question of the smallest size of gravel particles and the largest admixture of foreign material permissible in gravel ballast is of considerable significance, from a parctical and economical point of view, to those railroads depending upon gravel for ballast. The carrying capacity of gravel depends primarily on its internal resistances, which are indicated by the angle of repose of material. For ordinary dry gravel, the following values are determined:—

Number.	Size of Grains.	Angle of Repose.
I.	Less than 1 mm.	31° 11′
II.	1 mm. to 2 mm.	33° 45′
III.	2 mm. to 3.1 mm.	36° 9′
IV.	3.1 mm. to 4.2 mm.	37° 10′
V.	4.2 mm. to 5.6 mm.	40° 15′
VI.	5.6 mm. to 9.2 mm.	39° 48′
	Mixture of I., II., VI. = 1:1:5	34° 35′
	Mixture of II., IV. = 1:1	36° 52′

Hence, the angle of repose increases from 30 to 40 degrees, with increase in size of the grains. The carrying capacity of the bed increases very rapidly as the angle of repose of the bed material increases from 30 to 40 degrees, and at 40 degrees it should be three to five times as great as at 30 degrees.

The size of the gravel particles are not alone in determining the carrying capacity of the material, but the effect of the moisture present and the condition of material also influence it considerably. Light moisture, as is usually present at the base of the roadbed, tends to increase the adhesion between the particles, and, hence, enhances the carrying capacity of the finer grained gravel. It was found that fine grained gravel in a moist condition had twice to four times the carrying capacity of the same gravel in a perfectly dry state; on the other hand, coarse grained gravel revealed no striking difference between the dry and the moist stage. A surplus of water, however, loosened up the adhesion of the finer grains when subjected to quick change in loading. If proper drainage is provided, then coarse grained gravel can hardly be saturated with water; while, on the other hand, fine grained gravel may easily be saturated, since it retained the water up to its point of saturation.

The principal requirements for a permanent and uniform roadbed with gravel ballast may, therefore, be summed up as follows:

The sub-soil upon which the roadbed rests should consist, to a depth of the frost line, of a material which is not affected by weather conditions, nor, when frozen, heaves upward, thus disturbing the ballast.

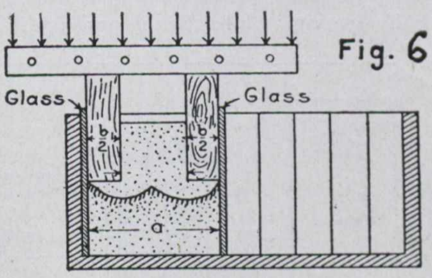


Fig. 6

The continued settling of the rail bears a distinct relation to the internal resistances of the ballast. Hence, ballast, as far as it is subjected to such forces, should consist of material which is uniform in its carrying capacity. When the carrying capacity of the sub-soil, therefore, is not high or varies greatly, as is the case with all earthly soils, the roadbed should be of such strength that the individual loads on the ties are evenly distributed throughout the ballast and uniformly distributed over the sub-soil. Furthermore, all sidewise and circulating movements should be confined within the ballast.

In order to meet these requirements, a depth of bed of about 550 mm. underneath the ties would be sufficient, provided some particularly unfavorable conditions of the sub-soil did not make a greater depth necessary. A clean sand, readily permitting water to pass through it, would act well at the bottom of this bed. The actual depth of the ballast should not exceed 300 mm. underneath the ties in order to prevent mixing with the bottom layer of sand. Regarding the size of the gravel grains, it is desirable, in order to secure a ballast which drains readily in its upper layers, and in order to prevent the undue formation of dust underneath and following trains, and in consideration of the future increase of fine grain content due to tamping, to prevent as much as possible the admission of fine grained particles in the ballast. This, however, only means particles less than 2 mm. in size. As a matter of fact, a mixture of fine and coarse grains is desirable, since it permits of a more solid packing of the gravel underneath the ties than when only coarse gravel is used.

The width of roadbed bears a certain relation to the length of ties and the spacing of the ties. It is considered that an extension of the ballast outwards from the ends of the tie, with their usual length of 2.7 to 28 m., amounting to 300 mm., is sufficient.

As the height to which the ballast is packed increases, the carrying capacity of the roadbed increases. Hence, material should be piled between the ties as high as operating conditions will permit.

The width of the tie is also of considerable importance, since with constant load the unit pressures on the bed are reduced as the area of the tie increases, and the carrying capacity of the tie increases directly as its area. A general use of larger wood ties is not permissible, owing to the high purchase price and the greater difficulty of obtaining the same. It is desirable to have the ties 2.8 m. in length. Strict consideration should always be given the proper and uniform spacing of ties and shaping of the roadbed in order to utilize to the limit the resistance of the roadbed.

Of greater importance than the width of the ties is the spacing of the ties. As the spacing is decreased two advantages are derived: first, the unit pressure decreases; secondly, the carrying capacity of the roadbed is increased. It is just within the limits of tie spacing usually considered that the relation a/b, ranging from 3½ to 2 (spacing 900 mm. to 500 mm.), that the carrying capacity increases at a high rate. The limiting feature of decreasing tie-spacing is the ability to tamp the ties properly. Ties 160 mm. in height can still be tamped with convenience when separated 350 mm. But this (the relation being 2.3), 600 mm. from centre to centre, is the lowest limit. This is the one most effective and simplest means of increasing the strength of the roadbed, and to utilize it to the fullest advantage.

The portion of the ballast under the joints requires special consideration, since the impact at these points makes extraordinary demands on the roadbed. It has been attempted several times to strengthen this part of the ballast by packing crushed stone underneath the ties supporting the joint, however without success.

AUSTRALIAN TRANSCONTINENTAL RAILWAY.

According to advices received by the department of trade and commerce, the government of the Commonwealth of Australia has under consideration the construction of a transcontinental railway, which will connect South Australia with Perth, in western Australia, the bill for which is at the present before the commonwealth parliament. The length of the line surveyed is 1,060 miles, though the engineering difficulties are not so great as compared with Canada. The greatest obstacle is that of an adequate water supply on the route, but a liberal outlay of £3,000,000 is provided for this item. The average rainfall over a very considerable distance is only four inches. Artesian boring has already proved successful at a few places on the surveyed track. Upon a standard gauge of 4 feet 8½ inches the estimates of construction aggregate about £3,988,000, and after parliament has granted authority for the construction of the line work will be commenced without delay.

CANADIAN GYPSUM.

Three hundred thousand tons of gypsum were exported to the United States last year, according to a mining authority in Eastern Canada, owing to lack of grinding facilities. The manufacture of gypsum (plaster of Paris) in brief consists of heating calcium sulphate to a certain degree which drives off a portion of the water of constitution; when this condition is arrived at the sulphate is ground into powder for commercial purposes. The process of wetting the plaster allows the water driven off to combine again, giving the substance its familiar firm qualities.

REPORT OF A DUTY TRIAL ON THE SIX MILLION GALLON PUMPING ENGINE AT THE HIGH-LEVEL PUMPING STATION OF THE TORONTO WATERWORKS.

The city of Toronto has two pumping stations for the supply of water to the city proper, exclusive of that supplied to the residents of Toronto Island. Of these two the main pumping station is situated at the foot of John Street, close to the bay, and all the water supplied to the city passes through pumps in this station, the pressure being maintained at slightly over 90 pounds per square inch.

In order to maintain the proper pressure in the northern part of the city the high level pumping station was built on Poplar Plains Road, a short distance above the Canadian Pacific Railway tracks.

The growth of the northern part of the city has been very rapid af late years and the consequent consumption of water has so increased that the pumps originally installed in the station were unable to maintain a sufficiently high pressure, so that an additional pump, having a capacity of six million Imperial gallons per day, has been installed and it is this latter pump with which this report deals.

To maintain steadiness of motion and uniformity of stroke, each steam piston is connected through a connecting rod to a crank shaft, on which are two flywheels each of 12-foot diameter. The cranks are placed 120 degrees apart.

Steam Cylinders and Piping.—(See diagrammatic sketch Fig. 1.) Steam is delivered to the engine through a 4-inch pipe, which is branched close to the engine so as to deliver steam directly to the admission valves at the upper and lower ends of the high-pressure cylinder. After passing through the high-pressure cylinder the steam goes through the first receiver, in which it is reheated, and passes on to the intermediate cylinder from which it is delivered to the second reheating receiver, then on to the low-pressure cylinder and to the condenser in the regular way.

The high pressure and intermediate cylinders are respectively 16 inches and 30 inches diameter, and both the admission and exhaust valves are of the Corliss type, there being one of each kind of valve at each end of the cylinder. The low-pressure cylinder is 44 inches diameter, and the two admission valves are of the Corliss type as in the case of the other cylinders, but the exhaust valves are of poppet construction, there being two of the latter in each end. These poppet valves are opened by a cam driven by the engine, the lower pair closing by gravity while the upper ones are closed,

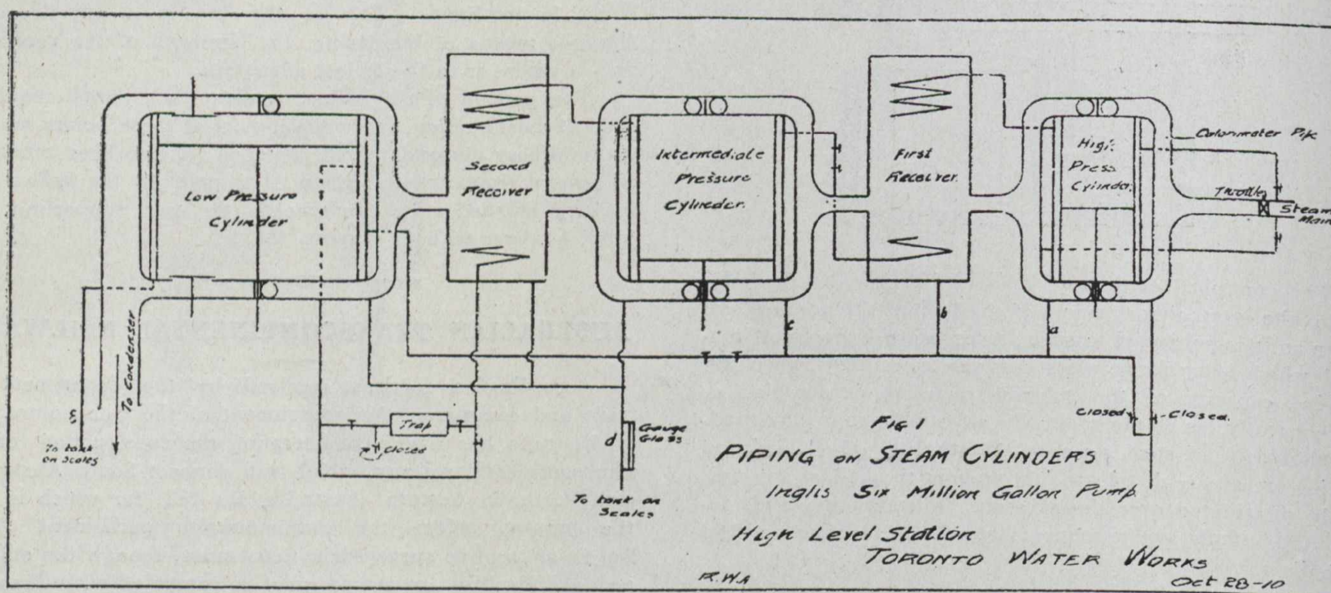


Fig 1
PIPING ON STEAM CYLINDERS
Inglis Six Million Gallon Pump
High Level Station
TORONTO WATER WORKS

through an air piston, by compressed air delivered by a compressor attached to the low-pressure plunger.

The test was conducted and the report completed by Professor R. W. Angus, Professor of Mechanical Engineering, University of Toronto.

Description of the Engine.—The engine on which the test was made is located in the High Level Pumping Station of the Toronto Waterworks and was built by the John Inglis Co., of Toronto. This engine, along with the others at the same station, is used to raise the pressure in the northern part of the city from that of about 20 pounds per square inch, as delivered to this station from the main pumping plant, to the pressure of about 75 pounds per square inch, which is the ordinary domestic pressure in this northern section.

The engine now under consideration is of the vertical triple-expansion type, having three steam cylinders and three single-acting outside-packed plungers, the plungers being attached directly to the steam pistons by rods. It is designed to deliver six million Imperial gallons per twenty-four hours against a pressure of 75 pounds per square inch, the suction entering at 20 pounds per square inch. The engine is also capable of delivering the above quantity against 100 pounds per square inch for fire purposes, and the plunger speed is limited to 180 feet per minute.

The cylinders are all jacketed on the barrels by steam originally drawn from the steam main before it reaches the engine. No separate jacketing is, however, arranged on the heads of the cylinders, but the construction is such that one half of each cylinder head is in contact with its own admission steam while the other half of each head is in contact with the exhaust steam from that cylinder.

Jacket, Reheating and Drainage Piping.—From the steam main on the boiler side of the throttle valve two separate pipes, with valves, lead to the engine, the one the by-pass leading to the exhaust of the high-pressure cylinder and used for starting up, while the other pipe is used as the jacket supply and is connected to the high-pressure cylinder jacket, this jacket being thus supplied with steam at the full boiler pressure. After passing through this jacket the steam is conveyed, **without loss of pressure,** to the reheating coil in the first receiver, from which it passes through two valves, in which the pressure is reduced, to the intermediate jacket. From the intermediate jacket the steam next goes to the reheating coil in the second receiver, and thence through a trap to the low-pressure jacket, the pressure being reduced between the coil and the jacket, and the piping being arranged with a by-pass around the trap which may be used if desired. From the low-pressure jacket the steam is delivered to the waste.

As shown in the sketch, drainage pipes are connected to all cylinders and receivers, and of these the pipe from the steam pipe on the high-pressure cylinder is always closed during the operation of the machine. The three pipes, a, b, and c, from the high-pressure exhaust pipe, the first receiver and the intermediate pressure steam pipe respectively are connected together and the drainage from these, after passing through two valves for reducing the pressure, is delivered to the low-pressure jacket. The drains from the intermediate pressure exhaust pipe, the second receiver and the low pressure steam pipe are also connected and pass through a pipe d, on which is a water glass, to the waste drain.

The arrangement of the exhaust piping to the condenser is such that the exhaust may be passed through the heater on the way to the condenser if desired.

Pumps.—As already stated, there are three outside-packed single-acting plungers of about 21⅝ inches diameter and of different weights so as to counetrbalance to some extent the weights of the steam pistons and rods. There are three suction and three discharge air chambers and two by-passes are arranged for each pump cylinder, one a 4-inch pipe with valve from suction main to the under side of the plunger, the other a 2-inch pipe with valve from the under side of the plunger to the discharge main. These valves are normally closed.

Pump Piping.—The suction pipe is directly connected to the surface condenser so that all the water pumped is used as cooling water before reaching the engine.

Details as to the valves are given in the general data for the pumps.

The suction pipe is 24 inches diameter, and a gate valve is placed on it before it reaches the condenser; the delivery main is 20 inches, and after leaving the engine contains a check valve which is immediately followed by a gate valve, the pipe then passing on to the city mains after joining with the discharge main of the Macdougall pump.

Auxiliary Apparatus.—Attached to the low-pressure plunger are three pumps: the air pump, the boiler feed pump, which was disconnected during the trial, and an air compressor which delivers air to the air chambers and also for the closing of the exhaust valves on the top end of the low-pressure cylinder.

Normal Dimensions of the Engine.—The dimensions given in this table were all taken from the working drawings, and as most of them were not essential to the duty trial, many were not verified. The diameters and stroke of the plungers are merely set down here for reference as the exact measurement of these appear in the report of the duty trial.

High Pressure Cylinder.

Diameter of piston, inches	16
Fa e of piston, inches	9
Stroke of piston, inches	36
Length between heads, inches	45½
Diameter of piston rod, inches	4⅜
Per cent. of clearance, top	1.85
Per cent. of clearance, bottom	1.94

Intermediate-Pressure Cylinder.

Diameter of piston, inches	30
Face of piston, inches	9
Stroke of piston, inches	36
Length between heads, inches	45½
Diameter of piston rod, inches	4⅜
Per cent. of clearance, top	1.80
Per cent. of clearance, bottom	1.83

Low-Pressure Cylinder.

Diameter of piston, inches	44
Face of piston, inches	9
Stroke of piston, inches	36
Length between heads, inches	45½
Diameter of piston rod, inches	4⅜
Per cent. of clearance, top	0.893
Per cent. of clearance, bottom	0.895

First Receiver.

Diameter inside, inches	25
Length, mean inside, inches	66
Length of reheating tube, feet	84
Diameter of tube outside, inches	1¼
Diameter of tube inside, inches	1⅛
Steam inlet diameter, inches	4
Steam outlet diameter, inches	6

Second Receiver.

Diameter, inside, inches	36
Length, mean inside, inches	66
Length of reheating tube, feet	134
Diameter of tube, outside, inches	1¼
Diameter of tube inside, inches	1⅛
Steam inlet diameter, inches	7
Steam outlet diameter, inches	9

Condenser.

Diameter inside, inches	42
Length between tube plates, inches	66
Number of tubes	207
Diameter of tubes outside, inches	1¼
Thickness of tubes, No. 15 B.W.G	
Suction pipe entering condenser, diameter, inches	24
Suction pipe, leaving condenser, diameter, inches.	24
Steam pipe entering condenser, inches	10
Outlet to air pump, inches	6
Total cooling surface, square feet	372

Air Pump, Single Acting.

Diameter of piston, inches	14
Stroke of piston, inches	36
Suction pipe, diameter, inches	6
Discharge pipe, diameter, inches	6

Feed Pump, Single Acting.

Diameter of plunger, inches	1¾
Stroke of plunger, inches	36
Suction pipe, diameter, inches	1½
Discharge pipe, diameter, inches	1½

Air Compressor.

Diameter of plunger, inches	1¾
Stroke of plunger, inches	36

Fly Wheels.

Number	2
Diameter, feet	12
Face, inches	12
Thickness of rim, mean, inches	10
Weight of one wheel, pounds	15,527

General.

Length of connecting rod, centre to centre, inches	90
Crank shaft, diameter of main shaft, inches	11
Crank shaft, diameter in flywheels, inches	13
Crank shaft, crank pins, inches	6 x 6
Main bearings, four bearings each, inches	11 x 16
Diameter of steam pipe, inches	4
Diameter of exhaust pipe, inches	10

Heater.

Diameter inside, inches	20
Height, mean inside, inches	56
Total heating surface, square feet	51
Steam inlet and outlet pipes, inches	10

NOMINAL DIMENSIONS OF THE PUMPS.

(Taken from the working drawings.)

Plungers.

Diameter of all plungers, inches	21⅝
Stroke values of all plungers, inches	36
Valves of rubber	
Number of valves on each cage	35
Extra valves on each discharge cage plate	2
Number of cages on each cage plate	7
Number of suction valve cage plates	3
Number of discharge valve cage plates	3
Total number of suction valves	735
Total number of discharge valves	741
Area of water opening in each valve seat, sq. in.	2.75
Total area of valves in each cage	96.25

THE DUTY TRIAL.

General conditions of Trial.—The duty trial was conducted on October 28th and 29th, 1910. The specifications lay down the following with regard to the trial:

"The engine shall have a capacity of six million Imperial gallons in twenty-four (24) hours when operated at a plunger speed of not over 180 feet per minute, against a head equal to 75 pounds pressure per square inch on the pumps."

"The engine shall perform a duty of not less than one hundred and sixty million (160,000,000) foot pounds for each one thousand (1,000) pounds of commercially dry steam used by the engine and any auxiliary pumps supplied by the contractor and operated during the duty trial. Steam containing less than 1½ per cent. of entrained water, as determined by calorimeter measurements, shall be considered as commercially dry steam. In computing the duty, the work performed by the engine shall be based upon plunger displacement. The head for computing the duty shall be that shown by an accurate pressure gauge attached to the discharge main at a point inside of the engine room and beyond the last pump, less the reading shown by a gauge attached to the supply main at or near entrance to pumps. No allowance shall be made for friction of water in pumps, or pipes between the pump well and the gauge attached to the discharge main. In computing the duty, the total steam used, including that used by jackets, reheaters and auxiliary pumps, shall be charged to the engine. The duty trial shall be of twenty-four hours' duration. The engine shall be operated continuously at the rated capacity against a head equal to 75 pounds pressure per square inch, on the discharge main, and shall be supplied with steam of not more than 150 pounds pressure per square inch, by gauge at the boiler.

This pump receives water under pressure, and although no definite statement as to the amount of this pressure is given in specifications for the duty trial, yet the general data in the "Information of Tenderers" states that the pressure in main supplying pumps is 20 pounds per square inch, so that I decided to accept this.

Starting the Trial, Etc.—The engine had been in operation for over a year and had run continuously for over twenty-four hours before the trial.

The test began at 2 p.m., Friday, October 28th, and concluded at 2 p.m. the following day, the watch used during the trial being compared with a chronometer at the beginning and end and found to be correct. All observers were in place and the instruments were adjusted at 1 p.m. Friday, preliminary readings being taken to insure that the observers understood their work.

The plungers were comparatively tight, there being no leakage from one of them and very little from the others. There were no steam leaks.

Speed of the Engine.—The specifications require that the delivery of the pump shall be six million Imperial gallons per twenty-four hours with a plunger speed of not over 180 feet per minute, so that I decided to run so as to give a plunger displacement slightly in excess of the rated capacity, the plunger speed being slightly below the allowable maximum. In this way the speed averaged 29.3 revolutions per minute, as determined from the counter attached to the engine.

Pressure on the Pumps.—The pressures on the pumps were determined by two reliable pressure gauges which were also calibrated with great care, slight inaccuracies in the gauges being corrected for. The suction gauge was connected by a pipe to the main at a point outside the condenser and between the latter and the gate valve which is used to close off the suction of the pumps from the city mains. The discharge gauge was connected by a pipe to the discharge main at a point between the last pump and the check valve, which in addition to the gate valve connected to it, is used to shut off the connection between the pumps and the city discharge main.

An observer was stationed at these two gauges and readings were taken every five minutes. Workmen were also stationed at the gate valves on the suction and discharge mains, who regulated the gate valves so as to keep both the suction and discharge pressures equal to those required by the specifications. In this way the pressures were kept remarkably constant and as the two gauges were set at the same level the difference between their corrected readings gives the net pressure acting on the pumps.

Plunger Displacement.—As a duty is based upon plunger displacement it was necessary to determine accurately the diameter and stroke of each plunger. The diameters were determined by calipering them immediately after the pump had been stopped, measurements being taken at various points on each plunger and the results being read to thousandths of an inch.

The stroke of each plunger was also measured to thousandths of an inch, while the pump was running, by a method already described by me in my report on the fifteen million gallon engine at the Main Pumping Station and the MacDougall engine at the High Level Station tested last year.

Quality of the Steam.—The quality of the steam was determined by a throttling calorimeter which was well-lagged and attached to the engine in the position shown in Fig. 1. The pressure of steam in the pipe was determined by a calibrated gauge, while the pressure in the calorimeter was obtained by the use of mercury manometer, the reading being corrected for water which condensed on top of the mercury. The temperature of the steam in the main supply was also taken by a thermometer in order to be certain that there was no superheating, some of the boilers being equipped with superheaters which were, however, not in use, and the temperature of the steam was found to be that corresponding to the pressure of saturated steam.

The quality of the steam remained constant during the entire test.

Indicator Diagrams.—A large number of simultaneous indicator diagrams was taken at intervals throughout the trial and showed uniformity in the working conditions.

Steam Pressures.—As the specifications required that a pressure of 150 pounds per square inch be maintained at the boiler, the regular boiler gauge was removed and an accurate and calibrated gauge put in its place. An observer remained on a ladder in front of this gauge during the entire run and by directing the fireman maintained very constant pressure, the variations from the average being rarely as great as 0.5 pounds per square inch.

In addition to the above, readings were taken on the gauges attached to the first and to the second receivers and also on those attached to the intermediate and the low-pressure jackets, all of the gauges being calibrated and the readings being corrected for water column.

The vacuum was read on a gauge which had been compared with a mercury column and found to be correct.

Barometer Reading.—The barometer readings during the trial were obtained from the Government Observatory on Bloor Street. The average for the whole period was 29.38 inches.

The Weight of Steam Charged to the Engine.—In order to get the weight of steam used by the engine the discharge from the hot well was piped into a weighing tank and the weights discharged for each twenty-minute interval during the run were determined.

The condensation in the jackets, receivers, etc., was weighed separately by discharging it through two pipes, d and e, into a separate tank on scales. One of these pipes, e, took the condensation in the low-pressure jacket, the other, d, the condensation in the second receiver and in the steam pipes directly connected to it as shown in sketch Fig. 1.

All outlet valves other than those used as above were closed and all weighings were made at twenty-minute intervals. As the condensation from the jackets and receiver was very hot, this water was run into cold water which effectually prevented re-evaporation.

The scales used were examined immediately before the test by the Government Inspector of Weights and Measures and were found to be correct. They were also balanced just before the readings began.

All weights were inspected by two independent observers.

Observations.—All observations were made at twenty-minute intervals, with the exception of the suction and discharge water pressures which were observed at five-minute intervals.

The observers were all advanced engineering students in the University of Toronto and are skilled in such work, and there was no indication of error anywhere in the trial.

The contractors, The John Inglis Co., Limited, were represented by their engineer, M. F. B. Ward, and Mr. Walsh, the chief engineer of the station, was in charge of the engineers and firemen engaged on the plant.

Ceneral Remarks.—During the tests the conditions remained quite uniform and the results represent very fairly the action of the engine during the test period, and are very gratifying in that they show that the engine has considerably exceeded the guarantee in regard to duty.

MEASUREMENTS OF THE PUMPS USED IN COMPUTATIONS.

High-Pressure Plunger.

Stroke, actual, inches	35.979
Diameter, actual, inches	21.651
Displacement per revolution, cubic feet	7.666

Intermediate-Pressure Plunger.

Stroke, actual, inches	35.963
Diameter, actual, inches	21.636
Displacement per revolution, cubic feet	7.651

Low-Pressure Plunger.

Stroke, actual, inches	35.996
Diameter, actual, inches	21.615
Displacement per revolution, cubic feet	7.664
Total displacement per revolution, cubic feet	22.961
Total displacement per revolution, Imperial gals.	143.096

(Volume of the Imperial gallons = 277.274 cubic inches.)

OBSERVATIONS AND RESULTS.

Date of Trial.—Two p.m. Friday, Oct. 28th, to 2 p.m. Oct. 29th, 1910.

Duration of trial, hours	24

Corrected Average Pressures.

At boiler, by gauge, pounds per square inch	150.0
At engine, by gauge, pounds per square inch	148.47
In first receiver, pounds per square inch	29.9
In second receiver, below atmosphere, pounds	1.0
In intermediate jacket, by gauge, pounds per square inch	30.8
In low-pressure jacket, by gauge, pounds per square inch	1.8
Vacuum, by gauge, inches mercury	28.3
In discharge main, pounds per square inch	74.92
In suction main, pounds per square inch	20.02
Correction for difference of level of gauges	none
Pressure difference on pumps, pounds per square inch	54.90
Barometer, inches mercury	29.38

Average Temperature.

Of engine room, degrees Fahrenheit	67.

Calorimeter.

Pressure of supply steam at calorimeter, pounds per square inch	148.47
Pressure of steam in calorimeter, inches mercury	2.29
Pounds per square inch	1.125
Temperature in calorimeter, degrees Fahrenheit	301.9
Moisture in steam, per cent	0.3

Speeds.

Total revolutions by counter	42,212
Average revolutions per minute	29.32
Average plunger speed, feet per minute	175.82

Water Pumped.

Total number of revolutions	42,212
Plunger displacement per revolution, Imp. gals.	143.096
Displacement per twenty-four hours, Imp. gals.	6,040,368

Work Done.

Total number of revolutions	42,212
Displacement per revolution, cubic feet	22.961
Pressure difference on pumps, pounds per sq. in.	54.90
Work done in twenty-four hours, foot pounds	7,662,342,569

Steam Used by Engine During Trial.

Total condensation from condenser, pounds	40,077.5
Total condensation from jackets, etc., pounds	6,806.5
Total steam used by engine, pounds	46,884

Duty.

Work done by pump in twenty four hours, foot pounds	7,662,342,569
Steam used by engine in twenty-four hours, lbs.	46,884
Duty per thousand lbs. of steam used, foot lbs.	163,431,900
Duty guaranteed, foot pounds	160,000,000

CONSTRUCTION AND MAINTENANCE OF RURAL TELEPHONE SYSTEMS.*

By D. F. Hulfish.

I see that I am to address you upon the subject of the construction as well as the maintenance of rural systems. I had expected to address you only on the subject of the maintenance of rural systems in general, and we will get some idea of construction as we go along.

A talk about maintenance is a talk about troubles. Troubles are the easiest thing I know to talk about; a couple of women over a back fence seldom talk about anything else. So I will tell you about a few difficulties I have met. Line troubles first—the hard ones.

We had a cut out on a line—a line which gave good service usually—sometimes it did not give any service at all. The operator at the switchboard would test the line, and the lineman, when he felt like it, went out and tested the instrument. Sometimes he put in a new battery on the supposition that the farmer owned an automobile—and the trouble was reported O.K.—usually reported O.K on test. But the lineman noticed that his trouble came in cold weather. One day the telephone was not working, the operator could not raise the party. The lineman went out right away and tested the line from the subscriber's pole, and got the switchboard, but not the subscriber; tested the wires outside the house and got the subscriber, but not the switchboard. The next day he put in a new piece of duplex wire from the pole to the house. That cured the trouble. That is the word I have been waiting for—"That cured the trouble." We did not test the duplex wire later, but I have a suspicion that there was a bad joint which separated when pulled tight by the cold, and came together when it got warm. This goes back to construction, for it means reliable duplex wire should be used, and suggests a test on the duplex wire before leaving it for service. That piece of duplex wire certainly was bad from the day it was put in.

I will tell you of other troubles still of the same kind. There was a bad joint in a duplex. Sometimes the line cut off and sometimes the line was noisy. It was a magneto line, not exactly a farmers' line, because it was in a village, and the local man at the exchange had been unable to locate it, so an outside man came in and watched it for a while. He found the cut-off when he listened from the subscriber's instrument, but not from the pole outside. He put in a new span of duplex wire, the old duplex he stretched, and found the cut-off in it. He cut the insulation open and found a bad joint in one of the wires. The two ends of one wire made a conducting wire when not under strain, but when you had stretched the wire, it let this joint open.

Another case of that kind occurred within the past three weeks. I had occasion to examine the bad joint in the duplex wire which had given trouble, and found in one wire two butt ends which would touch when the companion wire was not stretched, but which would separate when the companion wire was stretched.

Now, this means a lot in maintenance, and perhaps something in construction. If you do not find a thing like that when you go out on a case of trouble, you go again, because you have not cured the trouble. It is getting at the cause and curing it which remedies the trouble and stops the expense. Now, good construction means that you put it in so there will be no cause for troubles. Good maintenance means that you cure the cause the first time.

*Address delivered at the Sixth Annual Convention of the Canadian Independent Telephone Association, November 15th, 1911.

Another trouble on the line, which I have had some acquaintance in chasing, is induction. That is not always a line trouble. One I will tell you about was a pretty clear case of line trouble to us, because when we took the instrument off the line, the induction was still on. The location was in an office building and the telephone was a desk set with the induction coil and ringer on the wall. To make the story short, a dentist had an office next door, and he put in an electric motor on the other side of the partition wall. We fixed that by moving our telephone terminal to the other side of the room. In a farmer's telephone that would not occur, but defective lighting systems at the telephone stations sometimes will cause induction trouble on your line. You are almost sure to think it is on the line. It is most likely to be there or in the carbon blocks.

Here is another story of troubles, from the mining districts this time, about a line trouble fixed several times before it was cured. Mr. Miner, who thought he was a telephone lineman, strung a line up into the mountain, two wires, side blocks, one placed on the pole higher than the other. To make the wire separation greater, he left the lower wire slack. The very first time he had a good wind storm he had troubles, and after every storm he went over his line chasing the crosses out. An outside man came along, saw how the line was constructed, and Mr. Engineer told Mr. Miner the cause of his trouble and how to cure it. He pulled the two wires up to equal slack. When two wires get to swaying in the wind, and the lower wire is slack, the lower wire will wrap around the upper one. Sometimes the upper one swings down and the lower one swings up; then they strike and wrap together and stay there. Two wires of the same sag will not do that.

In chasing troubles the lineman will find a difference with the weather. Chasing troubles in a rain storm is quite a different matter to chasing them in fine weather, and in cold weather different to warm weather. The first story of my talk shows that. When the sun came out and slackened up the span of duplex, it worked all right; with a little zero weather it went out of business. If the line is bad in wet weather and good in dry, the lineman has his cue there; it is to look for overhanging limbs and broken insulators.

PRICES OF GAS.

The following table is a comparison of gas prices in several large cities of North America. These prices are for the manufactured article and do not include communities using natural gases:—

	Per 1,000 ft.
Toronto, Ont.	$ .70
Montreal, P.Q.	1.05
Hamilton, Ont.	1.00
Winnipeg, Man.	1.20
Vancouver, B.C.	$1.15 to 1.75
Ottawa, Ont.	1.00
New York, N.Y.	.80
Buffalo, N.Y.	.95
Philadelphia, Pa.	1.00
Boston, Mass.	.80
Columbus, Ohio	1.00
Brooklyn, N.Y.	.80
Denver, Col.	.90
Portland, M.	.95
Seattle, Wash.	1.00
Pittsburg, Pa.	1.00
San Francisco, Cal.	.90
Cleveland, Ohio	.80
Oakland, Cal.	1.25
Chicago, Ill.	.85

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The Canadian Engineer absorbed The Canadian Cement and Concrete Review in 1910.

NOTICE TO ADVERTISERS.

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CONTENTS OF THIS ISSUE.

ENGINEERING TRAINING.

We have referred before in these columns to the results of the Conference on Engineering Training recently held by the Institution of Civil Engineers of Great Britain. Professor E. W. Marchant, in a paper read at the joint meeting of the Liverpool Engineering Society and the Manchester Section of the Institution of Electrical Engineers, draws up a summary of the results agreed upon at that Conference, or at least on which there was a semblance of agreement.

It is interesting to note what Prof. Marchant has to say on the subject, for many of his arguments and conclusions agree with the present methods used by the Canadian engineering colleges. These methods are quite different from those advocated by some of the engineering schools in the United States, as may be easily seen by reference to Prof. A. G. Christie's paper, published in last week's Canadian Engineer, in which Engineering Education at the University of Wisconsin is described.

Prof. Marchant states that the three essential conditions as formulated at the Conference noted were: First, that the engineer should have a good general education as a foundation for his future knowledge, and that this education should include a good grounding in mathematics; second, that he should have a good college training, which should include a grounding in the general principles underlying all branches of engineering; and third, that he should have a good workshop training on pupilage.

That is all very well, but the trouble comes in understanding what is meant by "good." A good grounding in mathematics may mean very much or very little. In fact, we believe that mathematics, as at present taught in our Canadian engineering schools, is decidedly weak. This follows as a natural result from the fact that the schools are at present teaching elementary mathematics, such as algebra, trigonometry and geometry in the first year of their course, when, as a matter of fact, this work should be taken up in the collegiate institutes or preparatory schools.

Prof. Marchant advocates strong support to the extension of college laboratories to the exclusion of workshop training. This is no doubt the wiser plan, and is the method advocated here in Canada; that is, to utilize the school and college time mainly for educational subjects and theory as distinct from manual work. By extension of the laboratories much valuable research work might be done, and there is no doubt that this should be regarded as one of the most important parts of the training of the engineer, because it teaches him better than in any other way the art of deduction from experiment and the art of observation. However, while this principle of laboratory work is held here, there is room for great extension along that line. It is our feeling that too little attention is paid to this department in the college curriculum. No doubt, one reason for this is the fact that extensive equipment is necessary for the thorough prosecution of the work; and this, the engineering schools lack on account of inadequate endorsement and income. The different governments have not yet realized the absolute necessity of providing generously for this phase of technical education; and the governing bodies of the universities, made up, as they usually are, of men drawn from professions other than engineering, and interested in furthering the pure rather than the applied sciences, have neglected to provide a fair share of the income for this work.

The conclusions to be drawn from Prof. Marchant's paper, as applied to Canadian conditions, are, in short, that the entrance standards to the engineering schools should be raised, not alone by requiring a higher percentage on the present subjects, but by refusing entrance to students until they have covered the mathematics as given in the final year of the Ontario Collegiate Institutes; and that the laboratory work of the engineering faculties should be extended and provision made for more research work.

THE DISPOSAL OF THE SEWAGE OF TORONTO.

It would appear that it has been left to the Medical Health Officer of Toronto to make a suggestion to the City Board of Health of some practical value with reference to the sewage disposal of the city.

In a recent report the Medical Health Officer suggests that the Works Department combine with the Health Department in making the necessary experiments, in order to provide some accurate data relative to what should and can be done with the sewage of Toronto before it is handed over to Lake Ontario.

To the ordinary, as well as the scientific mind, the above suggestion appears so sensible and apparent in its usefulness that we are at a loss to understand how and why the suggestion has not been made long ago.

Here is one of the most important questions affecting the purity of the city water supply. The Commission of consulting engineers appointed to look into the water question appear to hold a strong opinion; in fact, appear to have concluded that the contemplated sewage works will only have the effect of removing a nuisance from Toronto Bay and installing a worse nuisance in the lake itself. They state in their last interim report that the proposed changes will even have a worse effect upon the lake as a source of water supply than the present conditions. On the other hand, we understand that the City Engineer is firmly of the opinion that the lake is sufficient to oxidize all the organic matter contained in the discharged sewage, and that no evil results will follow.

As far as we can follow the question, it appears that the Health Department are not questioning the City Engineer's statement with reference to the oxidizing effect of the lake on the organic sewage, but they do question the advisability of allowing the sewage germs to enter the lake. It appears that the bacteriological samples recently taken by the Health Department show that sewage germs under present conditions travel for considerable distances from the Bay, and that the Commission of Water Engineers have confirmed this conclusion to the end that they state that there is no water to be found within ten miles of Toronto which is, or may at any time be, uncontaminated.

In fact, there appears to be some want of conformity between the Works Department and the Health Department. The Health Department say: Do something to remove the sewage germs; and the Works Department say: Do nothing, but wait and see what the results will be.

In the meantime, the suggestion thrown out by Dr. Hastings appears the right one. No harm can be done in the city finding out by actual experience just what is required to remove these germs, and what the cost to the city is likely to be.

There appears to be a considerable amount of want of any defined information as to just what will happen to the sewage when it is conveyed to Morley Avenue, the point of discharge. If the conclusion is that the works as at present proposed will effect no further purification of the sewage than the removal of just such matters as are visible to the naked eye, than we certainly think that the suggested experiments be hurried up, so that the city may prepare for the necessary work of keeping the lake free from these disease poisons, which are acknowledged to result from sewage contamination.

THE TOWN ENGINEER OF BARRIE.

We published in our issue of November 16th a comment on the fact of the town of Barrie advertising for an engineer, and offering the salary of $1,000 per annum. The following is clipped from the Barrie "Saturday Morning," which is self-explanatory:—

"The above criticism, from the viewpoint of The Canadian Engineer, cannot be called unjust, as the spirit in which it was written is intended to be a help and guide to Barrie and Kingston, holding up the case of St. Catharines, where evidently a tangle ensued through the employment of an incompetent engineer.

"Now for the situation as it really is: Mr. K. S. MacDonald, the engineer, has been, and is still, engineer for the town of Collingwood at a salary of $1,500 a year. This salary may be somewhat reduced, now the Barrie position is Mr. MacDonald's, but he has the two towns, which can be easily taken care of with the competent assistant now in his employ. The engineer will not need to devote his whole time to two towns. For instance, last year he engineered the sewer work at Penetanguishene, and, being a resident of Barrie, the county town, will no doubt be given a share of the county work. So this Page contends the engineer has a fairly good thing in sight.

"As to experience, Mr. MacDonald has had twelve years' experience in engineering work, a graduate of the School of Practical Science. His ability as an engineer can be proven when it is stated that the sewer system he designed for Barrie last year was so well done that on a contract of $10,000 the bill of extras was under $100. Compare this with the work of the Toronto engineer who designed and superintended the sewers in Wards Five and Six: $15,000 in extras on a $30,000 contract.

"While on the engineer question it may be noted that, since last week's article on the engineer problem was published, this Page has learned that the town of Barrie has paid on an average, for the past ten years, the sum of $1,200 for engineering services, exclusive of the salary of the plumbing inspector."

This explanation, of course, puts a different aspect on the question. Our impression was that $1,000 was offered for the whole time of the engineer. As a matter of fact, he will devote only a small portion of his time to the work in Barrie. The editorial in question was not intended in any way as an attack on Mr. MacDonald, whom we know to be a man well qualified for the position; but the stand was taken as a protest against the employment of municipal engineers at the ridiculously small salaries offered. We are pleased to understand that Barrie's case does not fall into this class.

EDITORIAL COMMENT.

In another column of this issue will be found part of a symposium delivered this week at the Canadian Public Health Association Convention, entitled "Engineering Problems Involved in Biological Methods of Sewage Disposal." This article will be read with interest by all sanitary engineers, for it deals with some of the peculiar conditions which must be met with in designing sewage disposal plants for our Canadian climate.

* * * *

In the report for 1910 of the Department of Public Works of Manitoba attention is drawn to the difference between the nominal and actual dimensions of bridge timber. A strong stand should be taken against the present system of charging for a large percentage of timber which is not delivered. Many instances have been noted in which the thickness of dimension timbers has been found to be from quarter inch to half inch less than specified. This has become a custom, and no doubt has been brought about in an endeavor to lessen the cost of freight to the dealers. To the engineer it is a source of difficulty when designing a structure, as it nullifies calculations and renders misleading the factor of safety adopted.

* * * *

Of great importance to the mining industry in Kootenay is the discovery of the new metal, Canadium, hitherto unknown to science. It was first noticed by Mr. A. G. French last spring in the platinum-bearing ores of the Kootenay district. After he had ascertained the qualities of the metal he announced its discovery, naming it in honor of the Dominion. It belongs to the platinum group, having qualities that make it valuable commercially. As it is present in Kootenay in large quantities, the discovery will mean much to the mining industry there. Canadium was found first during experiments at the Granite and Poorman mine, then at Shannon Creek, and afterwards on the south side of the west arm of Kootenay Lake, as well as in the dyke rocks in the Nelson district. The pure metal occurs in semi-crystalline grains and in short rods about half a millimetre long, one-tenth of a millimetre thick. When burnished it is brighter than silver or any of the white metals.

ENGINEERS' CLUB OF TORONTO.

PROGRAMME FOR DECEMBER.

It has been decided to depart from the usual Lecture Room meeting, and on

Thursday, December 7th, at 6.30 p.m.,

dinner will be served to the members, after which Mr. J. B. Tyrrell, M.A., will give a descriptive talk on "Exploration in the Far North," illustrated with a large number of lantern slides.

Those who find it inconvenient to be at the dinner should arrive not later than 8 p.m., at which time the lecture will commence in the Dining Room.

Wednesday, December 13th, 1 p.m.

The Hon. Mr. Justice William Renwick Riddell will address those present at luncheon, which will commence promptly at 1 p.m., and members are requested to be in their seats before that time.

There will be no meeting in the Lecture Room on Thursday, December 14th.

LADIES' NIGHT,

Thursday, December 21st, at 8 p.m.

On this evening the ladies are invited to hear an address on "Mountain Climbing" by Major Charles H. Mitchell, who will show a fine collection of views.

The House Committee will provide music and refreshments and endeavor to entertain the guests in a suitable manner.

Members attending are requested to contribute $1 towards the expenses. Tickets can be obtained from the Secretary for presentation in the Supper Room.

There will be no meeting on Thursday, 28th December, of the Toronto Branch of the Canadian Society of Civil Engineers.

GENERAL NOTES.

Precipitation was deficient to a considerable extent in the Western Provinces, and also in a few localities in Ontario and Quebec, but elsewhere in Canada the average was exceeded, and on both the Pacific and Atlantic coasts by a large amount. Snow fell during the month in all parts of the Dominion, and an exceptionally heavy fall occurred in British Columbia over the Lower Mainland and Vancouver Island.

On the last day of the month the ground was snow-covered from Saskatchewan to the Maritime Provinces with the exception of a large part of Southern Ontario where the ground was bare. In northern districts the depth exceeded 12 inches, elsewhere it was from 2 to 8 inches.

The table shows for fifteen stations, included in the report of the Meteorological Office, Toronto, the total precipitation of these stations for November, 1911:—

	Depth in inches.	Departure from the average of twenty years.
Calgary, Alta.	0.6	—0.21
Edmonton, Alta.	0.5	—0.34
Swift Current, Sask.	0.6	—0.05
Winnipeg, Man.	0.1	—0.98
Port Stanley, Ont.	4.9	+1.89
Toronto, Ont.	3.825	+1.295
Parry Sound, Ont.	5.8	+1.80
Ottawa, Ont.	3.3	+0.95
Kingston, Ont.	3.7	+1.11
Montreal, Que.	3.3	—0.14
Quebec, Que.	3.9	+0.83
Chatham, N.B.	4.5	+0.68
Halifax, N.S.	9.8	+3.92
Victoria, B.C	7.4	+1.33
Kamloops, B.C.	2.5	+1.38

LONG DISTANCE WIRELESS TRANSMISSION.

On Monday evening, November 20, 1911, the receiving instruments at Glace Bay, Nova Scotia, responded to Hertzian waves originating in Caltona, Italy. The distance is approximately four thousand miles and exceeded the ordinary transatlantic distance by two thousand two hundred and fifty miles. The message was received in full and then relayed to New York.

ENGINEERING PROBLEMS CONNECTED WITH BIOLOGICAL SEWAGE TREATMENT.*

By T. Aird Murray, M. Can. Soc. C.E.

The term, "Biological Sewage Disposal," is here used to designate systems which depend upon artificial filters for the reduction of putrescibility. The term does not include natural systems, such as "Land Intermittent Filtration," or "Broad" or "Sub-Irrigation," all of which may provide similar results with reference to cause and effect.

Efficiency results and the design of any system of biological sewage disposal depend upon the combined efforts and conclusions of the chemist and the engineer.

Up to within a recent period the chemist has taken little or no interest in sewage disposal. The engineer has been left alone to build sewage disposal works upon entirely empirical bases without reference to any axiomatic data relative to the chemical and biological processes accompanying the reduction of putrescible matters to non-putrescible. This has been well illustrated in Great Britain, which presents the greatest variety of sewage disposal systems to be found. It is not uncommon to find two adjacent towns discharging their effluents into the same river with entirely different systems of sewage disposal constructed in order to obtain the same results.

Great Britain has been, and remains, the post-graduate field, where the schoolman can study every feature of failure as well as of success. This is to a large extent due to the fact that the "Old Country" presents the earliest attempts at sewage purification, and that other countries have profited by its experience, more or less.

Great Britain itself has recognized the chaotic and undetermined want of defined principles, and within recent years formed a Royal Commission to report upon the whole question of sewage disposal. Germany and several of the American States also determined to get at the base of things, and make an effort to put the question on a scientific basis. The Lawrence Experiment Station of Massachusetts as representing the American States and the Hamburg State Institute of Hygiene are illustrations of this scientific activity.

The result of this scientific activity is simply this: that the man who designs works can guarantee certain results if they are based on certain data.

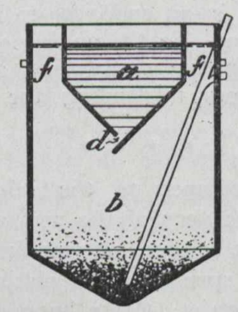
There is no longer any reasonable apology for the hypothetical theories on which either the septic tank or the contact filter bed were founded. These are taken as simple illustrations of empirical conclusions based on no scientific data relating to cause and effect. It was held that, with a septic tank it was necessary to exclude light, independent of the fact that the scum forming on the surface of such tanks excluded all light. It was also held that the exclusion of air was necessary, although it is necessary in order to provide ultimate oxidation or non-putrescibility. It was further held that a contact filter bed was the ideal method of obtaining oxidation of a sewage liquid, in spite of the fact that during the period of contact all oxygen was excluded from the bed, and that it acted at such times as a septic tank.

*Part of a Symposium on Biological Sewage Disposal, Canadian Public Health Association, Annual Meeting, Dec. 13-15, Montreal.

It required the Fifth Report of the Royal Commission on Sewage Disposal, with all its experimental work at the original installation and elsewhere, to prove the whole fallacy of total sludge elimination, and also the experiments of Dunbar, of Hamburg, to show that it required just three times the area of filtration works to oxidize a septic effluent than a fresh sewage effluent. It even took a lot of hard arguing to prove that no oxidation of sewage took place in a contact bed when the bed was full of sewage and no oxygen was present.

What was the excuse for the contact bed? Simply this: no sooner was it found that liquid sewage was rendered non-putrescible by passage through sand or gravel, and the problem was presented of equal distribution over the sand and gravel. This problem was answered by the easiest and most apparent solution of simply filling the gravel or sand bed so that every particle of material was brought into contact with the sewage. When the filter became mature, then nitrates and nitrites were found in the effluent. It was judged that the bed should have a period of time allowed when saturated with sewage during which certain bacteria might have their fill; and that it should have a further period of rest when the sewage was drawn off, allowing the same bacteria to recuperate. It required the chemist to point out that the supposed time of rest was really the period of bacterial activity, and that the time of contact was just so much waste time, during which the

THE EMSCHER TANK.



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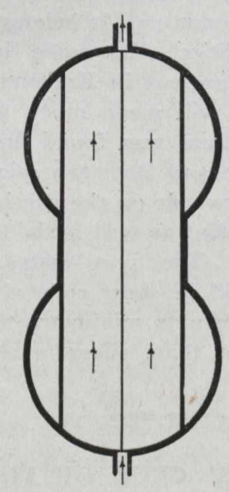


— Plan —

sewage was robbed of any dissolved oxygen it originally contained.

Also, we have heard the statement that oxidation requires sunlight, and that a filter must not be covered in to the exclusion of light, independent of the fact that, six inches below the filter surface, all light must be excluded.

We have said that the Sanitary Engineer has now a surer basis for determining design. The old excuse, "of just having to try something to see how it will work," can no longer be made in case of failure. All the recent research and experimental work, together with collection and classification of practical data, point to certain defined principles which are now being held in common by most authorities. The subject of sewage disposal, instead of being conglomerate, may be said to be, at least, approaching the crystallized stage.

The limited space of time allowed will not permit an examination of all the engineering problems affected by recent scientific investigation. It may suffice to give some attention to the following:—

1st. The immediate removal of settled solids from contact with the fresh flowing sewage, so as to avoid a septic liquid, and yet obtain all the benefits due to a septicized sludge.

2nd. The equal distribution of a settled sewage liquid over the surface of a filter bed, avoiding saturation and the consequent exclusion of air.

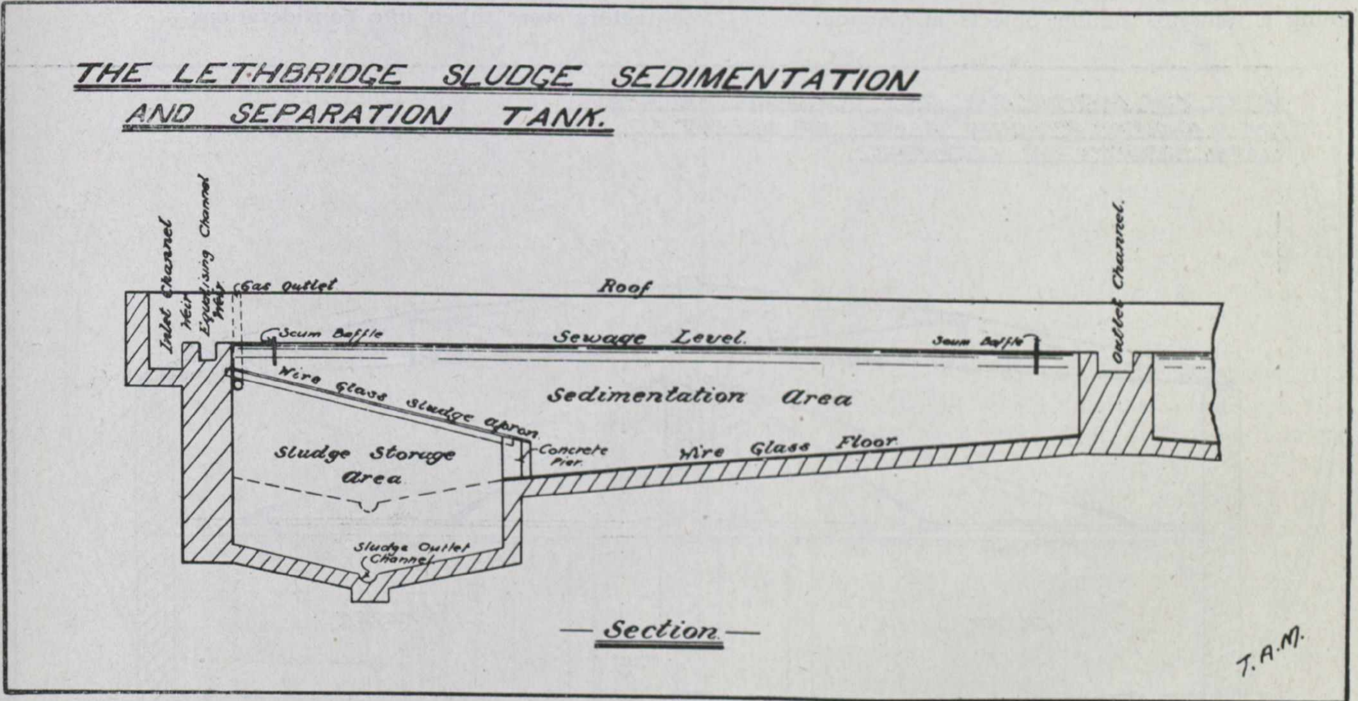
3rd. The protection of various parts of a biological sewage plant from frost conditions.

First.—The author in reviewing the Fifth Report of the Royal Commission on Sewage Disposal in the fall of 1908, published in the Canadian Engineer, referred to the now well-known conclusions of the Commission, that the so-called septic tank fell short in accomplishing some of the main claims set up by its promoters. He pointed out that if it is desirable to maintain septic action, then such should only be allowed to take place in an independent tank for sludge storage. This conclusion has found almost general acceptance, with the result that several new designs of sedimentation tanks have been promoted.

Septic action when confined to the settled sludge provides the following features: (a) A more concentrated form of sludge containing about 80 per cent. of water as against 90 per cent. in the case of fresh, settled sludge. (b) A sludge which, if thoroughly septicized, is practically without odour. (c) A sludge which is reduced by about 25 per cent. by the partial elimination of its organic content by putrefaction. (d) Septic action, if allowed to take place in an enclosed tank, provides control of the gases which are the products of decomposition.

The main objections to the usual form of septic tank lay in the fact that putrefaction of the settled solids took place in contact with the supernatent liquid. This caused a similar phenomena to that observed in a glass of soda water containing lemon seeds. The gases attach themselves to the seeds, raising them to the surface; the gases escaping, the seeds sink. So with a septic tank. The liquid flows over an area of putrefying, settled sludge; the evolved gases are constantly attaching themselves to and raising particles of sludge, with a consequent return of much of the already settled solids to the supernatent liquid in the form of fine particles. The history of a septic tank is simply the gradual increase of the amount of suspended solids in the settled liquid effluent. Instead of a maximum removal of suspended solids we obtain a minimum, requiring either a very much extended filter area, or a constant chokage of filters. Further, it is acknowledged that the duty of a biological filter is not to act as a straining, but as an oxidizing machine; and it has been clearly shown that with such filters it is much more difficult to obtain non-putrescibility with septic liquids than with fresh, the products of decomposition being less easily oxidized than the organic compounds usually found in fresh sewage. Two forms of tanks are here described, both constructed in order to obtain the maximum benefits due to septic action, and at the same time avoiding the above objectionable features. The one is called the "Emscher" Tank and the other the "Lethbridge" Tank.

The Emscher tank is the invention of Dr. Imhoff, and was designed by him in connection with the Emscher drainage area in Germany. The tank is based on

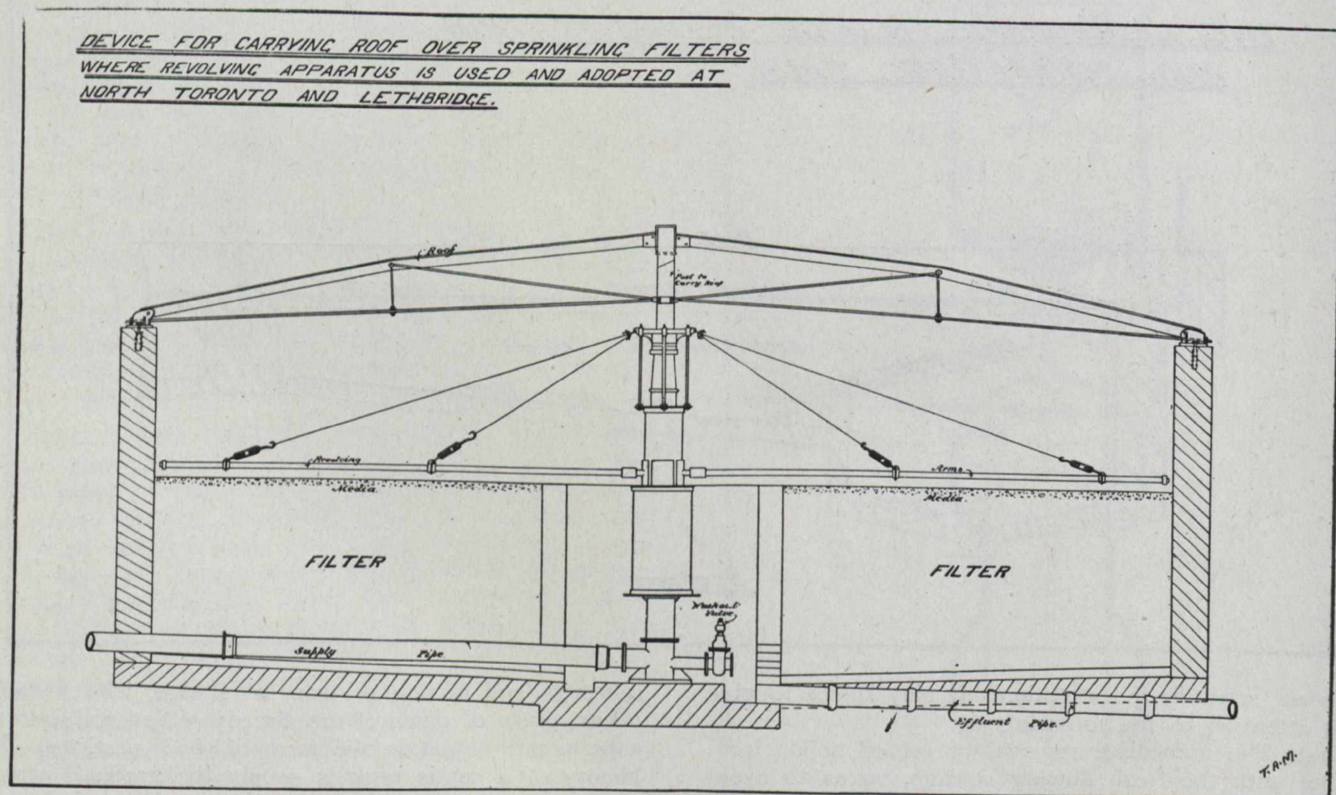


the Dortmund type; that is, it is circular cone-shaped. The upper portion is used as the sedimentation area, and is separated from the sludge storage area by the aprons as shown. The solids in settling pass down and through the opening at the base of the apron, and the overlap prevents any gases or particles of sludge from entering the sedimentation area. The gases are carried off by vents at the perimeter surface. This form of tank has received a great amount of attention of late on this continent. Rudolph Herring has called favorable attention to it in contributions to the Engineering News, of New York, and that journal has further published a very full description, giving efficiency working data collected in Germany. Experimental plants have also been installed in Chicago and elsewhere. The author has no personal experience or knowledge of the tank, but would judge that there is no reason why it should not fulfil the objects for which it is designed. His interest in the tank is accentuated, however, by the fact that, while Dr. Imhoff in Germany has been puzzling out a form of tank for the above-named objects, he has also been engaged in designing a tank for similar objects in Canada.

base is also given a steep grade to allow of solids to gravitate to the sludge storage basin. The apron and forward base are lined with wire reinforced glass for the purpose of reducing friction and ensuring immediate delivery of the settled solids into the sludge basin. The capacity of the sludge basin is made equal to three months' storage of sludge at 80 per cent. of water. The gases given off from the putrefying sludge rise and impinge against the under surface of the apron and follow up the inclined plane, and are drawn off by vent-pipes to the outside of the tank. The overlap of the apron over the forward base makes it impossible for the scepticized sludge or its products to come into contact with the supernatent sewage liquor in the sedimentation area.

The essential difference between the "Lethbridge" tank and the "Emscher" lies in the basis of design The former is designed to suit the rectangular shape, and the latter, the circular.

In adopting the rectangular shape the following factors were taken into consideration:—



DEVICE FOR CARRYING ROOF OVER SPRINKLING FILTERS WHERE REVOLVING APPARATUS IS USED AND ADOPTED AT NORTH TORONTO AND LETHBRIDGE.

Last year in designing sewage disposal works for the city of Lethbridge the author, with reference to separation of suspended solids, determined to meet, as far as possible, the folloming problems:—

(a) The maximum removal of suspended solids.

(b) The immediate separation of the settled solids from contact with the supernatent liquid in the sedimentation area.

(c) The production of septicized sludge and the production of a non-septic settled liquor.

It is considered that these problems are solved in the "Lethbridge" tank, which, under this name, has been patented.

Referring to the sketch, it will be seen that the tank is of the usual rectangular shape. A sludge apron projects into the tank, overlapping a sludge storage basin. The apron is given a steep grade to allow of settled solids to slide to the forward base; the forward

It is generally concluded that more efficient sedimentation, even velocity of flow, and avoidance of eddies can be obtained by the rectangular form than by the circular.

Circular tanks have been adopted more generally for the removal of grosser solids and such heavy matters as humus given off from biological filters.

Rectangular tanks are generally less expensive than circular in construction, are more simple in operation, and require less depth of excavation.

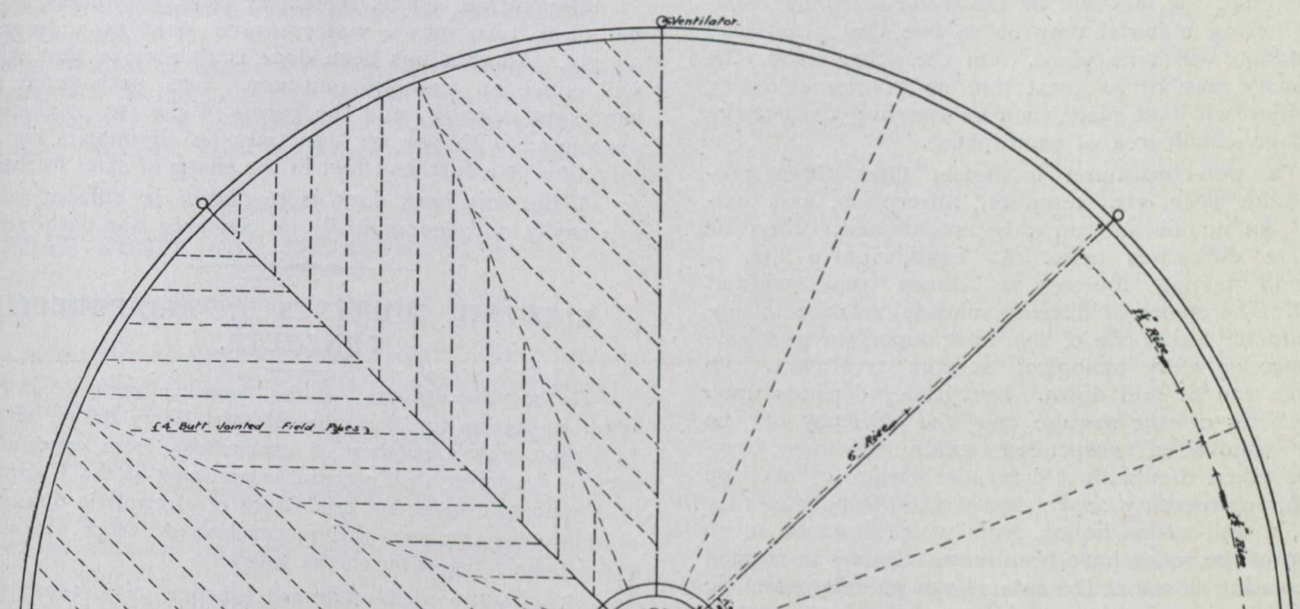
Reliable data exists as to the possible efficiencies of rectangular tanks, and it is known that a sufficient proportion of the solids can be removed in order to obviate chokage of the filter media; and, therefore, there does not appear to be any good reason for departing from this particular form of design.

Second.—The equal distribution of a sewage liquor over the whole surface of a filter, and at the same time avoid saturation, has presented a somewhat difficult problem to the sanitary engineer.

The contact bed was the first attempted solution. That every particle of the filter media came into contact with the sewage was ensured by simply filling the filter. This, unfortunately, also ensured the total exclusion of all air, and enabled the Royal Commission to report that collected data proved that a cubic yard of filtering media in which air is constantly present will oxidize twice as much sewage as a cubic yard in a contact bed.

sprays it is practically impossible to obtain equal rates of distribution. As a rule, only from 80 to 90 per cent., and sometimes less, of the filter area is in operation. Further, fixed sprays are apt to cause an odour nuisance by the liberation of gases.

Clarke, the chemist employed at the Lawrence Experimental Station, Mass., after a recent trip to Great Britain, stated before the Boston Society of Civil Engineers, that he formerly held the opinion that fixed sprays were the common-sense solution, but that he now concluded that revolving or travelling distributors gave greater efficiency per unit of filter area.



Method of Draining Filter Floor to Center.

Various designs of distributors to provide a continuous sprinkling of sewage over the filter area have been put on the market, and have given the name of the "sprinkling" or "percolating" filter to such types.

Distributors may be divided into "fixed sprays," "revolving" or "travelling" distributors.

Fixed sprays have been used more generally in America, and revolving or travelling distributors in Great Britain. There is a decided tendency to adopt the latter type in preference to the former. With fixed

It has been felt that moving distributors are more likely to be affected by frost conditions than fixed sprays. However, the cities of Moscow and St. Petersburg have lately adopted these types, and in the Canadian West, Regina, Lethbridge and Calgary are also adopting them, while Moose Jaw and Swift Current are adopting the fixed Stoddart type. Comparative efficiency data will be collected as soon as possible with reference to frost conditions in this country.

The question of avoiding saturation is one of extreme importance in connection with a sprinkling filter. Filtering material in its voids has two capacities, viz., its water-retaining and air-containing capacity. Water-retaining capacity is obtained by filling a filter with a measured quantity of water to saturation, measuring the quantity run off, the difference representing the amount retained by adhesion. Air capacity is represented by the measured quantity run off. The finer the filter material, the less will be the air capacity, and the coarser the filter material, the less will be the water-retaining capacity. Filtering material may be so fine that practically no oxidation will take place. On the other hand, the air capacity may be so great that no greater efficiency in oxidation will take place than by spraying the sewage through an equal area of atmosphere.

In a well-constituted biological filter three processes take place, viz., retention, absorption, and oxidation. An equilibrium must be maintained, otherwise immediate difficulties arise. At equilibrium a filter is capable of lasting fourteen to sixteen years without renewal. The choice of filtering material relative to size and character forms one of the most important problems in connection with biological sewage treatment. No fixed rule can be laid down. Everything depends upon the character of the sewage and the efficiency of the primary removal of suspended solids. It may, however, be taken that with a domestic sewage of average strength, representing a per capita water supply of fifty gallons, a well-settled liquor, from which from 60 to 70 per cent. of the solids have been removed, may be treated on percolating filters at the rate of 150 gallons per cubic yard of filter area with material ranging from two to three inches in cube.

THIRD:—The question of frost interference appears to trouble many minds in this country. Well, we have frost, and we have got to have sewage disposal. If it is possible to overheat houses, hotels and railway cars, it may also be possible to spare a little of this superheat to warm up a filter bed. The question is, Does the biological treatment of sewage lend itself to a cold climate? It certainly does, because it occupies less area than any other system. Every part can be easily roofed in, from the detritus chamber to the final humus basin.

Certain modifications in structure are, however, advisable. For instance, on referring to the sketch of the percolating filter, it will be observed than the usual method of draining to the perimeter into an open channel is departed from, and the sub-drainage is taken to the centre of the filter. Also, it will be noted that an improvement has been effected in the design of the central drum of the distributor by enlarging it so that a stationary metal standard is carried through to carry an iron structural roof. The latter contrivance reduces the roof cost by 40 per cent.

The best form of covering for the detritus and sedimentation chambers will usually be met by providing reinforced concrete roofing, either arched or beamed, while the filters can be cheaply covered with iron constructional frame work and timber or corrugated iron roofing.

The question of the necessity or otherwise of artificial heat cannot yet be answered, as we have no data in the colder parts of Canada as yet. It may be possible to do without artificial heat when we consider that sewage is usually delivered at about 42° F.

In conclusion, let us remember that any biological system for the treatment of sewage will only do so much and nothing more. By detritus chambers and sedimentation tanks a large proportion of the solids can be retained, and have to be subsequently dealt with. By biological filtration the settled liquid can be rendered non-putrescible. Do not expect a more clarified effluent from the filter than the influent from the filter than the influent. The object of the filter is not to clarify, but to oxidize. A clarified effluent means the retention of the 20 to 30 per cent. of solids not retained by the sedimentation tank and the eventual chokage of the filter. A good filter effluent should show an apparent amount of solids in the form of humus, which is easily settled out.

Beyond all, let us remember that the effluent is not yet fit to turn into a water source used as a domestic supply. All that has been done is to remove that which will cause an æsthetic nuisance. The pathogenic nuisance yet remains, and the germs of disease particularly associated with sewage can only be eliminated by disinfection or a further effort in the shape of sand filtration.

What has been done is to obtain an effluent which can easily and economically be rendered non-pathogenic.

ELECTRIC CURRENTS ON REINFORCED CONCRETE.

In the "Proceedings" of the American Institute of Electrical Engineers for November Messrs. Harry Barker and W. L. Upson draw a number of conclusions from experiments carried out under their general supervision at the University of Vermont to ascertain the nature of electrolytic disruption of reinforced concrete. These conclusions, which are stated to be merely tentative, are as follows:

The disruption of reinforced concrete may result from stresses produced by local thermal expansion where the current density is high, with either alternating or direct current and irrespective of the direction of the current in the latter case.

With small current densities and without temperature stresses being developed disruption finally results from the accumulation of iron oxide at and near the imbedded iron where direct current leaves the iron to enter the concrete.

The bursting stresses developed with low current densities are largely caused by the formation of iron oxide, immediately at the anodic surfaces to a slight extent, but largely in the concrete near the anodes, the depth of penetration depending on the porosity of the concrete, the gas pressure, current strength, etc., among other things.

No gradual reduction of the strength of the concrete has been shown to accompany progressive corrosion of the iron. The oxygen for the formation of oxide probably is furnished mostly by the electrolysis of water and only to a slight degree is taken from the cement compounds.

Disruption may result with low-current densities where iron is not the anode material if other compounds are formed from the anode or from the concrete and expand during the secondary reactions. In all cases pressure of gases developed may slightly assist or hasten disruption.

The general softening of the concrete after rupture is similar to that in specimens crushed mechanically and may be here regarded as largely the result of the bursting stresses.

A single current of small density may cause corrosion and disruption at several points by passing to and leaving a number of pieces of reinforcing steel, each completely imbedded.

With large leakages of either direct or alternating current to reinforced concrete, structural failures may be expected within a few hours of the start of current and as the result of thermal effects.

With small leakages of direct current an insidious undermining of structural strength must be expected.

With alternating currents, when the current density is low enough to eliminate local temperature stresses, repeated tests have shown no danger of structural troubles. This is in accord with the findings reported by Mr. J. L. R. Hayden before the A.I.E.E., March, 1907, but does not mean that there is absolutely no effect from alternating currents. It would indicate rather that the secondary reactions were so slow that the primary reactions were practically reversed each cycle.

Structural trouble is not to be expected with dry concrete unless random high direct-current voltages are noted on the structural members.

Present methods of electrical survey seem sufficient to detect dangerous (to the structure) voltages about reinforced concrete structures, and remedies are available for application as each individual case under consideration seems to demand.

ROAD COSTS AND MAINTENANCE.*

By Arthur H. Blanchard, M. Am. Soc. C.E.†

The propaganda of the American Association for Highway Improvement contains the following important fundamental principles:—

First—"The elimination of politics from the management of public roads."

Second—"The introduction of skilled supervision in the management of public roads."

Third—"Continuous and systematic maintenance of all roads."

Fourth—"The classification of all roads according to traffic requirements."

It is only through the medium of the recognition, dissemination and fulfilment of these axiomatic principles that the important problem of the adoption of that type of road or pavement best suited to local conditions from the standpoints of economy and efficiency can be successfully solved.

The determination of the most economical and efficacious method of construction and maintenance to be employed on roads of various classes constitutes one of the most interesting subjects which the highway engineer has to consider. The solution of the problem depends upon many variable factors, all of which must be given due consideration and the proper value attached to each. The great variety of materials and methods of construction and maintenance used, together with the absence of such essential information as traffic censuses, cost data, etc., makes it a difficult matter sometimes to reduce all of the different types of roads to a comparable basis for a given location. It is only within the past few years that anything has been done relative to a scientific method of taking traffic censuses on trunk highways. At this time, however, there is considerable valuable information relative to the construction or maintenance of roads to meet modern traffic conditions. Another source of confusion is the conflicting reports as to the results obtained by the use of a certain method or material. In many localities where engineers have adopted some one general method for construction or maintenance it may be found that such methods, although they may be successful as far as use is concerned, are not the most economical types which are equally efficacious. The cost data covering construction furnished by many highway officials unfortunately is so brief that it is practically worthless. Many times in otherwise elaborate reports a total cost per mile is the only information furnished under the heading cost data. It is self-evident that in order that cost data should be of value to the public and the engineering profession besides a complete description of construction, characteristics of materials employed and local conditions, there should be given figures relative to rates of labor, cost of equipment and detail data covering construction.

The topic "Road Costs and Maintenance" will be considered from the viewpoint of the annual cost to a community of improved highways of various types. Annual cost is a combination of the following variables: interest on the initial cost of the road, the annual maintenance charge, and an annuity which will in n years, the so-called life of the road, provide a fund equal to the cost of reconstruction. In the case of types of roads permitting partial reconstruction every m years, a second annuity should be included. As an illustration of the second case will be cited the practice of Parisian engineers in the reconstruction of wood block pavements. The surface of this type of pavement is maintained by the substitution of good blocks in such places as depressions have been formed, usually attributable to excessive wear of blocks of poor quality. After a certain period the entire wood block surface is taken up, the blocks planed off and relaid. Again, in the cases of many types of roads having as a characteristic a broken stone surface a partial reconstruction of from one to two inches in depth is required every m years.

The other factors enumerated under annual cost need no explanation, with the exception of maintenance charge. Unfortunately in maintenance we have a much abused word, as the standard upon which the definition of maintenance rests varies widely throughout this country. Hence reports relative to the cost of this item as a factor of annual cost are of little value except in those cases where it is known what the highway officials mean by the statement that a road is well maintained. The ideal maintenance, which should be striven for in every case, is a method by which the surface of the highway is kept in as good condition as when accepted on the completion of construction. It is self-evident that it is only possible to conform to this ideal by the adoption of the principle of continuous maintenance. It is certainly deplorable that in the case of some of our public work the idea of maintenance possessed by certain lay boards will permit the surface of a macadam road to remain covered with loose broken stone caused by disintegration due to motor car traffic for a period of over two months. This practice in cases where funds are available for the improvement of the conditions noted is obviously absurd to designate as maintenance. Rather it should be characterized as criminal negligence. This association has an admirable opportunity to emphasize the absurdity of the popular idea that an appropriation for the construction of a highway will provide a surface, which, once constructed, will endure until eternity.

Unfortunately, first cost in many cases is the only element which is considered in the selection of the type of road while in other cases the number of years which a pavement will last or will remain dustless is the only factor given due weight. The interest charge, maintenance required and the annuity item seldom receive the attention deserved. Although it is self-evident that the problem cannot be solved exactly, nevertheless it is practicable to analyze the problem presented in a manner that will give as satisfactory results as are characteristic of the results obtained in many engineering problems of a similar type and thus approach within reasonable limits the ideal of economy and efficiency.

An ideal road or pavement should be durable, noiseless, sanitary, efficacious for road users, easily cleaned and made

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*Presented before the American Association for Highway Improvement at the Richmond Convention, November 21st, 1911.

†Professor of Highway Engineering, Columbia University, New York.

dustless, provide good foothold for horses and be non-slippery for all classes of vehicles under varying climatic conditions, yield neither dust not mud, have a low tractive resistance, low annual cost, low first cost, low maintenance charge, and an æsthetic and impervious surface.

It should not be considered, therefore, that the idea of annual cost is paramount in every instance. For example, in Monaco, the winter home of the father of superficial tarring, Dr. Guglielminetti, ordinary macadam made absolutely dustless by ideal watering has been adopted because the primary prerequisite in that case was of an æsthetic character. In this instance it was necessary to select a dustless surface which would harmonize with the tropical gardens and yellow limestone palatial cafés, hotels, shops and villas clustered about the Casino of Monte Carlo. Again, although the annual cost is greater, many engineers favor the use of a bituminous filler for brick pavements rather than a cement grout filler, because the pavement constructed with the former is not as noisy as with the latter.

As illustrative of the method of analysis which should be employed in consideration of annual cost, a few examples will be given of cases which have come under the writer's observation.

The first illustration cited refers to a road built of water bound macadam located in an isolated and exposed district subjected to a traffic of five horse-drawn vehicles and thirty motor cars per foot of width of a 14-foot roadway during the period from 8 a.m to midnight in the summer season. A large percentage of the motor traffic consisted of heavy touring cars, limousines and landaulets travelling at speeds between 40 and 55 miles per hour. The kind of treatment adopted consisted of the periodic application of light oil, which, under the traffic and other local conditions, was efficacious from the standpoint of dustlessness for a period of one month. The annual cost of a superficial treatment with a bituminous material will be investigated for comparison. The interest on first cost and the annuity will be considered the same in both cases, although it is self-evident that the bituminous surface road will have a much longer life. The light oil was used during the maximum period for this locality, that is from May to November, inclusive. The cost of oiling, being one cent per sq. yd. per treatment, was 7 cents, while it was found that the cost of repairs to the macadam surface was 3 cents. It should be said in this connection that, although the surface was maintained dustless throughout the above period, disintegration by high speed motor car traffic took place. The total maintenance charge was 10 cents per sq. yd. per year. On the other hand, if an annual superficial treatment had been employed, thus providing a bituminous surface which would have been efficacious throughout practically the entire year, the average cost of the superficial treatment would have been 5 cents per sq. yd., while the repair item would not have exceeded 0.5 cents, thus giving a total maintenance charge of 5.5 cents, as compared with 10 cents with the light oil.

In another case coming under the writer's observation, it was decided to first construct a water bound macadam and afterwards provide a bituminous surface by a superficial treatment. The annual cost of a bituminous concrete pavement, finished with a flush coat which, under the traffic to which this road was subjected, would last 5 years, will be investigated for comparison. Granted that it will be necessary to reconstruct both roads by replacing the wearing surface of 2 inches every 20 years, the annual cost may be compared as follows. For the annual superficially treated road, the first cost was 67 cents, the interest charge at 4 per cent. 2.7 cents, the maintenance charge 7 cents, composed of a 5-cent charge for annual bituminous treatment and 2 cents for repairs, the annuity, 0.9 cents, based upon the cost of reconstruction. Hence the annual cost will be 10.6 cents. In the case of the bituminous pavement the first cost would, under the existing local conditions, be 90 cents, the interest charge 3.6 cents, the maintenance 2.5 cents, made up of a repair charge of 0.5 cents and the cost of the flush coat, having a life of 5 years distributed throughout this period, of 2 cents, and an annuity of 1.7 cents, thus making the annual cost 7.8 cents as compared with the annual cost of the superficial treatment of 10.6 cents per sq. yard. It will be noted that the annuity covering total reconstruction is not considered in this case. In the opinion of the writer the advantage would be with the bituminous pavement.

The lack of appreciation of the intimate relationship existing between road costs and maintenance is attributable to many causes, among which may be noted the following:—

First—Political interference in the selection of the men placed in control of highway work, and with the work of design, construction and maintenance of roads and streets.

Second—The interference by controlling bodies of laymen in the legitimate work of the highway engineer.

Third—Division of responsibility in the supervision of highway work, particularly in municipalities, but also applicable in some States, for instance, those in which the State Department supervises the design and construction, while the responsibility for maintenance is placed upon the county or town.

Fourth—The comparatively small number of well-trained highway engineers who have devoted the requisite time and energy to the new problems which have arisen during the last decade.

Fifth—The comparatively infinitesimal amount of investigation which has been considered necessary as preliminary to the design of a road or street or a system of highways.

Sixth—The general meagreness of detail knowledge of the many different materials on the market and the varied methods in connection with which they may be used.

Seventh—A confusion of ideas on the part of many as to the reasons for the success or failure of various methods considered both from the standpoint of road preservation and dust prevention.

Eighth.—Non-observance of the relationship between the adaptability of various methods and the variability in the cost of labor and materials, and the accessibility of new bituminous materials and machines.

Ninth—The search by many officials for a panacea for the treatment of all classes of roads and streets.

By an analysis of this brief outline of the relationship existing between road costs and maintenance it is apparent that the principles enunciated heretofore must have the enthusiastic support of all interested in highway improvement if economical highway construction and maintenance is to be characteristic of the future development of American highways.

HEATING, VENTILATING AND AIR-WASHING SYSTEM IN A LARGE MODERN FACTORY.

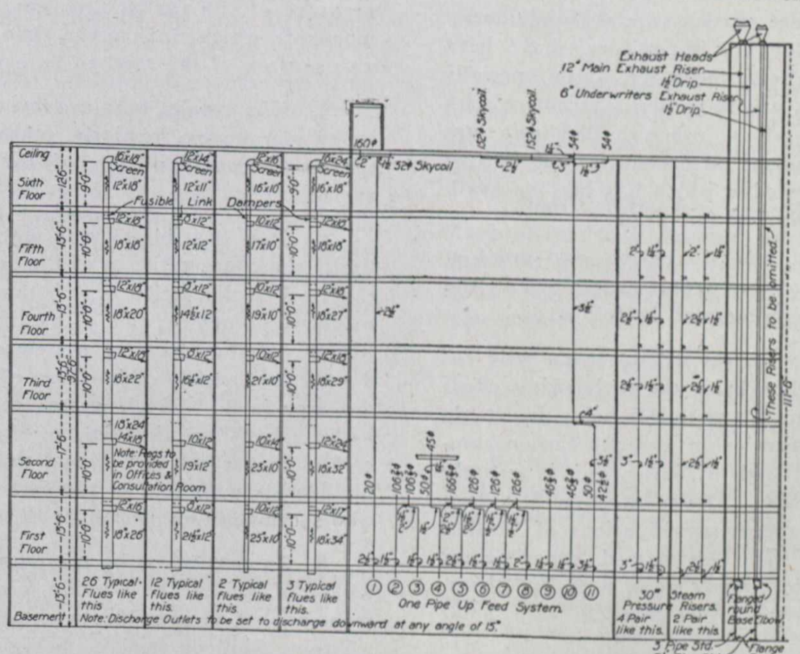
In every respect the factory of Brewster & Co., Long Island City, New York, designed by Stephenson & Wheeler, New York, is an example of modern factory building construction. Instead of having a plain exterior, the appearance of this six-story structure, surmounted by a large tower, is not unlike a convention hall. It is evident that much attention has been given to the consideration of the comfort of the occupants, as the heating and ventilating system consists in every detail of the latest type of apparatus, including arrangements for cleansing and humidifying of the air by air-washers manufactured by Warren Webster & Co.

Three systems make up the heating and ventilating plant, though practically the entire building is heated by the fan system. In certain quarters on the second and sixth floors, additional radiation service is secured from a one-pipe system. A two-pipe system of domestic steam supply is provided for certain domestic steam radiation, including glue heaters, steam boxes and kettles. The main office vestibule is taken care of by an indirect heater suspended from the basement ceiling immediately below, this heater being encased in galvanized iron ducts that connect to main supply air ducts. For heating the tower and the tank house on the roof, there are radiators connected with the one-pipe system.

Situated in opposite sides of the basement are two sets of apparatus, making up the fan system. Each of these supplies to half of the building properly cleansed and humidified fresh, warm air. Each group consists of a tempering coil, air-washer, reheater, and a fan, driven by a direct-connected vertical steam engine. Inasmuch as the only difference in these sets is that one fan is a right-hand top horizontal and left-hand bottom discharge, while the other is the reverse, the same description applies to both.

The fresh air intake for the respective fans are located on Prospect and Radde Streets sides of the building. They the air is drawn over the reheater and then forced to the various parts of the building. The inlets of the fans are 68 inches, the discharge being horizontal at the top and annular at the bottom. The 12-in. by 10-in. vertical enclosed self-oiling steam engine is capable of driving them at 250 r.p.m. A Powers system of temperature control is used in connection with the tempering and reheating stacks. This is accomplished by a cold air thermostat operated at 38 to 40 degrees Fahr. in such a manner as to guard the air-washer at all times against freezing. If the temperature of the entering air falls below 38 deg. F. the tempering coils receive steam, the thermostat being connected to the supply and return valve of the individual groups of the tempering coils. In connection with this system there is an automatic electric air compressor with suitable storage tank, automatic governor, indicating gauge, etc.

The tempering stack is made up of two groups of 60-inch "Vento" cast iron radiators, each group being 36 sections wide and three sections high. The reheating stack is similar to this, with the exception that it is five groups deep instead of two. Steam is supplied to all the systems by three Heine (150 h.p. each) water tube longitudinal drum type boilers that are located in the basement. The working pressure



The Heating System for the Brewster Factory.

are made of copper capped with a storm-proof hood and furnished with fine mesh copper screens and dampers. Leaving the fresh-air chamber the air passes over the tempering coils made up of 2,448 square feet of American Radiator Co.'s "Vento" radiated surface and then enters the Webster air-washer. From this point it is drawn through the reheater of 6,120 square feet of "Vento" radiated surface and distributed by the fan to the two main ducts, from whence it is supplied to the various floors.

Each of the air-washers has a capacity of 85,000 cubic feet per minute. They are built of galvanized steel braced with 2 x 2 x 3/16-inch angles. Extending the full width of the spray chamber is the spray device made up of brass water pipe with 7/32-inch holes on both sides. Over this pipe runs a curved copper hood. The water jets from the spray pipe impinge on the inside surface of this hood in such a manner that a double sheet is formed through which all the air must pass before being delivered to the building. Falling into a tank below, the spray water is recirculated by a Tacony Iron Co.'s brass fitted turbine pump direct-connected to a Crocker-Wheeler motor. After leaving the air-washer,

carried is 150 pounds. A reducing valve permits of the domestic steam system using a pressure of thirty pounds. The exhaust from the fan engine is used in the heating system and supplemented by live steam where necessary.

The flues of the fan system discharge in general about ten feet above the floor of the room, and downward at an angle of about 15°. Screens of plain lattice or diamond design mesh are provided. Above the register faces are placed adjustable regulating dampers.

A recirculate flue connection is made to each intake chamber so that during the closed down period of the factory the building is heated by recirculated air. An additional advantage of this arrangement is that it permits of the rapid heating of the building during the early morning hours by a rapid circulation of the recirculated air.

Messrs. Griggs & Holbrook, of New York, consulting engineers for the Brewster Co., designed the entire steam power plant, heating and ventilating and forge supply exhaust plants, all of which were installed by the Fentzlaff Heating & Plumbing Co., also of New York.

Metallurgical Comment

T. R. LOUDON, B.A. Sc.

Correspondence and Discussion Invited

CASE-HARDENING OF STEEL.*

Dr. F. Giolitti.

During the last four years the author, in collaboration with Carnevali, Tavanti, Astorri, and Scavia, has carried out a series of experiments, the results of which have served to clear up several highly controversial points connected with the theory of the processes of the case-hardening of steel, by means of which it has been possible to formulate a few rules for the application of those processes on an industrial scale.†

As the result of the experiments and from the theoretical considerations elaborated by the author in his several reports, and chiefly in the more recent ones, several fundamental facts, besides many of secondary importance, have been proved with certainty. It has, moreover, been specially demonstrated that these facts are in perfect agreement with the work of previous investigators, although they were unable to arrive at exact conclusions on account of the lack of the necessary theoretical knowledge which has become available to science only within the last few years.

These fundamental facts, the discussion and proof of which the reader will find in the reports contained in the bibliography, may be briefly enumerated as follows:—

1. Where case-hardening is carried out with solid cementing agents having a carbon base, the carburizing effect of the free carbon on the iron, the materials being in simple contact and without the intervention of gaseous carbon compounds, is exceedingly weak, and in any case is entirely negligible in industrial practice. This assertion has been fully confirmed by the more recent investigations of Guillet, Griffith, Weyl, and Charpy. The last-named experimenter even comes to the conclusion, already dealt with by others, that the direct effect of carbon in cementation with solid agents is absolutely nil.

2. Where case-hardening is effected with the solid case-hardening agents ordinarily employed in the industry, the specific effect of the nitrogen is very weak, as admitted and variously explained by many investigators. Only with the cementing agents containing a high proportion of the cyanogen compounds (alkaline cyanides, ferro-cyanides, &c.), does the direct action of volatile nitrogen compounds have any marked effect.

3. In the cementations by means of the solid agents ordinarily employed in the industry, the specific direct carburizing effect of carbon monoxide preponderates enormously over every other carbonizing effect.

4. Pure carbon monoxide carburizes iron at all temperatures within the range (700 deg. to 1,300 deg. Cent.), at which the process of case-hardening can be performed by means of any other medium whatever. Moreover, the rate of case-hardening (by which is understood the depth of carburization which can be obtained in a given time) when working under suitable conditions is greatest when carbon monoxide, or a mixture in which the carbon monoxide can efficaciously exercise its specific carburizing effect, is used as the agent.

5. This specific carburizing effect exerted by the carbon monoxide on the iron at high temperature is due to a series of chemical reactions, the course and state of equilibrium of which has been actually observed with precision. Moreover, the conditions of equilibrium of the systems in which these reactions take place are in general comprised within the ranges of temperature and pressures ordinarily employed in practice. It is therefore possible to obtain with certainty a predetermined result using case-hardening agents whose activity is due, if not exclusively, at least very largely, to the specific carburizing action of the carbon monoxide. More particularly, it is possible to obtain with such agents carburized zones in which the concentration of the carbon does not exceed a predetermined maximum limit and varies in a well-defined degree towards the inside of the carburized zone. Such definite results, variable at will within sufficiently wide limits, are obtained by varying, in accordance with fixed rules, the temperature at which the case-hardening is performed, the pressure of the carburizing gas, and the amount of carbon monoxide which, in a given time, comes in contact with the unit surface of the steel to be carburized.

6. The results obtained by the use of carbon monoxide as an agent vary regularly, other conditions being equal, as the chemical composition of the steel to be carburized is varied.

7. It is possible to vary regularly and within fairly wide limits the characteristics of the desired product by subjecting the steel to the action of substances along with carbon monoxide which are capable of modifying the conditions of equilibrium of the chemical systems under which the reactions due to the specific carburizing effect of the carbon monoxide are completed. Such substances may be gases, such as hydrocarbons or nitrogen, or they may be solids, such as carbon in various forms, and their actions can proceed simultaneously with that of the carbon monoxide throughout the whole cementation period or during a portion only of it.

8. In particular, by means of the agents, the activity of which is due to the specific carburizing effect of carbon monoxide, it is possible to obtain with ease and certainty—whatever kind of steel is being operated upon—soft case-hardenings and graduated case-hardenings; that is to say, carburized zones in which the concentration of the carbon without being excessive in the outer layers, diminishes slowly and with regularity in the succeeding deeper layers. This is the essential condition for the avoidance of the dangerous phenomena of brittleness and peeling, which defects manifest themselves so frequently in steel pieces case-hardened by the processes ordinarily used in the industry.

9. The chemical reactions produced by agents in which cyanogen is the active element are at present but imperfectly understood, particularly as regards their condition of equilibrium, upon which depends the concentration of carbon in the carburized zones. It is, however, certain that in the conditions under which case-hardening should be performed in practice, the conditions of equilibrium just now alluded to correspond to a very high concentration of carbon passing into solution in the iron. Thus it happens that the cyanides, ferro-cyanides, and other derivatives of cyanogen, if used alone as case-hardening agents, always give rise to too rapid (energetic) a case-hardening; that is, carburized zones are produced in which the concentration of the carbon is excessively high in the outer layer up to a certain depth, and is

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*Paper read before the Iron and Steel Institute.

†At a later date the remainder of this paper, dealing with the actual commercial process evolved will be printed.

then suddenly lowered in the succeeding layers. Zones of that type, the formation of which has been fully studied and their cause explained by the author, produce brittleness and peeling.

10. Further, gaseous or volatile hydrocarbons, when used alone as agents, also give rise to too rapid case-hardening, the causes being identical with those referred to in the case of cyanogen and its compounds.

In the light of the facts recited in the foregoing, the great advantage of the use of agents, the activity of which is due, if not exclusively, at least principally, to the specific carburizing action of carbon monoxide, is clear. In order to obtain the best results with such an agent, the author has demonstrated in his publications previously quoted that it is necessary to satisfy the following fundamental conditions:—

1. The chemical composition of the agents should be absolutely definite, and should be accurately known.

2. The compounds should be as simple as possible.

3. The reactions which take place during the case-hardening process between the various constituents of the agent and those of the steel should be simple, and should proceed rapidly—under the conditions most easily obtaining in practice—to a well-defined state of equilibrium corresponding to definite concentrations of carbon in the carburized zones.

The author in his previous work has demonstrated from the theoretical point of view that the agent which best satisfies these conditions would be pure carbon monoxide, except that by its use the concentrations of carbon in the carburized zones, which correspond to the conditions of equilibrium, are in general too low, when working within the ranges of temperature and pressures ordinarily maintained in practice, and when the metal subjected to case-hardening is an ordinary mild carbon steel or a steel containing a low percentage of nickel or chromium.

On the other hand, that inconvenience can be avoided, and the three conditions indicated above can be sufficiently well realized by the use of case-hardening agents, in which along with the carbon monoxide small quantities of hydrocarbons of known composition, or solid carbon in a properly divided state, are allowed to act either throughout the whole period or during a portion only of it.

Further, of these two classes of agents, those of the second-class, based on the simultaneous use of free carbon and of carbon monoxide, are the most suitable for the majority of ordinary technical applications, since by their use the operation can be performed with the maximum degree of simplicity and the certainty of obtaining predetermined results.

Below are enumerated the principal technical advantages which the author has shown to be obtainable by the employment of case-hardening agents, which satisfy the three essential conditions previously mentioned, and, in particular, of the "mixed" agent based on the simple simultaneous action of carbon and carbon monoxide. The following are the principal advantages:—

1. The great speed of penetration of the carburized zone. That fact, if indeed it does not constitute the chief value of any given case-hardening process, as many manufacturers still believe, is certainly most advantageous on economical and technical grounds too numerous to mention.

2. Great uniformity in the distribution of carbon in the carburized zones, which is the cause of the fact, as already stated, that the peeling of case-hardened and tempered pieces are reduced to a minimum.

3. The possibility of regulating, either by diluting the carbon monoxide with nitrogen, or by limiting the contact of the solid carbon with the surface of the steel, or by suitably varying the temperature during the case-hardening process, the concentration of the carbon in the carburized zone so as to maintain it within the most suitable limits for conferring the maximum hardness combined with minimum brittleness. The extent of carburization must, of course, vary according to the composition of the steel subjected to cementation.

4. The possibility of establishing with certainty from the start the necessary conditions for obtaining a predetermined result which may be chosen within sufficiently wide limits, and may be obtained with great accuracy.

5. Continuous use of the same carburizing materials (solid carbon and carbon monoxide), which do not become attenuated, but may be used up to their last residue. This also permits of carburizing to any depth without the necessity of renewing the agent during the operation.

6. Absolute security against the introduction into the steel of any foreign substance apart from the carbon. This is an advantage of the highest importance in most cases, and cannot be realized in the case of most of the case-hardening powders habitually used, consisting of organic nitrogenous substances, such as alkaline cyanides, or ferrocyanides.

7. The ease with which the surface of the case-hardened pieces is preserved without alteration, thus obviating the necessity of any subsequent dressing of the case-hardened pieces.

8. The deformation and change of volume which the steel pieces may undergo during case-hardening are reduced to a minimum. In any case it is possible to determine from the start the extent of such volume changes as may occur.

For a full account of the experiments and their results the author would refer readers to his previous reports on his research work on this subject.

Besides the advantages enumerated above, which refer particularly to the quality of the product, the use of the mixed agent having a carbon monoxide base offers other practical benefits, consisting in the ability to modify very advantageously the method of operation. In one of the reports referred to, it is shown by the author how the method may be used even without discarding the ordinary horizontal muffle generally used for case-hardening. The same advantages, to a greater extent, may be more easily secured by using the mixed agent in a furnace the form of which differs radically from that of the ordinary case-hardening furnace, and by following a special method of operation.

FURTHER RESULTS OF ELECTRO SMELTING IN SWEDEN.

The following important results in connection with the electric smelting of iron ores at Trollhättan, Sweden, were recently forwarded to the Canadian Engineer by the Canadian Boving Company, who represent the above referred to Swedish interests:—

As might have been expected, the first six months' working suggested various alterations in the construction of the furnace. It was, therefore, shut down at the beginning of June last, for the carrying out of these alterations. The plant was again started during the first week of September, and has been in uninterrupted work ever since. During the week from September 3 to September 9, the following results were obtained:—

Pig-iron produced	131.4	tons
Quantity of slag	22.1	"
Charcoal used per ton of iron	0.036	"
Pig-iron produced per kw.-year	5.05	"
Pig-iron produced per h.p.-year	3.79	"
Current consumption per ton of iron	1,736 kw.-hours	
Power consumption per ton of iron	2,315 h.p.-hours	
Average load	1,357 kw.	
Average CO_2 contents in the gas (by vol.)	30 per cent.	

The current and fuel consumption depend, of course, to a large extent on the quality of the ore. The results for a protracted period during which the same kind of ore used are, therefore, of interest.

Working Results.

	Sept. 3rd to Sept. 30th.
Pig-iron produced, tons	537.9
Quantity of slag, tons	88.9
Iron in the ore, per cent.	67.65
Iron in the ore and lime, per cent.	65.02
Quantity of slag per ton of iron, kg.	165
Charcoal used per ton of iron, kg.	339.9
Average load, kw.	1,407
Average power, h.p.	1,913.5
* Current used per ton of iron, kw.-hours	1,749
† Iron produced per kw.-year, tons	5.01
Iron produced per h.p.-year, tons	3.68
Average CO_2 contents in gas, per cent.	29.27
Average analysis of iron:—	
C, per cent.	3.64
Si, "	0.36
Mn, "	0.40
S, "	0.009
P, "	0.018

Comparing these figures with the earlier results it will be seen that a great improvement has been obtained over the first six months' working results.

Per ton of iron there were then used from 2,150 to 3,800 kw.-hours, and for the entire time an average of 2,391 kw.-hours. The ores then used varied somewhat in quality, but it will be seen that a reduction of 20 to 25 per cent. has been effected in the current consumption. Correspondingly, the output of pig-iron per kw.-year has been raised from an average of 3.66 tons to over 5 tons. The charcoal consumption has been reduced from 418 kg. to 345 kg. per ton of iron, and the electrode consumption has also been reduced The electrodes now used are supplied by the well-known Planiawerke, and are provided with screw joints so that there are no waste stumps.

The practical importance of the process is best proved by the fact that there are now built or building furnaces for an aggregate of 27,000 h.p., while in addition, furnaces for about 36,000 h.p. are projected.

* According to instruments at the furnace.

† Estimated on the basis of 8,760 kw.-hours per kw.-year.

WORLD'S PRODUCTION OF BAUXITE.

The following table shows the world's production of bauxite from 1907 to 1909. One noteworthy feature is that the production in the United States in 1909 exceeded the production of France for the first time in the history of the world's bauxite industry:—

	1907 Tons	1908 Tons	1909 Tons
United States	97,776	52,167	129,101
France	155,834	167,991	128,099
United Kingdom	7,537	11,716	9,500
Italy	3,445	6,890	3,881
Total	264,592	238,764	270,581

The chief uses of bauxite are (1) as raw material in the production of metallic aluminium; (2) in the manufacture of aluminium salts; (3) in the manufacture of artificial abrasives; and (4) in the manufacture of bauxite brick.

EXTENSIVE FINDS OF POTASH MADE AT GODERICH AND IN EASTERN ONTARIO.

A discovery of value has been made, according to a report cabled from Berlin, Germany, of extensive finds of potash at Goderich and in the region around Lakes St. Clair and Huron. This area has a great salt industry. Last year the output was 84,071 tons, valued at close upon half a million dollars. Many inquiries have been made regarding the deposit of potash supposed to have been found in connection with salt wells at or near Goderich.

During the negotiations between the United States potash buyers and the German potash trusts, a rumor was circulated of extensive finds of potash in the area named. At that time the opinion was expressed in Berlin that the report had been circulated in order to affect the negotiations. The German potash trusts sent a corps of geologists to Canada to investigate. The reports of these corps have been received in Berlin and are sufficiently encouraging to justify the formation of a syndicate. Advance reports of a rich potash tract are encouraging and the Germans are prepared to exploit the field to the fullest possible extent.

The annual report of the Ontario Bureau of Mines received in Ottawa, contains an elaborate statistical review in the course of which, under the heading of, "The Pursuit of Potash," this subject is discussed and it is stated:—

"There is no doubt that the discovery of potash salts in quantity would be a boon to the agricultural interests of Ontario, and indeed of the Dominion at large. Wood ashes, which in the early days of settlement when the forest was being cleared away and burned, were plentiful, and were largely made use of for the extraction of potash salts, are now no longer to be had in quantity, and our agriculturists are dependent for potash upon foreign sources of supply, which means Germany."

The report goes on to say: "A bountiful supply of potash is contained in the feldspar deposits at Verona and elsewhere on the line of the Kingston and Pembroke Railway, this material containing as much as 13 or 14 per cent. of potash. The difficulty is that no feasible method has yet been discovered for converting the contained potash into soluble form. It has been stated that finely pulverized feldspar when applied directly to the ground will part with potash, though slowly, and thus act as a fertilizer. With the view of ascertaining the value of ground feldspar, a quantity from the deposits of the Kingston Feldspar and Mining Company has been forwarded to the Ontario Agricultural College, at Guelph, where experiments will be conducted by the authorities of that institution."

CONDITIONS IN NORTHERN ONTARIO.

The Canadian Northern Railway engineers engaged on construction work in Northern Ontario, have found where the maps had shown them "The Height of Land" nothing in the way of rockwork at all. The Height of Land, it is stated, is not high at all, but is really a low-lying swamp. The big plateau, which is the highest part of Ontario, is well wooded with a fine quality of white pine. The cutting of timber in this country is not a good proposition commercially, for the reason that logs skidded into the rivers north of the Divide, would find their way into James Bay. With the building of the railway this difficulty has been overcome. The Canadian Northern will make possible the marketing of the timber in the big markets of the south.

PERSONAL.

Mr. R. D. Brown has been appointed to the position of city engineer for the municipality of St. Catharines, Ont.

Mr. Hugh. D. Lumsden, formerly chief engineer of the G.T.P. Transcontinental railway, and latterly with the C.P. R., has been appointed to the position of chief engineer of the Toronto Harbor Commission.

Mr. J. O. Meadows, sanitary engineer for the Provincial Board of Health, Province of Quebec, has been appointed chief expert in charge of the new filtration plant of the Montreal Water & Power Company. Mr. Meadows is well known in this province, having been brought on some two years ago by the Board of Health to investigate for them the water supplies of the province generally. Mr. Meadows graduated in Science from the University of Wisconsin in 1906. From 1906 to 1907 he was assistant in the United States Department of Agriculture, co-operating with the Ohio State Board of Health in the examination of filtration plants. From 1907 to 1909 he was employed by the United States Government on the Isthmean Canal Commission in charge of the sanitary control of the water supplies of the Canal Zone.

CLEVELAND ENGINEERING SOCIETY.

Various phases of water purification were discussed at a meeting of the Cleveland Engineering Society on November 14th. Mr. R. Winthrop Pratt gave an illustrated talk on the purification of water by filtration, in which he summarized the average cost, per 1,000,000 gal. daily capacity, of mechanical filters at $9,000 to $17,000. The cost of the Cincinnati plant was $50,000 per 1,000,000 gal. Operating costs run from $2.50 to $12.50 per 1,000,000 gal.

Dr. R. G. Perkins spoke briefly on the theory of sterilization by chloride of lime and ozone. He discussed the conditions at Cleveland, and explained that the present water sterilizing plant at Kirtland Street had been installed to avoid an impending typhoid fever epidemic. In his opinion the water supply of the city was periodically threatened with gross pollution, principally from the discharge of the Cuyahoga River. At present 0.8 part per 1,000,000 of available chlorine is being used. Taste is noticeable at the pumping station and at the houses located near it. The chemical is applied to correspond with the operation of the pumps. The question of taste and smell, said Dr. Perkins, was a matter of time and temperature, the degree of taste being proportional to the time elapsing after the application of the chemical. In warm weather taste disappears more rapidly than in cold.

"Purification by Ozone," a paper by Mr. R. M. Leggett, described the Ann Arbor plant, in which three ozonizers are treating the water from a roughing filter. The claim was made that the ozone process was economical with sterilized water, and that the cost at the Ann Arbor plant was $2.75 per 1,000,000 gal. treated.

Mr. D. D. Vincent read a paper on a patented process for the electrolytic production of aluminum hydrate by passing an electric current between aluminum plates, the water then being filtered through a mechanical filter.

So far it has been found much cheaper to add the sulphate of aluminum than to make aluminum hydrate electrolytically. Filtration is necessary, and there is no value in the electric current as such.

AMERICAN ASSOCIATION FOR ADVANCEMENT OF SCIENCE.

The following information relative to the meetings of Section D of the American Association for the Advancement of Science, to be devoted to highway engineering and held in Washington, D.C., on December 29th and 30th, will be of interest. The papers to be presented on December 29th are:

"History of the Washington Bituminous Concrete Pavements." Captain Martin Brooke, Engineering Commissioner of the District of Columbia, Washington, D.C.

"History of Tar Concrete Pavements in Ontario." W. A. McLean, Provincial Engineer of Highways of Ontario, Canada.

"Surface Treatment of Park Roads." Col. Spencer Cosby, Colonel U.S. Army, in charge of Buildings and Grounds, Washington, D.C.

"Oyster Shell Roads." Maj. Walter W. Crosby, Chief Engineer, State Roads Commission, Baltimore, Md.

"The Chemistry of Modern Highway Engineering." Prevost Hubbard, Chief, Division of Roads and Pavements, The Institute of Industrial Research, Washington, D.C.

"A Review of the Use of Bituminous Materials in the Construction and Maintenance of American Highways During 1911." Arthur H. Blanchard, Professor in Highway Engineering, Columbia University, New York City.

"Organization of the Highway Maintenance Department of the Borough of The Bronx." William H. Connell, Assistant Commissioner of Public Works, Borough of The Bronx, New York City.

"Organization of the Engineering Department of Coleman du Pont Road, Inc." Frank M. Williams, Chief Engineer, Coleman du Pont Road, Delaware.

"Organization of Convict Labor on the Virginia State Highways." P. St. J. Wilson, State Highway Commissioner of Virginia, Richmond, Va.

"Cost of Road Building with Convict Labor." Dr. Joseph H. Pratt, State Geologist of North Carolina, Chapel Hill, N.C.

"Utilization of Motor Truck Train in the Maintenance of Trunk Highways." Logan Waller Page, Director, Office of Public Roads, Washington, D.C.

"Pipe System in Streets." C. E. Bolling, City Engineer of Richmond, Va.

"Street Asphalt Paving Mixtures." H. B. Pullar, Chief Chemist, The American Asphaltum and Rubber Company, Chicago.

"Some Limitations of Distributing Machines." Henry B. Drowne, Instructor in Highway Engineering, Columbia University, New York City.

"Impact Testing Machines for Bituminous Binders." Walter H. Fulweiler, Engineer in the Department of Research, United Gas Improvement Company, Philadelphia.

"Changes in Pitch Under Exposure and Traffic." Maj. Walter W. Crosby, Chief Engineer, State Roads Commission, Baltimore, Md.

"Value of Blown Asphalts and Their Manipulation." H. B. Pullar, Chief Chemist, The American Asphaltum and Rubber Company, Chicago.

"Method for the Determination of Centrifugal Free Carbon in Bituminous Compounds." Walter H. Fulweiler, Engineer in the Department of Research, United Gas Improvement Co., Philadelphia.

"Voids in the Aggregates of Bituminous Concrete Pavements." Arthur H. Blanchard, Earl R. Donle and Clifford M. Hathway, Columbia University, New York City.

The programme for Saturday, December 30th, is as follows:—

Saturday morning.—Investigation of the plants of the Office of Public Roads and the Institute of Industrial Research and inspection of the experimental bituminous surfaces and bituminous pavements at Chevy Chase.

Saturday afternoon.—Inspection of the experimental sections of bituminous pavements on Park Heights Avenue, Baltimore, Md.

COMING MEETINGS.

THE CANADIAN PUBLIC HEALTH ASSOCIATION.—Dec. 13-15. Montreal. F. C. Douglas, M.D., D.P.H., Secretary, 51 Park Avenue, Montreal. (The date of the meeting has been changed from Nov. 21-23 to Dec. 13-15)

PROVINCE OF QUEBEC ASSOCIATION OF ARCHITECTS.—Tuesday, Dec. 19th, 1911, lecture by Dr. T. A. Starkey, of McGill University, Professor of Hygiene, on "Ventilation of Public Buildings." No. 5 Beaver Hall Square, Montreal. J. E. Ganier, Secretary.

THE ENGINEERS' CLUB OF TORONTO.—Dec. 21, 96 King Street West, Address on "Mountain Climbing," Major Charles H. Mitchell. Ladies night. Music and Refreshments. Secretary, R. B. Wolsey.

THE CANADIAN SOCIETY OF CIVIL ENGINEERS.—Jan. 24, 25, 26, 1912, General meeting, 413 Dorchester St. West, Montreal. Prof. C. H. McLeod, Secretary.

THE CANADIAN FORESTRY ASSOCIATION.—February 6, 7 and 8, 1912. Annual Meeting, Ottawa. James Lawler, Secretary.

ENGINEERING SOCIETIES.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—413 Dorchester Street West, Montreal. President, C. H. Rust; Secretary, Professor C. H. McLeod.

QUEBEC BRANCH—
Chairman, P. E. Parent; Secretary, S. S. Oliver. Meetings held twice a month at Room 40, City Hall.

TORONTO BRANCH—
96 King Street West, Toronto. Chairman, H. E. T. Haultain, Acting Secretary; E. A. James, 57 Adelaide Street East, Toronto. Meets last Thursday of the month at Engineers' Club.

MANITOBA BRANCH—
Secretary E. Brydone Jack. Meets every first and third Fridays of each month, October to April, in University of Manitoba, Winnipeg.

VANCOUVER BRANCH—
Chairman, Geo. H. Webster; Secretary, H. K. Dutcher, 319 Pender Street West, Vancouver. Meets in Engineering Department, University.

OTTAWA BRANCH—
Chairman, S. J. Chapleau, Ottawa; Secretary, H. Victor Brayley, N. T. Ry., Cory Bldg.

MUNICIPAL ASSOCIATIONS.

ONTARIO MUNICIPAL ASSOCIATION.—President, Chas. Hopewell, Mayor, Ottawa; Secretary-Treasurer, Mr. K. W. McKay, County Clerk, St. Thomas, Ontario.

UNION OF ALBERTA MUNICIPALITIES.—President, H. H. Gaetz, Red Deer, Alta.; Secretary-Treasurer, John T. Hall, Medicine Hat, Alta.

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