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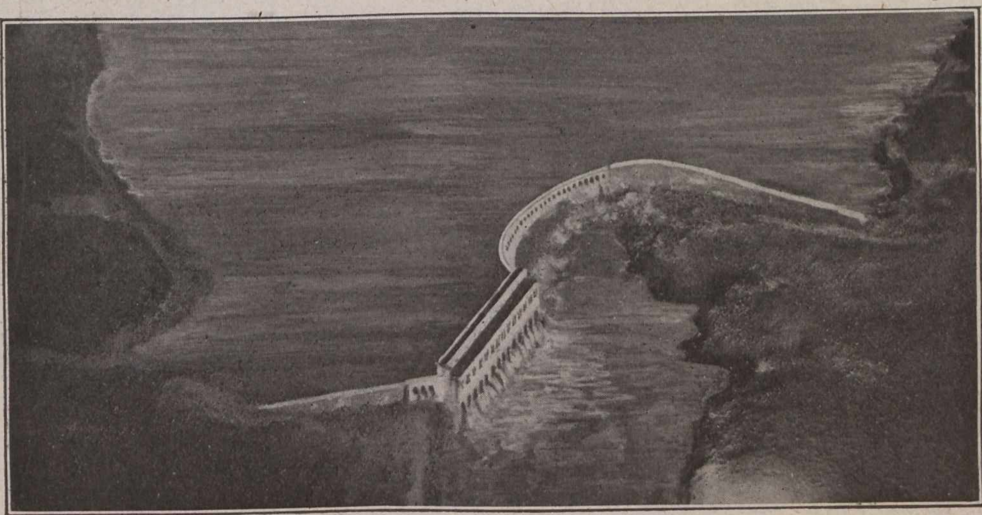
WINNIPEG RIVER POWER AND STORAGE INVESTIGATIONS

A BRIEF REVIEW OF WATER RESOURCES PAPER No. 3, AN OFFICIAL PUBLICATION OF THE DOMINION WATER POWER BRANCH, COVERING THE DEPARTMENTAL INVESTIGATIONS INTO THE POWER RESOURCES OF THE WINNIPEG RIVER WATERSHED.

PART III.

As typical of the detailed character of the investigations of the Dominion Water Power Branch into the proposed power concentrations on the Winnipeg River, and as indicating briefly the manner in which the data secured and compiled has been made available to the public in "Water Resources Paper No. 3," the following notes from the report on the proposed concentration at the Du Bonnet Falls have been prepared.

After full consideration of all aspects, the river reach in question was divided into three proposed concentrations—Pine, Du Bonnet and McArthur respectively. The Du Bonnet concentration includes the natural drop at Whitemud, at Little du Bonnet and at Grand du Bonnet Falls.



Model of Proposed Du Bonnet Layout.

Head and Tailwater Elevations. — The headwater at the proposed Du Bonnet plant has been placed at elevation 808. This will result in a 4-foot rise in the present normal water level at the head of the falls, and will flood back to the foot of the second McArthur Falls.

Flooding.—Little flooding will result from raising the headwater to elevation 808. An embankment is necessary on the west side. This embankment is designed with a 10-foot top at elevation 815, and with 1½ : 1 slopes. It is 800 feet in length, and at regulated level in the pond will withstand a head of from 5 to 7 feet at its heaviest sections.

Pondage.—A regulated level of 808 will create 1,700 acres of pondage. A draw of 1.7 feet on this pond will supply a four-hour peak load to the full installation considered, *i.e.*, 140,000 horse-power, assuming a continuous flow of 20,000 second-feet in the river. While this provides very fair pondage facilities, they are not as favorable as the conditions at the majority of the sites proposed along the river.

Ice Conditions.—During the winter season the channel in the vicinity of island No. 2, below the Little du Bonnet Falls, becomes at times somewhat choked with a deposit of frazil and anchor ice. This is largely due to the long stretch of agitated water in the Grand and Little du Bonnet Falls, presenting ideal conditions for the formation of frazil and slush ice. The contracted river channel in the vicinity of the island, together with this formation of frazil, forms a combination favorable to the formation of an ice barrier, and is at times the cause of more or less choking and consequent raising of the water level above.

Layout.—The general layout (Fig. 1) connects with contour 815 on the right bank by means of a corewall embankment, ice sluices, and power station joined direct with a sluice and spillway dam of solid gravity section arched in plan so as to follow the high rock above the falls, and finally closes with the high land on the opposite bank by means of a second embankment.

East Embankment.—The east embankment has been estimated with a 15-foot top at elevation 815, and 1½ : 1 slopes, constructed from the material most readily available. Impermeability is secured by a concrete corewall with a 1-foot crest at elevation 814; and a batter of 1 : 12. This core will be bonded to the bedrock should the latter be within reasonable distance of the surface, and if not, a tight and safe bond can readily be obtained with the clay subsoil.

Ice Sluices.—Between the east embankment and the power house are located three 20-foot sluices with sills at elevation 793. These serve the double purpose of providing a suitable ice run and additional discharging capacity to the whole layout. The sluices are so placed as to clear the forebay of ice and drift by tending to produce a current parallel to the line of the power station. It has been assumed that rock will be available for the foundation at elevation 775 under the easternmost sluice, and at 770

(1) Initial Development.—This consists of the seven 10,000-horse-power units next the dam. It will provide for the utilization of 12,000 second-feet at 46-foot head, with the turbines running at eight-tenth gate.

(2) Intermediate Development.—This consists of twelve 10,000-horse-power units, the additional five being adjacent to the initial installation. Twelve units will pro-

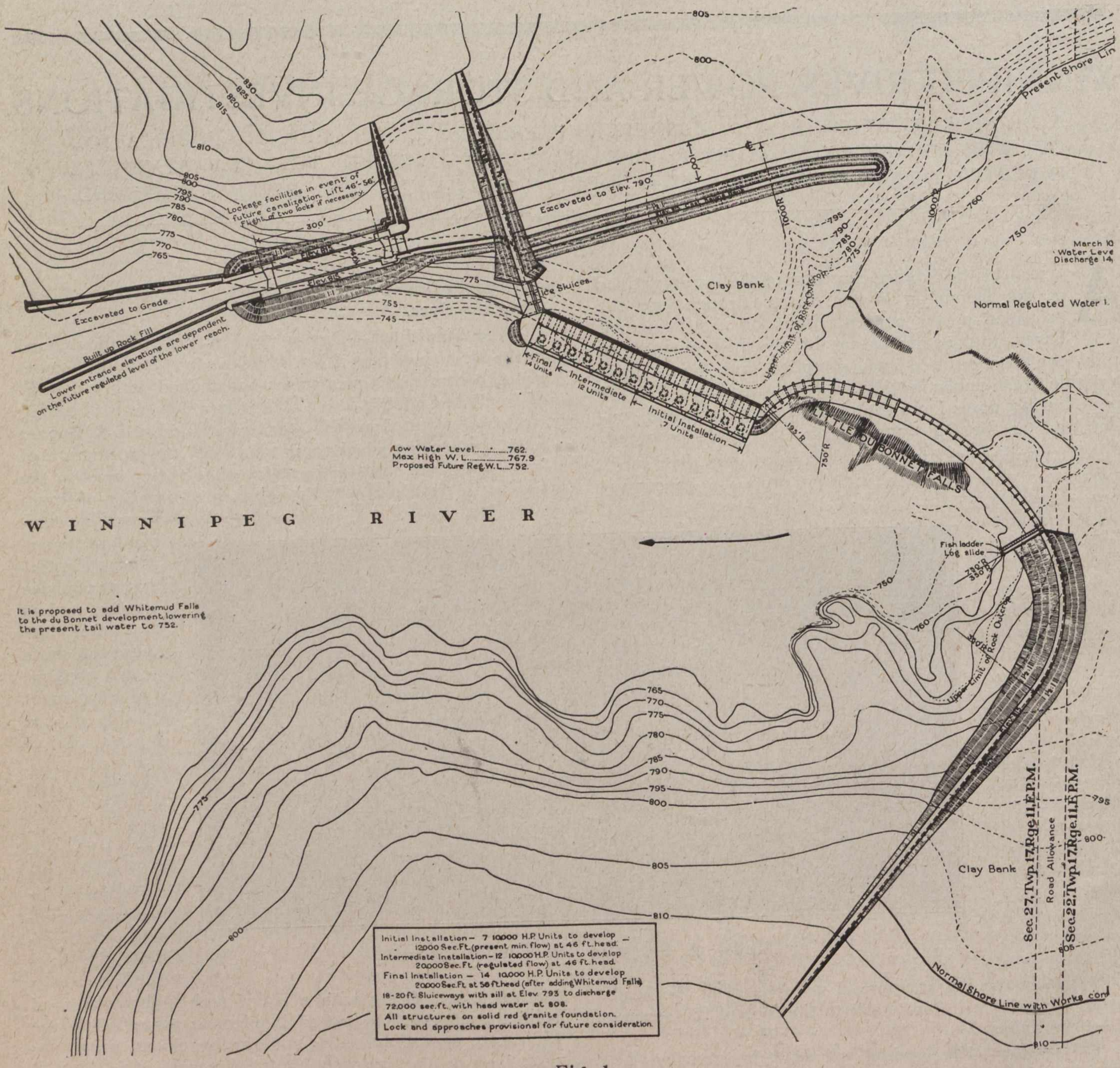


Fig. 1.

under the remaining two. It is exposed on the river bank at the latter elevation.

Power Station.—The power station (Fig. 2) has been designed for single runner vertical turbines of 10,000 horse-power at full gate. The section has been developed only in sufficient detail to enable a fairly accurate estimate being made of the quantities involved. This was mainly a question of the size of the water passages to carry the requisite supply at permissible velocity to and from the turbines.

vide for the utilization of 20,000 second-feet at a 46-foot head, with the turbines running at eight-tenth gate.

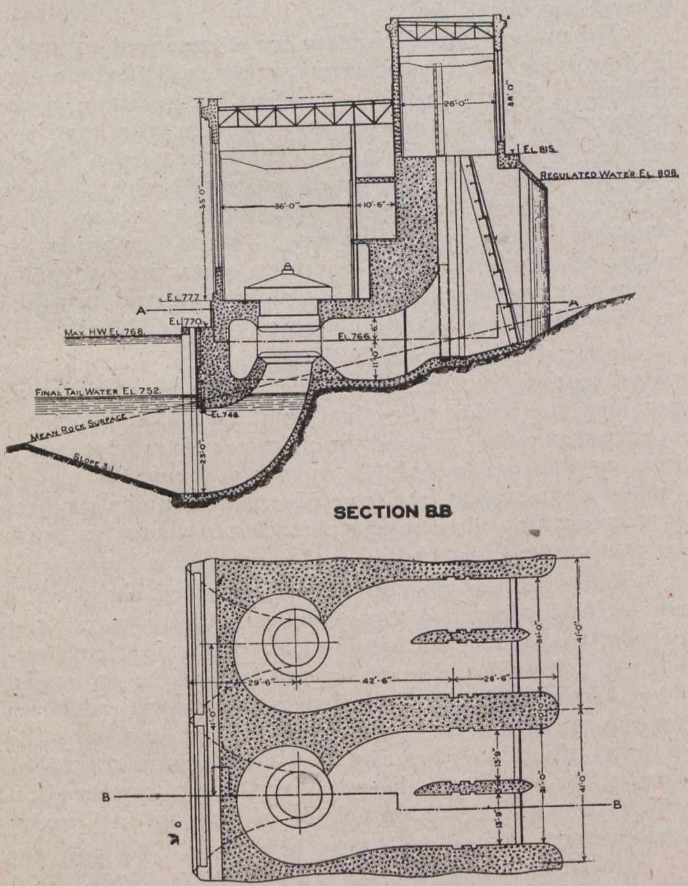
(3) Final Development.—This consists of fourteen units which will provide for the utilization of 20,000 second-feet at 56-foot head with turbines at eight-tenth gate.

Sluiceway Section of Dam.—Fifteen 20-foot sluiceways with sills at elevation 793, are immediately adjacent to the power station. The sluiceway deck, with its underside elevation at 813.5, will permit of a 5½-foot rise in the regulated level. Solid rock underlies the sluiceway section. Its elevation has been assumed at 765.

Spillway Section of Dam.—The spillway section of the dam, 400 feet in length, has its crest at elevation 808, and is surmounted by a 10-foot platform supported by 3-foot piers, spaced 23 feet centre to centre. The platform will give ready access to the plant from the rail connection on the west bank.

Discharge Capacity.—At regulated level the fifteen sluiceways and three ice sluices will discharge 72,000 second-feet. In addition to this the completed power station will pass an additional 20,000 second-feet, which, although not a source to be relied upon at all seasons, may be considered as a safety factor.

A free spillway, 400 feet in length with crest at 808, provides for automatic regulation. Three feet over this crest, with all sluiceways open and the power station in operation, gives a total discharging capacity of 113,000 second-feet. Five and one-half feet above the spillway crest can be carried by all structures.

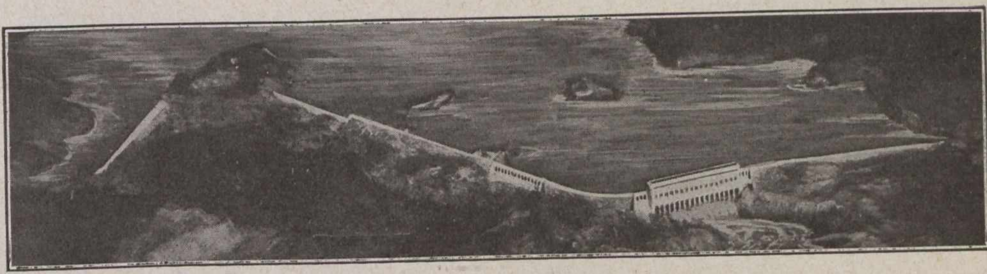


PLAN ON LINE A.A

Fig. 2.

Estimates of Cost.—The estimates place the power on the switchboard in the power station, and do not include transmission. It is considered that the assumptions which have been necessary are more than warranted. Actual construction will possibly lead to a considerable reduction in the totals submitted, as it has been considered advisable at all points where any reason for doubt exists, to make the most liberal provision for eventualities.

The estimates include a 13-mile spur line from the present terminal of the Canadian Pacific Railway at Lac du Bonnet. This will bring rail connection to the west bank of the river. An item has been included for the construction of a ferry for the transport of loaded cars across the river to the power station site.



Model of Proposed McArthur Layout.

In addition to the above, 10 per cent. has been added for contingencies, 5 per cent. on this total for engineering and inspection, and 5½ per cent. on the whole for one year for interest during construction. The estimated cost of the Whitemud Falls excavation has been inserted as a unit.

The annual operation costs include capital charges, and represent the cost of operation at the power station. They do not include transforming and transmission.

Du Bonnet Site.—(1)—Initial Development. (Seven 10,000-h.p. Units.)

Capital Cost of Installation.

Dam and equipment	$ 542,000
Embankment (flood protection)	5,000
Ice sluices	72,000
Power station and equipment	657,000
Hydraulic installation	665,000
Electrical installation	805,000
Railroad	156,000
Ferry	50,000
Permanent quarters	25,000
Contingencies, 10%	298,000
Engineering and inspection, 5%	164,000
Interest during construction, 5½%	189,000
Total initial cost	$3,628,000

Twenty-four-hour power available at 75% over-all efficiency	= 47,000 h.p.
Capital cost per twenty-four-hour h.p.	= $77.19
Capital cost per installed h.p.	= 51.83

Annual Cost of Operation.

Interest, sinking fund and depreciation charges:	
Interest, 5½% on $3,628,000	$200,000
Sinking fund, 4% (40-year bonds)	38,000
Depreciation: 1% on permanent works = $12,000; 4% on machinery, etc., = $64,000.	76,000
Operation charges: staff = $21,000; supplies = $20,000	41,000
Total annual charge	$355,000

Annual cost per h.p.-year, 24-hour power	= $7.55
Annual cost per h.p.-year, machinery installed	= 5.07
Annual cost per kw. hour	= 0.115 cent
Annual cost per kw. hour on basis of 50% load factor	= 0.230 cent

(2)—Intermediate Development. (Twelve 10,000-h.p. Units.)

Capital Cost of Installation.

Dam and equipment	$ 542,000
Embankment (flood protection)	5,000
Ice sluices and roadway	72,000
Power station and equipment	926,000
Hydraulic installation	1,140,000
Electrical installation	1,380,000
Railroad	156,000
Ferry	50,000
Permanent quarters	25,000
Contingencies, 10%	430,000
Engineering and inspection, 5%	236,000
Interest during construction, 5½%	273,000
Total intermediate cost	$5,235,000

Twenty-four-hour power available at 75% over-all efficiency	= 78,500 h.p.
Capital cost per 24-hour h.p.	= $66.69
Capital cost per installed h.p.	= 43.62

Annual Cost of Operation.

Interest, sinking fund and depreciation charges:	
Interest, 5½% on $5,235,000	$288,000
Sinking fund, 4% (40-year bonds)	55,000
Depreciation: 1% on permanent works = $14,000; 4% on machinery, etc., = $106,000	120,000
Operation charges: staff = $27,000; supplies = $32,000	59,000
Total annual charge	$522,000

Annual cost per h.p.-year, 24-hour power	= $6.65
Annual cost per h.p.-year, machinery installed	= 4.35
Annual cost per kw. hour	= 0.102 cent
Annual cost per kw. hour on basis of 50% load factor	= 0.204 cent

(3)—Final Development. (Fourteen 10,000-h.p. Units.)

Capital Cost of Installation.

Dam and equipment	$ 542,000
Embankment (flood protection)	5,000
Ice sluices and roadway	72,000
Power station and equipment	1,035,000
Hydraulic installation	1,330,000
Electrical installation	1,610,000
Railroad	156,000
Ferry	50,000
Permanent quarters	25,000
Contingencies, 10%	483,000
Engineering and inspection, 5%	265,000
Interest during construction, 5½%	307,000
Whitemud Falls rock-cut	671,000
Total final cost	$6,551,000

Twenty-four-hour power available at 75% over-all efficiency	= 95,500 h.p.
Capital cost per 24-hour h.p.	= $68.60
Capital cost per installed h.p.	= 46.79

Annual Cost of Operation.

Interest, sinking fund and depreciation charges:	
Interest, 5½% on $6,551,000	$360,000
Sinking fund, 4% (40-year bonds)	69,000
Depreciation: 1% on permanent works = $15,000; 4% on machinery, etc., = $123,000	138,000
Operation charges: staff = $30,000; supplies = $38,000	68,000
Total annual charge	$635,000

Annual cost per h.p.-year, 24-hour power	= $6.65
Annual cost per h.p.-year, machinery installed	= 4.54
Annual cost per kw. hour	= 0.102 cent
Annual cost per kw. hour on basis of 50% load factor	= 0.204 cent

COST OF MAINTAINING NEW YORK STATE HIGHWAYS.*

By Fred W. Sarr,
Deputy Commissioner, New York State Highway Department.

UPON receiving your kind invitation to be with you to-day and address you on the subject of highways, I was at first reluctant to accept same owing to the voluminous and important work which has been before the Commission during the past few months. In finally accepting, however, I did so with the idea in mind of addressing you on the subject of the maintenance and repair of improved highways in the State of New York, which end of highway engineering in that State, I am at present associated with.

The proposition of maintenance of improved highways in New York State is an enormous one, practically ninety millions of dollars having been spent by the State for the construction of roads in the past seventeen years, and yet, with this huge expenditure, the experience gained and the system now in force, the maintenance of highways, even in our great State, is, I might say, still in its infancy. The evolution in the kind of traffic to which our roads are subjected, particularly the adoption of the use of motor trucks carrying very heavy loads, and the general increased traffic necessitates a continuous study of individual cases.

General maintenance is comprised of keeping the paved roadway surfaces in as nearly uniform condition as possible, due regard being had for the relative importance of each particular road and the character of traffic it bears; keeping the earth shoulders smooth and safe for traffic; the drainage system free from obstructions; all structures in good repair and removing obstacles to vision, as brush or overhanging branches.

If the work of maintenance of improved highways is consistently performed throughout successive years, it is certain that the efficient life of such roads will be lengthened, and it would appear as though it could be prolonged almost indefinitely, if year by year the material added to the paved surface be equal or a little in excess of the material which has worn away during the same interval of time. This applies to the macadam type of construction which constitutes the vast bulk of the mileage under maintenance.

Maintenance should commence when construction leaves off, because in order to effectively and economically maintain improved roads it is necessary that the roadway be in a good state of repair at the time the maintenance work begins.

As an illustration of the magnitude of highway construction and maintenance in New York State, there were on April 1, 1915, 5,345 miles of improved and accepted state and county highways, and this mileage was increased as the season advanced, and on December 31, 1915, there were 5,926 miles of improved and accepted highways which has been maintained and repaired.

*Read before the Third Canadian and International Good Roads Congress, March, 1916.

The following is a summary of the maintenance and repair work performed during the past season, including sums obligated on uncompleted contracts:

276 miles of highway resurfaced or reconstructed at an average cost of approximately $5,471 per mile; total expenditures and obligations under this item	$1,510,112
2,086 miles of highway given a surface treatment of bituminous material and cover of sand, fine gravel, iron ore tailings or fine crushed stone, at an average cost of $419 per mile; total expenditure and obligations under this item	874,137
728 patrolmen employed in the work of maintenance and minor repairs, at a total cost for labor	403,047
Expended for material and temporary labor in making miscellaneous repairs and supplying material to patrolmen for maintenance	998,462
Expended for rentals of large units of repair equipment	58,135
Expended for purchase of equipment and tools	31,958
Expended for engineering, supervision, inspection and expenses incidental thereto	334,724
Total amount expended and obligated for all purposes, approximately	$4,210,575

The State Highway Law, or our authority, provides for the maintenance and repair of improved highways either by contract or departmental forces, and all work which can be properly anticipated and foreseen, is incorporated into contracts which are awarded to the lowest responsible bidder, and emergency work and work of a minor nature, particularly such repairs as cannot be definitely measured or expressed in contract units, is performed by departmental forces.

During our past working season there were 230 maintenance contracts prepared, advertised and awarded to the lowest responsible bidder for a sum aggregating $2,271,566.59, or 61 per cent. of the total amount expended.

There was expended directly by the department for materials, labor, rental and purchase of equipment and tools, the sum of $1,604,285.

A study of the experience of our Maintenance Department in maintaining and repairing highways during the past year indicated that the expenditures are divided into three groups:

First. Maintenance, or the act of maintaining and preserving the various features of the highway in the same or uniform condition; the cost of such maintenance of all the improved highways of all types was approximately $350 per mile, which involves the cost of the patrol system and the material used by the patrolmen, together with the cost of the surface treatments with bituminous materials and cover and supervision.

Second. Repair, or the act of restoring the highway to its former condition after more or less extensive deterioration during the winter season with the contingent freezing, thawing, unstable foundation, obstructed drainage, floods, washouts, sliding banks, etc., and that the cost of such emergency repairs was approximately $140 per mile for roads of all types.

Third. Reconstruction and resurfacing. While on many of the improved highways it appears possible, with efficient maintenance, to preserve a standard of improvement from year to year, there are those that show marked deterioration in spite of efforts at maintenance and extensive repairs from time to time. This deterioration is generally due to peculiar traffic conditions, combined with unsuitable materials used in the original improvements, and is often the result of insufficient foundation material in the roadbed.

The total amount expended and obligated for all purposes in the year will average $750 per mile when distributed over the entire mileage of improved highways.

This statement is misleading in that a large percentage of the total improved mileage is of recent construction.

The first highways improved by the State under the Higbie-Armstrong Act were completed in 1899, and in thirteen years, or to the end of 1911, there had been completed and accepted but about 2,600 miles, while in the last four years there have been completed and accepted 3,226 miles. In other words, 55 per cent. of the improved mileage has been constructed an average of two years, while the 45 per cent. has been improved an average of ten years.

Assuming that no pavements should require resurfacing for a period of four years after construction, it is necessary to eliminate the 3,226 miles which have been improved during the past four years from the consideration of the cost per mile for resurfacing and reconstruction. Therefore, the total expenditure for this subdivision of the work should be distributed only on such mileage as has been constructed or improved for a period of four years, and when so distributed the cost per mile for this subdivision during the past year is approximately $560 per mile.

It would seem, however, that the average life of a pavement after reconstruction would be greater than that of the first improvement, as foundational weakness that has developed would be provided for in the reconstruction. Also, the maintenance and repairs for the first five years after the original improvement are greatly increased by heavy items which are properly chargeable to improvement, and are really a completion of the improvement, such as removal of slides from banks which have been cut into at the time of improvement; the construction of retaining walls to sustain such banks, and for the protection of the highway from the erosion of streams. Also the drainage conditions, as provided in the original improvement, are often the subject of much complaint from the abutting owners and necessitate modifications and construction of storm water sewers, all of which develop and are taken care of in the first few years, after the original improvement. It can, therefore, reasonably be expected that the cost of maintenance repairs and reconstructions will decrease in some proportion to the age of the improvement and that the high cost of $560 per mile for resurfacing and reconstruction, when applied to all the improved highways, would never be attained, and that the reduction in the item of repair would offset the increase in reconstruction as the improvements increased in age owing to the gradual elimination of weakness, together with the effect of efficient maintenance.

It would accordingly seem by this manner of reasoning that the improved State and county highways of all types could be perpetually maintained for about $750 per mile.

Our expenditures for the past have been segregated into groups to determine the expense of maintaining the roads of various types, the expenditures in each instance being charged to the type in which the highway was classed at the beginning of the season or before reconstruction.

There were under maintenance during the season 192 miles of gravel roads, upon which the average expenditure, including reconstruction to a different type, was $955 per mile, and the average expenditure, exclusive of reconstruction, was $577 per mile. Gravel roads, while most susceptible to deterioration under heavy traffic, are most easily and readily repaired. Said repairs are generally accomplished by scraping and honing in the spring and the addition of new material from gravel banks in the vicinity.

Surface treatments have been given to gravel roads, but are not generally satisfactory where any considerable traffic prevails. The treated gravel surface is soon converted into longitudinal ruts and ridges by displacement, and this condition is not as easily repaired after the surface has been treated. Where medium to heavy traffic prevails it appears preferable to lay a new macadam surface over the existing gravel, and this practice for the past season results in the heavy expense for reconstruction of this type.

There were under maintenance during the past season 2,298 miles of so-called waterbound macadam highways, upon which the average expenditure, including resurfacing and reconstruction, was $1,055 per mile, and the average expenditure, exclusive of resurfacing and reconstruction, was $564 per mile.

The expenditures on this type of pavement are larger than on any other type, both for maintenance and reconstruction. This is partially due to the fact that the average age of this type is greater than that of any other type. The maintenance is more expensive owing to the necessity of more frequent surface treatments and to the necessity for constant patching. The large charge for resurfacing is due to the large number of miles of pavement resurfaced, and not to the cost per mile of the highways thus treated.

There were under maintenance during the past season 2,387 miles of bituminous macadam penetration method pavement, upon which the average expenditure, including resurfacing and reconstruction, was $510 per mile, and the average expenditure, exclusive of resurfacing and reconstruction, was $448 per mile. A much larger percentage of this type of macadam is located on the main trunk lines than that of the waterbound macadam and, in general, the motor vehicle traffic over this type is very much larger, in spite of which fact the maintenance is less than for the waterbound macadam pavement.

Of the bituminous macadam mixing method type, there were 63 miles under maintenance during the past season, upon which the average expenditure for maintenance was $181 per mile.

The expenditures on highways of this type during the past season have, in general, been for labor on the shoulders and gutters and other work outside of the pavement proper, although in a few instances it was necessary to do considerable patching to the pavement, but, in general, little or no repairs were required to the pavements.

The most unsatisfactory type of pavement, from the maintenance standpoint, is that of concrete bituminous type, and the construction of this type has been abandoned by our state.

The body of this pavement is formed of a low grade of cement concrete which was given a light surface treatment of bituminous material and fine stone chips at the time of construction. This thin surface treatment does not adhere to the concrete, is readily removed by traffic, which then wears into the concrete, necessitating frequent and constant patching. Numerous experiments have been tried out with surface treatment of varying depths, and the consensus of opinion of those who have endeavored to maintain this class of pavement is that any surfacing to be satisfactory must be thick enough to have stability in itself and not less than two inches in depth.

There were under maintenance during the past season 295 miles of this type of pavement, and the average expenditure, including new surfaces, was $1,050 per mile, and the average expenditure, exclusive of resurfacing, was $532 per mile.

There were under maintenance during the past season 84 miles of first-class concrete pavement, and the average expenditure on highways of this class was $129 per mile.

These pavements are of recent construction, the average age being one year, and the expenditures were nearly all for labor and materials on the shoulders and gutters, a small expenditure only being required on the pavement for filling the frost cracks with pitch.

From the limited experience in the maintenance of this type of pavement, it would seem that an expression in regard to the efficiency of the type should be reserved for at least another year.

Under the heading of "Block Pavement" have been grouped the expenditures for all brick, stone block and asphalt block pavements.

There were under maintenance during the past season 291 miles of these types of pavements, and there was an average expenditure on highways of this type of $190 per mile, including the reconstruction of one section about one-third of a mile in extent, and the expenditure for maintenance was $176 per mile.

This expenditure is, perhaps, about evenly divided between the pavement and the shoulders. The expense of the maintenance of the shoulders is much heavier with the rigid pavements, such as concrete and block, than with the macadam types. This is due to the smooth, rigid edge which catches and holds the traffic parallel thereto for short distances, similar to the effect of street car rails. A rut is soon formed along the edge of the pavement which is generally filled with crushed stone, increasing the cost of shoulder maintenance.

On the older brick pavements there has been expended a considerable amount during the past season for taking up and relaying small areas that have broken down. In the western section of the state, wherein is located the greatest mileage of brick pavement, some 102 miles, the average cost of maintenance of this type was $245 per mile.

Summarizing the mileage and the average expenditure for maintenance, repair and construction per mile per year for each of the different types, we have:

193 miles of gravel roads cost $955 per mile.
2,298 miles of waterbound macadam roads cost $1,055 per mile.
2,387 miles of bituminous macadam, penetration method roads cost $510 per mile.
63 miles of bituminous macadam, mixing method roads, cost $181 per mile.
295 miles of concrete bituminous roads cost $1,050 per mile.
84 miles of first-class concrete roads cost $129 per mile.
291 miles of block pavement roads cost $190 per mile.
5,611 miles of all types cost $750 per mile.

A review of the above summary would indicate that the various types could be grouped in three classes, namely, low, medium and high maintenance types, and when so grouped we have 438 miles of low maintenance type, including bituminous macadam, mixing method, first-class concrete and block pavement, upon which the average expenditure for maintenance was but $177 per mile per year; 2,387 miles of medium maintenance type, including bituminous macadam, penetration method, upon which the average expenditure was $510 per mile per year; 2,786 miles of high maintenance type, including gravel, waterbound macadam and concrete bituminous, upon which the average expenditure was $1,059 per mile per year.

If the low and medium maintenance types are grouped in one class, we have slightly over half the improved highways upon which the expenditure for maintenance is about $440 per mile per year, and slightly under one-half the total mileage upon which the expenditure for maintenance and repairs was $1,060 per mile per year.

It is contended that with the present system of maintenance in many cases the life of a pavement may be extended indefinitely. The method referred to is that of treating the surface of the pavement with a light application of asphaltic oil or refined tar, and a cover of fine crushed stone, sand or gravel. This treatment consists of spraying on the surface of the pavement about one-quarter of a gallon of oil or tar and covering the same with from ten to fifteen pounds of cover material per square yard of pavement. These materials are worked and kneaded into the existing pavement by the traffic, and most efficiently by rubber tire traffic, and results in filling up the small interstices between the larger fragments of the existing pavement and increasing the thickness of the pavement from an eighth to a quarter of an inch. This increase in thickness should more than offset the constant wearing away of the surface by the abrasion caused by the pounding of the iron-shod feet of the horses and the iron-tire vehicles. The repetition of this treatment from year to year will gradually increase the thickness of the existing pavement. The ideal condition being where this treatment approximately maintains the pavement at its original thickness, as it has been found that where the treatment has been too heavy or too frequently applied and the oil and stone mat is built up to a greater thickness than one-half inch, it is liable to creep and become displaced by traffic, particularly in hot weather.

The experience in our state would indicate that a waterbound macadam pavement under the average condition of rubber-tire traffic, should be treated once each year for two years, after construction, then perhaps the treatment may be omitted the third year, and in subsequent years treatment is required two years out of three.

With the penetration type of bituminous macadam, a surface treatment is not generally required until the second or third year after improvement, and thereafter a treatment every second or third year. The advantage of this type of treatment is the ability to thereby incorporate a thin layer of new material with the existing pavement at a minimum cost and restore, at more or less frequent intervals, the part which has been worn away by traffic.

The most efficient material seems to be one that carries 65 to 70 percentum of bitumen or pitch and which can be applied in a spray under pressure at a temperature of from 80 to 100 degrees F. This grade of material is sufficiently liquid for several days after being applied that it may be worked and kneaded into the porous surface of the pavement by the rubber-tire traffic.

A heavier material that requires heating to a temperature higher than 130 degrees F. in order that it may be applied, cools after application and before receiving traffic, and assumes a consistency of rubber gum, and while it may be united with the stone chips by rolling, it cannot be as thoroughly worked into the body of the pavement, and simply lies on the surface as a mat which shifts around under traffic and is worked into waves and hollows. An example of the principle is the painting and varnishing of wood surfaces. A thin paint or varnish is applied and is worked into the pores of the wood by brushing and rubbing and a more desirable and permanent surface is obtained than by using a heavier or thicker varnish applied by pouring the same on the wood surface. The varnish being so heavy it is necessary to heat the material to make it sufficiently liquid to be poured over the surface. No one would expect such a finish to a hard wood floor to be very desirable or lasting. The floor could be opened to use very much quicker, but permanent results could not be expected. This simile is set—an explanation for the necessity of the disagreeable condition of the road surface for a few days after the bituminous treatment is applied, during which period the traffic is working and kneading the more or less liquid material into the existing pavement.

There is also the necessity for the use of the light material in the subsequent treatments in that the light carrier oils soften the hardened material of the former treatments and allow new material to unite and combine therewith.

The best results are also obtained where the least amount of cover material permissible is used. This can best be explained by comparing the bituminous material to Portland cement when used with sand in mortar. A surplus of sand weakens the cementing qualities of the cement. The same results are obtained by using a surplus quantity of sand to cover the application sufficiently to eliminate the disagreeable condition of the freshly treated pavement. Where the pavement is not open, requiring a filler for the interstices, and where previous treatments have been given, better results will be obtained where no cover is used, but a freshly treated surface with no cover is dangerous to fast-moving vehicles and such treatment is seldom resorted to in the country districts.

While the best results with surface treatments are obtained with a semi-liquid bituminous product and a minimum amount of cover, the disagreeable features of this treatment from a traffic standpoint have been given serious consideration, and changes have been made in the specifications for surface treatments, which it is hoped will materially reduce the period during which the treated surface is objectionable from a traffic standpoint.

The light surface treatment with bituminous material and cover does not appear to be suited to pavements where horse-drawn, iron-tire traffic largely predominates. The iron-tire traffic appears to grind the bituminous material with the mineral aggregate and keep the surface roughened and loosened, allowing the volatile oils to more readily evaporate. The bituminous material then loses its adhesive qualities, and is ultimately ground to dust and is washed or blown away.

The bituminous mat tends to make the surface waterproof, and as the moisture in the macadam leaches away through the foundation and not being renewed from the surface the so-called waterbound macadam is no longer waterbound but is simply dustbound and is ready to be loosened by traffic in any spot where the bituminous surface mat is worn through, and it is necessary to either provide a heavy mat or constant patching of the areas where the mat has worn through. The tendency is therefore with the waterbound type to give a general treatment more often than should be necessary, which results in building up a heavy mat which finally creeps and displaces under traffic in hot weather, and it is then necessary to remove the entire mat and start over with the light surface treatments.

With the bituminous bound macadam this precaution is not as necessary. While the bituminous carpet sheds off the surface water and the macadam dries out, the individual fragments are bound together with a bituminous material and are not susceptible to the loosening effect of traffic as they are in the dried-out, waterbound type. The results being that a much thinner bituminous surface can be maintained without constant patching, which results in less frequent treatments being required, and the expense of maintenance of the surface by light bituminous treatments on bituminous bound macadam roads is not much over half of that for waterbound roads.

The bituminous macadam, however, being of a more plastic nature, is more easily displaced by swift-moving traffic, resulting in transverse waves developing in the body of the macadam, which are not as pleasing to ride over as the more rigid waterbound.

With reference to the cost figures submitted herewith, while they are the result of but one year's experience, it would seem that the large mileage represented would make the data of some value. This can be better appreciated when it is stated that the improved highways of New York, if laid down in a continuous line, would provide an improved highway from Boston to San Francisco, and from Maine to Florida, and thence to New Orleans.

With reference to the cost as expressed in units of miles, I would state that the standard width of pavement on our state and county highways is 16 feet, with earth shoulders of four to eight feet on each side of the pavement.

Referring to any statements which I have made which are contradictory to those of some of the other speakers, I wish to qualify my statements to the effect that they are simply the opinion of the speaker as gained by the observation of the maintenance of some 5,600 miles of improved highways.

As can readily be seen from the above data, the problem of maintenance has not as yet been mastered, but I believe, however, that the assembling in congress and conventions of this character, of men engaged in road work, where a free discussion of experience and ideas is permissible, will tend to and eventually be resultant in perfecting to a very large extent, the matter of road construction and the maintenance of same, and finally reducing it to a practical and economical basis.

The Jeffrey Manufacturing Co. have opened offices at Dallas, Texas, in the Commonwealth National Building. This office will be in charge of F. J. U. Jones.

Several bridges in the southern part of the province of Saskatchewan were damaged by the high water this spring. In one or two cases the bridges were entirely submerged so that the ice-flow passed over, but after the water had subsided it was found that the bridges had not been injured in any way.

The Dominion Government has decided to exclude all foreign lumber in connection with the public work carried on by it. At the present time the Parliament buildings at Ottawa are being rebuilt, but only Canadian lumber will go into the new structure. A short time ago the Canadian Pacific Railway issued a similar order. Both movements have been made for the purpose of encouraging the industry in the Dominion. Last year, although the country was at war, Canada imported 95,000,000 feet of southern pine, valued at over three million dollars. These figures were much below the previous year, but show something of the heavy importations of pine from the United States. Practically all our hardwood has been imported from south of the forty-ninth parallel, but according to the new arrangement, only Canadian hardwoods will be utilized in the public works of the Dominion. At the present time a number of important works are going on in addition to the rebuilding of the Parliament buildings, harbor improvements are being made at Montreal, Quebec, Toronto, and in connection with the Hudson Bay terminals. In these works Douglas fir will take the place of Southern pine, formerly used. For the interior decoration of cars and the wood used in their manufacture, Canadian woods will hereafter be used. It is said that the movement will spread and that big implement manufacturers will take it up.—*American Forestry.*

THE USE OF OIL ENGINES FOR PUMPING.*

By C. R. Knowles.

INTERNAL combustion engines using gasoline as fuel have long been in use for railway water service. The increased consumption of water, necessitating larger pumps and heavier power, together with the increase in the cost of gasoline, has made it necessary to look to a cheaper fuel in the operation of water stations.

In order to utilize the existing equipment many of the gasoline engines now in service have been converted to kerosene and distillate engines by the addition of attachments for preheating the oil to or near the flashing point before the oil enters the cylinder. These attachments consist of generators or mixing chambers wherein the oil is heated by the exhaust of the engine. They are made in various sizes and types, both for throttling and for hit and miss governors. With these attachments the engine is generally started on gasoline and is allowed to run on this fuel until the cylinder and generator are heated, when the oil is cut in. On other types a retort is provided where the oil is converted into a vapor or gas by heating the retort with a blow torch. Either method requires from five to ten minutes to start an engine running on oil. Electric ignition is used, as with gasoline engines. Very little carbon trouble is experienced with the use of these attachments and the lubrication required is about the same as with a gasoline engine.

A series of tests of various fuels were made pumping against a total head of 61 feet, with an 8 x 10-inch single cylinder double acting pump direct connected to a 6-h.p., four-cycle, horizontal gasoline engine equipped to run on kerosene and distillates as well as gasoline, controlled by a throttling governor. This engine was one of the first gasoline engines ever equipped to operate on low-grade oils and has been continually operated on distillates from 36° to 32° Baumé for the past six years.

The fuels used were:

TABLE I.

Distillate ...	40.0° Baumé	Flash, 150	Burn, 145
Methyl alcohol	40.5° Baumé	Flash and burn	at room temp.
Kerosene	46.0° Baumé	Flash, 124	Burn, 170
Gasoline	62.0° Baumé	Flash and burn	at room temp.
Motor spirits	58.0° Baumé	Flash and burn	at room temp.

Efficiency Fuel Tests.

	Distillate.	Alcohol.	Kerosene.	Gasoline.	Motor spirits.
Pints per hour	6.0	7.0	6.0	7.0	6.0
Pounds fuel per hour	5.145	6.062	4.943	5.373	4.755
Pounds of fuel per h.p.h. ..	1.91	2.22	1.91	1.97	1.74
Pump, r.p.m. ..	43.35	43.32	43.54	43.72	43.79
Pumped, gal. per min. ...	175.0	177.8	176.8	176.8	178.1
Cost of fuel per gal.	0.04625	0.40	0.08	0.15	0.13
Cost fuel per hour	0.0347	0.35	0.06	0.1313	0.0975
Cost of fuel per h.p.h.	0.0129	0.1282	0.0220	0.0483	0.0356
Cost per 1,000 gallons	0.0033	0.0327	0.0056	0.0124	0.0092
	Deg.	Deg.	Deg.	Deg.	Deg.
Temp. of cylinder start..	165	90	135	46	46
Temp. of cylinder run ..	145	145	145	130	125
Temp. of inlet air	110	125	120	60	60

As will be seen from the above figures the distillate is the most economical of the fuels used, the cost per water horse-power being 53 per cent. of the cost of pumping

*Presented at meeting of Illinois Section of the American Water Works Association.

with kerosene, and only 27 per cent. of the cost of pumping with gasoline. The high cost of alcohol eliminates it as a fuel for pumping water and the result of the test is merely submitted as a comparative feature. No doubt better results could have been obtained by reducing the area of the combustion chamber as more compression is required to secure economical results from the use of alcohol in internal combustion engines. The power obtained from the use of kerosene was practically the same as from the distillate, the only difference being in the price of the two fuels. The gasoline test shows such results as might be obtained from the average gasoline engine under the same conditions. The fuel known as motor spirits, which has been widely advertised as a substitute for gasoline, operates under practically the same conditions as gasoline. An objectionable feature of this oil is a disagreeable odor, and it would perhaps be undesirable to use in certain localities.

A 12-h.p., four-cycle gasoline engine with a hit and miss governor pulling a 7½ x 30-inch working barrel in a deep well was equipped with a generator for burning low-grade oils. Comparative tests showed that the engine consumed the same amount of 39 degrees distillate per horse-power hour as gasoline. The difference in the cost of the two fuels, however, showing a saving of $.0434 per horse-power hour in the use of the distillate. The cost of pumping water at this point is comparatively high, due to the fact that the water is pumped with a single acting deep well cylinder.

The tabulated results obtained follow:

Table 2.

	Gasoline.	Distillate.
Pints per hour	14.0	14.0
Pounds of fuel per hour	11.746	12.005
Pounds fuel per h.p.h.	3.458	3.53
Pump, revolutions per minute	24.0	24.0
Pumped, gallons per minute	124.0	124.0
Cost fuel per gallon	0.125	0.04625
Cost of fuel per hour	21.875	8.093
Cost fuel per h.p.h.	0.0643	0.0209
Cost per 100 gallons water	0.0029	0.0108

The heavy oil engine is a comparatively recent development and is being extensively used in railway water stations, as well as for other service. The most popular engine of this type is the two-cycle oil engine constructed in units of 50 h.p. and under, using heavy oil as fuel. This type of engine is very often confused with high compression engines operating on the Diesel principle or with the converted gasoline engine using kerosene and distillates through a carburetor or mixing valve.

The cycle of operation of the Diesel engine is to compress air to 450 or 500 pounds per square inch, generating a temperature of approximately 540° C. Into this highly heated air the fuel is injected during the return or second stroke of the piston in a finely atomized form at such a rate as will maintain a constant temperature while burning and in such quantity as will do the required work for each stroke. The expanded gases of combustion are forced out of the cylinder during the third stroke, while the fourth stroke draws fresh air into the cylinder. This is the sequence of events in a four-cycle engine.

By expelling the burned gases with fresh air the necessary functions can be performed in two strokes of the piston, producing the so-called two-cycle engine.

The above-mentioned engine should not, however, be confused with the two-cycle oil engine as used in railway and other pumping stations and termed the Semi-Diesel engine. In order to avoid the high compression pressure and the resulting complication of design necessary in the Diesel engine this so-called Semi-Diesel engine has been devised, which does not compress the air sufficiently to raise the temperature to such a point that it will spontaneously ignite the injected fuel. It is this type of engine which we have to deal with, particularly with the two-cycle, valveless injection engine, in which the compression has been reduced, adding the required temperature in a heated combustion chamber. This engine is governed by throttling the oil supply and ignition is accomplished by means of a hollow ball. This ball is heated by a blow torch before starting, but after the engine is running the heat is maintained by the successive explosions. The fuel is introduced through fuel valves similar to the Diesel engine, but much less compression of air is required, the compression of the Semi-Diesel engines being from 80 to 130 pounds. Crank case compression is 1¾ to 3½ pounds.

Although these engines have a theoretically less efficient heat cycle than the Diesel they gain in simplicity of construction.

Intelligent lubrication is essential to the proper operation of the oil engine. Improper lubrication contributes largely to oil engine trouble. The high speeds and temperature at which these engines work necessitate a continuous and skilful use of good oil. A great deal depends upon the proper lubrication of an engine of this type and the prevention of the carbon forming in the cylinder. The destruction of the lubricating oil by combustion cannot be prevented. Just what occurs to the oil in an internal combustion engine cannot be entirely explained, but there is no doubt that a great deal of it is burned along with the fuel oil and as long as this is true it is necessary that complete combustion takes place, in order that a residue of unburnt oil is not left in the cylinder in the form of carbon.

The lubrication of the steam engine or pump is comparatively simple. In steam engines there is a certain amount of moisture to assist lubrication, but the flames of an oil engine dry the internal surfaces and unless the proper amount of oil is applied, the cylinder, piston and rings soon begin to suffer. In a steam engine or pump the temperature will at the most reach about 500 degrees while in an oil engine it rises to as high as 2,500 degrees. Added to this is the fact that the piston speed of an internal combustion engine is from three to four times that of a steam engine or pump. Consequently the oil engine requires a different method of lubrication and a great deal more of it.

Engines of this type are liable to suffer from carbon trouble and resultant deterioration due to the fact that an excess of oil injected into the cylinder breaks up into volatile compounds, such as the naphthas, heavy tar-like oils and free carbon.

Overloading the engine also will cause carbon trouble. When the engine is working up to its maximum power, a momentary overload will cause an excess of oil, and the resultant accumulation of carbon due to the fact that the oil engine is not flexible enough to adjust itself instantly to the varying loads, as does a steam engine or pump.

The carbon troubles may be reduced to the minimum by the use of the proper oil. Fuel oils vary in quality as do hard and soft coal and even to a greater extent. As a result, some oils are better suited for use in oil engines than others. While it is possible to burn almost any oil that will flow freely, the best results are to be obtained from oils of a paraffin base from 30° to 36° Baumé.

A number of tests were conducted on a 25-h.p. oil engine with a 10 x 14-inch cylinder belted to a 10 x 12-inch duplex power pump, using seven different kinds of oil, ranging from a heavy fuel oil of an asphalt base to a light distillate of a paraffin base. A brief description of the oils used follows:

No. 1. Diesel fuel oil, 26° Baumé, made from asphaltum base crudes from Texas and Louisiana fields.

No. 2. Gulf fuel oil, 24° Baumé, made from asphaltum base crudes from Oklahoma fields.

No. 3. Narico distillate, 39° Baumé, made from semi-paraffin base mid-continent crudes.

No. 4. Motor oil, 42° Baumé, made from paraffin base crudes from Cushing Oklahoma fields.

No. 5. Navy fuel oil, 26° Baumé, made from asphaltum base crudes from Texas and Oklahoma fields.

No. 6. No. 1 fuel oil, 32° Baumé, a non-sulphur oil paraffin base from Illinois crudes.

No. 7. Kentucky crude oil, 32.5° Baumé, paraffin base.

The following table gives the results obtained from the use of the above oils. The costs given cover the fuel only:

TABLE 3.

	1	2	3	4	5	6	7
Gallons of oil used per hour	1.51	2.29	2.04	1 88	2 19	2.00	2.10
Pounds of oil used per hour	11.30	17.33	14.07	12.20	16.38	14.40	15.07
Pounds of oil used per w.h.p.	1.02	1.12	0.98	0.80	1.01	0.96	0.85
Engine r p.m. ...	346.0	337.0	345.0	345.0	342.0	338.0	328.0
Pump r.p.m.	40 0	39.0	40 0	40.0	40 0	39.0	38.0
Gallons pumped per minute......	444.0	603.0	583 0	592.0	586.0	580 0	577.0
Cost of oil per gallon	0.029	0.029	0 031	0.03	0.029	0.025	0.016
Cost of oil per hour.............	0 044	0 066	0.063	0.056	0.063	0.05	0 035
Cost per 1000 gallons...........	0.0016	0.0019	0.0022	0.0016	0.0018	0.0015	0,0009

While these tests are not conclusive, they indicate the wide range of fuels it is possible to burn in these engines.

The following tables give the result of tests conducted in pumping with 4-inch centrifugal pumps using two-cycle Semi-Diesel oil engines for power, one pump being driven by a 25-h.p. horizontal engine and the other by a 25-h.p. vertical engine, both pumps being belt-driven.

Table 4 gives the result of one hour's run, while Table 5 gives the hours run and cost for a period of four months for each engine.

Tables 6 and 7 show the results obtained in pumping with a 25-h.p., horizontal, two-cycle, heavy-oil engine belted to a 10 x 12-inch double acting duplex power pump and a 30-h.p. vertical two-cycle heavy-oil engine belted to a 11 x 12-inch single acting triplex power pump.

TABLE 4.

Test One Hour's Run.

	Horizontal engine.	Vertical engine.
R.p.m. engine	315.0	380.0
R.p.m. pump	1587.0	1320.0
Gallons pumped per minute	571.0	571.0
Total head in feet	77.38	79.69
Fuel oil consumed in gallons	2.25	2.65
Water horse power	11.15	11.5
Brake horse power	21.4	22.1
Cost fuel oil per million gallons ..	$1.67	$1.97
Cost of fuel oil per gallon	0.0253	0.0253
Cost per h.p.h.	0.0026	0.0030

TABLE 5.

Cost of Fuel and Lubricants Four Months' Run each Engine.

	Horizontal engine.	Vertical engine.
Total number of hours run	331	316
Gallons water pumped	9,930,000	9,480,000
Cost of kerosene	$ 3.78	$ 1.50
Cost of fuel oil	18.01	18.47
Cost of lubricants	9.20	10.20
	$30.99	$30.17
Cost per 1,000,000 gallons	3.12	3.18

TABLE 6.

Test One Hour's Run.

	Duplex pump horizontal engine.	Triplex pump vertical engine.
R.p.m. engine	342	396
R.p.m. pump	40	44
Gallons pumped per minute	586	640
Total head in feet	104	106
Fuel oil consumed in gallons	2.19	2.70
Water horse power	15.33	17.5
Brake horse power	20.44	23.33
Cost fuel oil per millions gallons pumped	$1.80	$2.00
Cost fuel oil per gallon	0.029	0.029
Cost per h.p.h.	0.0031	0.033

TABLE 7.

Cost of Fuel and Lubricants Four Months' Fun each Engine.

	Duplex pump horizontal engine.	Triplex pump vertical engine.
Total number of hours run	687	677
Gallons water pumped	24,732,000	24,372,000
Cost of kerosene	$ 8.52	$ 9.78
Cost of fuel oil	26.26	31.37
Cost of lubricants	17.10	22.04
Total cost	51.88	63.19
Cost per million gallons	$ 2.09	$ 2.54

Table 6 giving the results for one hour's run and Table 7 cost for a period of four months for each engine.

Although the oil engine cannot yet be considered as fully developed, it has passed the experimental stage, and while it is, perhaps, not as reliable under all conditions as a steam engine or pump, much of the prejudice against the oil engine is undoubtedly due to lack of experience in handling. With the present imperfect knowledge of what the engine is capable of doing and of what particular oils may be burned in it, one cannot speak conclusively, but there is no doubt that the future of the engine is assured.

INCREASING MINERAL OUTPUT.

The war has given a marked stimulus to the demand for Canadian minerals. The returns of mineral production, as tabulated by the Ontario bureau of mines, during the first three months of 1916 show increases in that province in all products with the exception of iron ore. The Ontario figures are typical of activity in all our mining districts. They are taken as an example, being the most up-to-date returns, a matter upon which the Ontario bureau of mines is to be complimented. The value of the production in the province for the first three months of 1916 was $14,276,382 as compared with $9,358,210 for the corresponding period of last year. This large increase was due not only to the greater output but to the higher prices now prevailing for most of the metals.

There was an increase of 31,511 ounces in the yield of gold, a gain worth $656,000. The porcupine camp provided the bulk of the production for the quarter, namely, 99,282 ounces. The prospects are for considerable development in that camp. An increase occurred in the production of silver as compared with the first three months of 1915 and the value of the product was greater, due to the rise in the price of silver. The benefit of the higher price will be felt still more in the Cobalt camp during the second quarter of the year. The output at the Sudbury mines of nickel and copper in the matte was 50 per cent. greater than for the corresponding period of 1915. The blast furnaces of Ontario produced 70 per cent. more pig iron than they did in the first quarter of 1915 and the product was worth 100 per cent. more.

Greater mineral production is having a favorable effect upon the trade statistics. Exports of minerals for the fiscal year 1914 totalled $59,000,000. In 1915, they dropped to $51,740,000 but for the twelve months ended March 31st, 1916, they amounted to $66,589,000.

TEMPERATURE STRESSES IN A SERIES OF CONCRETE GIRDER SPANS UNDER DIFFERENT CONDITIONS OF END SUPPORT.*

THE following summary of the results of an investigation made to determine the most favorable arrangement, to resist temperature stresses, of a series of concrete girder spans supported on concrete piers, is of interest and value. In our summary we have omitted the derivation of general formulas:

The investigation was made in connection with the design of a viaduct over the tracks of the St. Louis, Iron Mountain & Southern Railroad at Little Rock, Arkansas. The design finally agreed upon consists of a series of six simple girder spans, the outer girders of which have somewhat the appearance of arches. The three east spans are each composed of eight steel girders covered and decked with reinforced concrete, while the three west spans are each composed of eight reinforced concrete girders with an integral reinforced concrete deck. All spans are supported on solid concrete piers, 3 ft. wide at the coping. Although the piers are similar in design they have different angles of skew, and therefore different degrees of stiffness in the line of the viaduct. The concrete spans, which alone will be considered here, are approximately of constant section except as to the amount of reinforcement.

pendicular to the axis of the bridge are given in Table I. The heights of the piers (shown in Fig. 1) are in each case given from the base to the neutral plane of the spans. Although these heights vary somewhat they are assumed equal in the investigation.

The problem arose from the proposal to build the three concrete spans integral with the piers and abutments, *i.e.*, without provision for changes in length due to temperature and shrinkage. It is evident that the piers offer resistance to the free expansion or contraction of the spans which they support, and hence must introduce corresponding stresses. If these stresses are not negligible, and if expansion must be provided for, the problem is to determine how many expansion joints are necessary, and where they should be placed.

The results summarized in Table II. were obtained for a change of 40° F. by the method of least work and the Castigliano theorem for one, two, and three spans of variable stiffness and inelastic abutments, the following cases being considered:

Case II. The three concrete spans monolithic, supported without friction on piers 3 and 4 and fixed with frictionless pins on pier 5 and the west abutment. (See Fig. 1.)

Case III. Spans supported without friction on the abutment and pier 3 and fixed on piers 4 and 5.

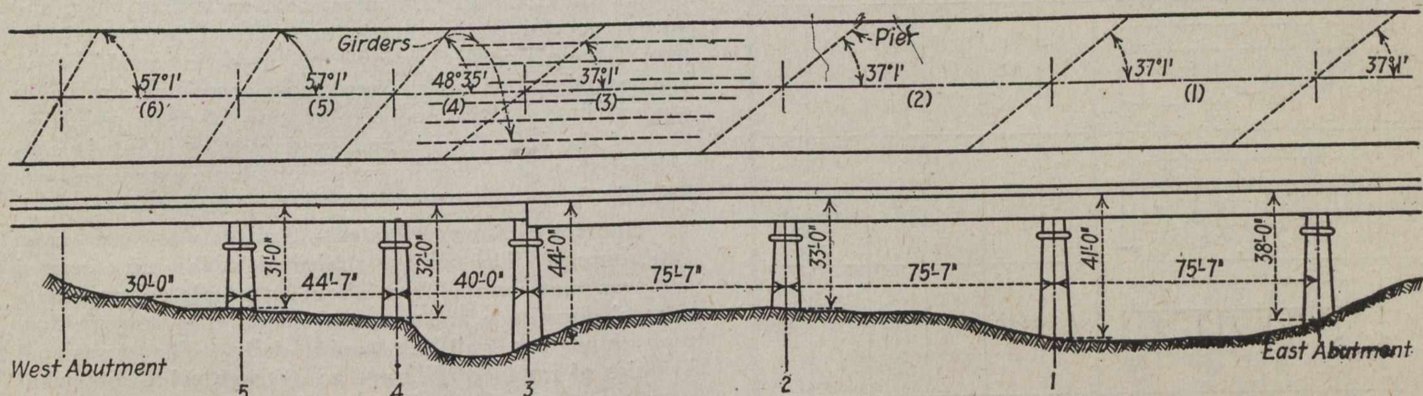


Fig. 1.—Sketch Showing General Features of Design of Viaduct Over Tracks of St. Louis, Iron Mountain & Southern Railroad at Little Rock, Ark.

Fig. 1 shows diagrammatically the general conditions of design. The outer or sidewalk girders of the concrete spans are continuous over the two intermediate piers; the other six girders of each span are not. The areas of steel and concrete in the several spans and the respective average moments of inertia of the piers about axes per-

Table I.—Data on Concrete Spans and Piers.

Girder span.	*Area, sq. ins.	Average span, ins.	Pier.	Assumed height, ins.	†Moment of inertia, I.	Width, ins.
6 ..	14,300	600	5	480	509,201,000	230
5 ..	13,960	536	4	480	752,342,100	275
4 ..	13,960	480	3	480	1,090,534,000	327

*Including steel in terms of concrete.

†$I = IA \sin^2 L + IB \cos^2 L$, in which L = angle between axis of pier and axis of I (perpendicular to viaduct axis), IA = moment of inertia of pier about its short axis, and IB = moment of inertia about its long axis.

$E = 3,000,000$; temperature range, 40° F.; coefficient of expansion, 0.0000055.

Case IV. Spans supported without friction on pier 3 and fixed on piers 4 and 5 and on the abutment.

Case V. Spans supported without friction on the abutment and fixed on piers 3, 4 and 5.

Case VI. Spans fixed on all four supports.

By referring to Table II. it will be noted that there are given the average unit stress in each of the three spans and the unit bending stress in each pier for each of the five cases assumed.

The arrangement for Case VI. causes severe stresses in all three spans and in piers 3 and 4. In the spans the stresses are increased from 72 to 92 per cent. of the allowable, and the bending stresses caused in the piers are from 21 to 143 per cent. of the allowable, assuming the piers to be of 600-lb. concrete. It will be noted that the stresses in the spans decrease as those in the piers increase.

For Case IV., with an expansion joint at pier 3, the temperature stresses in span 4 and in pier 3 are reduced to zero; those in spans 5 and 6 are reduced; and the bending stresses in piers 4 and 5, lacking the strong support of pier 3, are increased, pier 4 being stressed to 182 per cent. of the allowable.

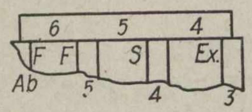
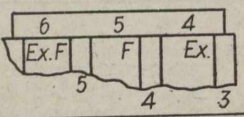
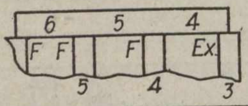
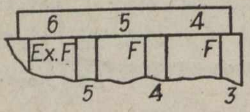
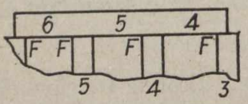
*Summary of paper by Tresham D. Gregg, in Proceedings, American Society of Civil Engineers, Vol. XLII., p. 213.

If, instead of placing a joint at pier 3, we place one at the abutment, as in Case V., the stresses in the spans are still further decreased, as are the bending stresses in piers 3 and 4. Pier 5, however, takes a heavy increase in stress to 126 per cent. of the allowable unit concrete stress.

Now, if we place expansion joints at both the abutment and at pier 3, as in Case III., we have the most favorable of the five cases considered. The stress in span 5 is only 27 per cent. of the allowable, but the stresses in the piers are 65 and 80 per cent. of the allowable; they can be neglected, however, as the direct stress is small.

For Case II. the stress in span 6 is 40 per cent. and in span 5, 125 per cent. of the allowable unit stress.

Table II.—Average Unit Stresses in Spans and Unit Bending Stresses in Piers for Various Assumed Conditions.

Case	Condition of ends of spans	Average unit stress in spans, lb.			Unit bending stress in piers, lb.		
		6	5	4	5	4	3
II		240	0	0	750	0	0
III		0	160	0	480	390	0
IV		480	400	0	145	1,090	0
V		0	250	300	755	115	600
VI		590	560	430	125	490	860

NOTE: Ex. = expansion joint; F = fixed on pier; S = sliding on pier.

The foregoing stresses will, of course, be modified somewhat by the fact that there actually will be considerable resistance at the expansion joints, due to friction.

The problem is now resolved into one of determining the relative economy of expansion joints and of reducing the maximum live and dead load unit stresses by increasing the section. Case III. is the only arrangement with a restrained span which would not produce prohibitive stresses in at least one of the piers. It should be noted that increasing the section of span 5 will increase the stresses in piers 4 and 5 in direct proportion.

The plan finally adopted was to place expansion joints at the abutment and at pier 3 and a sliding joint over pier 5. The steel-encased spans in the east half of the viaduct are all provided with expansion joints.

Those responsible for the design of this viaduct were I. L. Simmons and C. E. Smith, bridge engineers, respectively, of the Chicago, Rock Island & Pacific and the St. Louis, Iron Mountain and Southern Railroads.

RESULTS OF FIRST YEAR'S EXPERIMENTS WITH SMALL SEWAGE TREATMENT PLANTS BY U.S. PUBLIC HEALTH SERVICE.*

By Leslie C. Frank,
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IN attacking the problem of small-scale sewage treatment it is desirable to emphasize strongly the fact that the experiments by the very nature of the problem, should be prolonged. Most sewage treatment devices show seasonal variations and the result of one season's experimental work has about the same significance as a single laboratory experiment. It is by no means true, for example, that a sand filter which gives certain results under given conditions of operation one year may be expected to give the same results under the same conditions the next year. Accumulation phenomena, such as the gradual clogging of the pores of the sand, may occur and cause entirely different results the second or later years of operation. The following discussion of some of the first year's Public Health Service experiments is therefore very tentative, and no hesitation will be felt in subsequent progress reports in modifying any statement here made.

The devices that are being or will be subjected to experiment during these investigations are: Imhoff tank, biolytic tank, sand bed, contact bed, sprinkling filter, and automatic disinfection apparatus. Generally, more than one of the above devices will be used in combination. The combinations which seem most promising are being studied first. Only one combination is discussed here, that of the Imhoff tank and sand bed, as it is not considered that the other investigations have proceeded sufficiently far to merit any discussion.

Sources of Sewage Tested.—Sewage was tested from two sources. The sewage subjected to the most careful test was that coming from about 25 people comprising a nurses' dormitory and one residence. The sewage flow was about 100 gal. per capita daily. The occasional samples of raw sewage gave an average value somewhat over 1,000 parts per million total solids and 177 p.p.m., for 24-hour 20° C., oxygen demand. The other sewage used for testing was that from about 60 people in a small community in Chevy Chase, Md. The latter plant is being used merely as supplementary to the more important Hygienic Laboratory Testing Station.

Design of Experimental Imhoff Tank.—It was not considered certain that an Imhoff tank would be adaptable to small plants, for the small-plant sewage would generally be stronger, certain more grease, and its flow be more irregular. It was feared that the presence of large quantities of grease might result in scum difficulties in the first compartment of the settling chamber, and that the very low night flow might result in the sewage becoming septic. In addition, the depth of the small tank would, for economic reasons, probably have to be limited to about 10 or 12 ft., whereas large tanks are generally 20 ft. or more in depth, and the depth of the tank is considered by many authorities to have an important effect on the quality of the digested sludge.

In designing the experimental Imhoff tank the following points were considered: Volume and proportions of settling chamber, inclination of partition walls, scum boards, clearance and overlap of slot, treatment of grease, volume of sludge chamber.

*From a paper read before the New Jersey Sanitary Association.

Volume of Settling Chamber.—The volume of the settling chamber determines the detention period. If the detention period be made too short, the settleable solids will be incompletely removed, and if too long, the sewage will become septic. In the United States the settling chamber for large Imhoff tanks is usually made equivalent to 1/9 the daily flow, which is equivalent to a mean detention period of 2.6 hours. It was not considered advisable to design the settling chamber for a small tank on this basis on account of the wider variations of flow. It was estimated that the variations in flow might be properly allowed for by assuming the daily flow to take place in 12 hours and by giving a detention period on this basis of three hours; in other words, by making the settling chamber equal in volume to one-quarter the daily flow, which is equivalent to a mean detention period of 6 hours instead of 2.6 hours, as in the large plants. It was decided to risk the possible danger of making the effluent septic.

Relative Proportions of Settling Chamber.—The volume of the settling chamber is not alone responsible for the degree of removal of settleable solids. The chamber must neither be made so short and wide as to result in short-circuiting through local currents, nor so long and narrow as to approach the proportions of a channel, in which case swirling velocities will occur and hinder sedimentation. The proportions selected must depend largely upon experience, and while considerable experience is available for large plants, this is not so true of small plants. However, the dimensions of the experimental tanks were arbitrarily placed within the range of large-scale experience. The proportions of length, width, and depth were for the Hygienic Laboratoty tank 8 : 3 : 5, and for the Chevy Chase tank, 11 : 1.7 : 3.

Inclination of Partition Walls.—The inclination of the partition walls separating the settling chamber from the sludge chamber was made 2.6 vertical to 1 horizontal in the Hygienic Laboratory tank and 1.5 : 1 in the Chevy Chase tank. In small plants steepness of partition walls is even more important than in large plants, because in the latter the attendant may generally be relied upon to squeegee the inner surfaces if the accumulated sludge refuses to slide properly towards the slot, whereas in the former no such attendance can be expected. It was for this reason that it was decided to try different inclinations.

Slot Clearance and Overlap.—In large tanks the clearance of the communicating slot is generally made from 6 to 8 ins., while the overlap is generally made about 8 ins. This becomes a very serious matter for small plants. With a partition inclination of 1.5 : 1 an 8-in. slot clearance and an 8-in. overlap mean roughly about 2 ft. 3 in. vertical distance between the lower edges of the two partitions, which is a considerable proportion of a total depth of 10 or 12 ft., and deducts that much from the sludge capacity. It was decided to reduce the slot clearance arbitrarily to 5 ins. and the slot overlap to 6 ins. There is some question whether a small tank really needs so large a slot clearance, as it seems likely that the slot cloggings which occur in Imhoff tanks are often caused by the fact that the passage of settled sludge through the slot is not continuous, but intermittent. The sludge particles may be conceived as accumulating upon the inclined surfaces until the sliding thickness is reached, when the mass will begin to slide and pass rather suddenly towards the slot, perhaps developing one or more folds in the region of the slot. The clearance of the slot must be sufficient to pass these sliding sheets. The thickness of these sliding sheets and the extent to which they will fold upon themselves will depend upon the inclination and length of the surfaces upon which they develop. Since the length of these inclined surfaces will naturally be less as the size of the tank diminishes, it seems logical to reduce the slot clearance accordingly.

Grease Chamber.—On account of the tendency of grease in fresh sewage to mix with fecal and other solid matters, and to cause the whole mass to float and become sufficiently dry to prevent decomposition, it was decided to place a horizontal screen at the water level in the first compartment of the settling chamber. This would keep the floating solids submerged, and allow them to become waterlogged and sink to the bottom. The mixing caused by the incoming sewage would also tend to separate the grease from the other solids. The introduction of this horizontal screen has apparently been successful. There have never been more than 2 ins. of grease under the screen in the Chevy Chase tank and at the Hygienic Laboratory the material which has collected, while more voluminous, has been found to be almost pure grease, the removal of which was not at all objectionable.

Gas Vents.—Gas vents were provided on either side of the settling chambers. At the Hygienic Laboratory their total area is 8 sq. ft. and at Chevy Chase 40 sq. ft.

Sludge Capacity and Depth of Tanks.—Sludge capacity was provided for about 2 cu. ft. per person at the Hygienic Laboratory tank and 4 cu. ft. at the Chevy Chase tank. After providing the necessary settling chamber and sludge room capacities the total depth of the Imhoff tank at the Hygienic Laboratory was 10 ft., and at Chevy Chase 12 ft.

Sludge Removal and Disposal.—No permanent sludge pipe was included in the experimental tanks. Instead it was decided that when sludge was to be removed an ordinary bilge or trench pump would be used. No special provision was made for the disposal of the sludge, for the possibility was anticipated that for most small plants shallow trench disposal could be used. A relatively small area would be required.

Scum Boards.—One scum board was provided at the influent end and one at the effluent end of the settling chamber. The penetration below minimum water level of the first scum board was made 3 ft. because it was to serve also as one wall of the grease chamber. The penetration of the effluent scum board was made 2 ft., which was later found to be excessive.

Covers.—The tanks were provided with covers as a safety feature, as a possible preventive of odors, and to keep the grease and scum from drying.

Sand Bed and Dosing Chamber: Function.—The function of the sand bed is to satisfy as much as possible of the oxygen demand of the non-settleable organic substances in the sewage, and thereby to deliver an effluent which will not cause nuisance and which will remove part of the burden of possible water purification plants. The function of the dosing chamber is to control the manner of the application of the settled sewage upon the sand bed in such a way as best to promote the activity of the oxidizing organisms.

General Description.—The experimental sand bed as designed for the Hygienic Laboratory plant consisted of a layer of sand 2 ft. deep and 7 x 12 ft. in area, resting upon a drainage layer of gravel 6 ins. deep. The effective size of the sand was 0.24 mm. The dosing chamber was 3 ft. in diameter and contained a 3-in. Miller sewage siphon of 15-in. draw. Each dose from the dosing chamber discharged a layer of sewage upon the sand bed about 0.1 ft. in depth.

Experimental Results.

Imhoff Tank. Removal of Settleable Solids.—The average total solids in the raw sewage applied to the Hygienic Laboratory Imhoff tank for three months was 1,000 p.p.m. For the same period the average total solids in the tank effluent were 330 p.p.m. The total solids settled out by the tank were therefore 670 p.p.m. The average settleable solids in the tank effluent were 14 p.p.m. Hence the total settleable solids in the raw sewage were 684 p.p.m. and 98 per cent. of the settleable solids were therefore removed by the tank.

Volume of Sludge per Person.—The experimental tanks have not been operated for a sufficient length of time to justify definite conclusions as to the volume of sludge received. Our records to date indicate a probable rate of 2.6 cu. ft. per person per year at one plant and 4 cu. ft. at the other. This indicates a possible range of variation which may be expected in small tanks, apparently similar.

Condition of the Sludge.—The digested sludge is black in color, has the characteristic Imhoff sludge odor, streaks very quickly in a porcelain dish, showing that it has lost its stickiness and waterholding power, but has a relatively high moisture content, generally about 95 per cent. It is probable that the high moisture content is due to the shallowness of the sludge layer. Sufficient sludge has not accumulated as yet to justify drying experiments. Its appearance, however, indicates that there will probably be no difficulty in doing this without nuisance.

Freshness of Effluent.—The mean detention period in the Hygienic Laboratory tank is about five hours instead of six hours, as the flow has been somewhat higher than was expected. At Chevy Chase it is about six hours. These are higher values than those employed in large tanks, but the effluent has practically never been septic and has had at all times the odor of fresh sewage. It seems likely, therefore, that where sewage is settled so close to the source as is usually the case with small tanks, a mean detention of five or six hours will not render it septic or foul-smelling.

Scum and Foaming.—Both heavy scum formation and foaming occurred in the operation of the tanks. The most significant run on the Hygienic Laboratory tank began on November 19, 1914. Scum commenced to form almost immediately in the side vents and apparently continued increasing in thickness until July 5, 1915, with relatively little sludge being deposited in the sludge chamber. The scum was yellowish-gray, except the top quarter inch, which was black. Unless the scum was stirred no odor could be perceived outside the tank, even if the covers were removed. Upon spading or stirring, however, a distinct fecal odor could be noticed. At this time a sudden change took place and nearly all of the yellowish-gray scum changed to gray foam and began to boil over the top of the tank. Spading the scum caused it to deflate and collapse, but it soon became necessary to spade the scum twice a day in order to prevent it from foaming over. Finally, on July 13 and 14, some of the foam was removed and buried, in amount about 21 cu. ft., or somewhat less than 1 cu. ft. per person. It was impossible to determine what proportion this was of the total scum and foam present. From then until now, four months later, no further foaming has been observed. The scum is now entirely different, consisting mostly of seeds, grease, bits of cloth, and other not easily decomposable substances. It cannot be said, therefore, that difficulties with scum and foaming have occurred to a serious degree, since the foaming-over period at the Hygienic Laboratory lasted only about 10 days, and this could probably have been prevented by an earlier removal of the scum or by the provision of larger gas vents.

Sand Bed.—As above stated, the sand bed design intended a sand depth of 2 ft., but on account of compacting the depth decreased to 18 ins. after a few doses had been applied. The results, however, were so good that it was decided not to increase the depth, but to determine the purifying power of 18 ins. The rate of dosing was about 200,000 gal. per acre per day. For the month of October, 1914, the average dissolved oxygen present in the effluent was 5.4 p.p.m., the average 24-hour 20° C. oxygen demand was 2.2 p.p.m. and the relative stability over 90 per cent., corresponding to a time of decolorization of methylene blue of over 10 days. During the following winter much difficulty was experienced with the sand bed and frequent rakings and spadings were necessary. The bed was provided with tongue-and-groove covers, and while these prevented the formation of ice the frequent clogging did not diminish. More attention had to be given than can be reasonably relied upon for small plants. For some reason the depth of sand decreased during the winter and spring to about 15 ins. It seems probable that the frequent deep spadings caused some of the sand to pass down into the gravel layer. From November, 1914, to May, 1915, the average dissolved oxygen was 5.7 p.p.m., and the average oxygen demand 14.4 p.p.m. This included a period from April 7 to 30 when the dissolved oxygen was 2.6 p.p.m. and the average oxygen demand was 33.8 p.p.m. On May 15 green growths appeared quite copiously on the sand surface and continued forming until June 19. Several rakings were necessary during this time. From June 19 until October 4 no further rakings were necessary, and during this time weeds grew in abundance on the bed, but did not visibly increase the time of passage of a dose, which was generally about 15 to 20 minutes. Occasionally there seemed to be some evidence that short-circuiting was taking place through the 15-in. sand layer, but we were not able to establish direct evidence of this at any time. During the three months of July, August and September of the past summer, the net rate of dosage was 190,000 gal. per acre per day, the influent had no dissolved oxygen, demand, and no nitrates, while the effluent contained 2.2 p.p.m. dissolved oxygen, 12 p.p.m. of oxygen demand and 8 p.p.m. of nitrates.

Conclusions.—Our experience thus far justifies the following tentative conclusions:

(1) It is possible by means of a five-hour mean detention period in a properly designed Imhoff tank to remove from the raw sewage of small communities 98 per cent. of the settleable solids without producing a nuisance.

(2) A mean detention period of six hours, based on the average daily flow, will not cause the sewage to become septic or foul-smelling if it is fresh when it enters the tank.

(3) The accumulation of a disagreeable mass of grease and fecal matters in the first compartment of the settling chamber may be prevented by the introduction of a horizontal coarse mesh screen at the water level of this chamber. The screen keeps the floating matters submerged and apparently results in all fecal matter sooner or later becoming waterlogged and sinking through the slot into the sludge chamber.

(4) It is too soon to state with conviction the amount of digested sludge that may be expected from small-scale tanks, but one tank indicates an apparent accumulation of 2.6 cu. ft. per year per person and another tank 4 cu. ft.

(5) The only period during which the Imhoff tanks required daily attention was the foaming period, which

lasted about 10 days, and during which time some of the foam had to be removed and buried. At all other times attention once a month at the most was ample.

(6) Since the foaming period has been passed the scum formation has been slight.

(7) The decomposed sludge obtained from the small-scale Imhoff tanks resembled that obtained in large tanks except that it had a much higher moisture content. This may perhaps be explained by the shallowness of the sludge layer.

(8) A 15-in. sand bed dosed with settled sewage at a net rate of 190,000 gal. per acre per day during the second summer reduced an average oxygen demand of 63 p.p.m. to 12 p.p.m. (24-hour 20° C.). This is probably ample purification for many cases, but insufficient for others.

(9) The sand bed required very little attention during the summer months, but what would seem to be a prohibitive amount of attention during the winter months, even though covered with a tongue-and-groove wooden cover.

(10) No nuisance was produced during the summer months by the dosing of the uncovered sand bed with the Imhoff tank effluent.

(11) The growth of weeds on the sand surface did not seem to have an unfavorable effect upon the operation of the sand bed.

In General.—The foregoing work has indicated the desirability of continuing the experiments upon Imhoff tanks in order to confirm the past satisfactory results, and the desirability of continuing the experiments upon sand beds in order to improve only fairly satisfactory results. Further experiments will be made upon deeper sand beds at lower rates of dosing.

The work has been done under the general direction of Prof. Earle B. Phelps. The analytical work was done by Sanitary Bacteriologist H. L. Shoub. The writer, with Sanitary Bacteriologist C. P. Rhynus as assistant, was in immediate charge.

The Canadian Railway Club, Inc., Montreal, has elected the following officers for the season 1916-17: President, R. M. Hannaford, Assist. Chief Engineer, Montreal Tramways Co., Montreal; 1st vice-president, G. E. Smart, Canadian Government Railways, Moncton, N.B.; 2nd vice-president, Prof. Keay, McGill University, Montreal; secretary, Jas. Powell, Chief Draughtsman, G.T.R., Montreal; treasurer, W. H. Stewart, Imperial Munitions Board, Ottawa; executive committee, T. C. Hudson, Master Mechanic, C.N.Q. Railway, Joliette, Que.; E. E. Lloyd, C.P.R., Montreal; J. Hendry, Master Car Builder, G.T.R., Montreal; C. Manning, Secretary to Superintendent of Motive Power, G.T.R., Montreal; C. W. Van Buren, General Master Car Builder, C.P.R., Montreal; and W. H. Winterrowd, Assist. to Chief Mechanical Engineer, C.P.R., Montreal.

The largest combination of weight and size ever handled on one freight car by an American railway has been started on a journey to Joplin, Mo., from the yards of the Pennsylvania road at Greenville, N.J. This record-breaking load consisted of the generator for an 8,000 kilowatt turbine, purchased by Henry L. Doherty & Co. from the Brooklyn Edison Company. The generator is in one piece, weighs 160,000 pounds, and as measured by the railroad from the surface of the rails to the top of the machine stands 15 feet 7½ inches in height. Because of this extreme height the railroad was forced to lay out a special itinerary of detouring so that no tunnels or other possible clearance obstacles would be encountered on the run from New York to St. Louis. It is thought St. Louis will be reached in about six weeks, and then another journey must be taken to Joplin, where the generator will be installed at the plant of the Empire District Electric Company, a subsidiary of Cities Service Company.

TREATED WOOD BLOCK FLOORING.*

By C. H. Teesdale,
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SINCE 1900 there has been a steady and rapid increase in the use of creosoted wood blocks for paving the streets of our cities. A more recent development has been their adoption for a variety of uses other than street paving. Those qualities which make the wood block desirable for street work should also make it desirable for flooring where heavy trucking, the moving of heavy machinery, etc., make the maintenance of floors a serious problem.

Letters were written to those plants manufacturing creosoted wood blocks requesting data on their methods of manufacturing and construction. Not many of the treating plants have as yet produced very much of this product. Reports were received from 13 commercial plants and one railroad plant.

Eleven of the plants reported the use of southern yellow or longleaf pine. Five plants also recommended eastern tamarack as being satisfactory, and the three western plants recommended Douglas fir; black gum, beech, Norway pine, maple, hemlock, and western larch were recommended by one plant each.

Several of the plants, particularly those producing the largest quantity of this material, pointed out that the wood block flooring problem naturally divides itself into two classes:—

(*a*) Blocks used in very dry situations, as in factories and warehouses.

(*b*) Those used in alternately wet and dry, or in wet situations, as in stable floors, docks, wharves, slaughter houses, etc., where the blocks are exposed to the weather, to flushing with water, etc.

The treatment and method of handling the blocks differs radically in the two cases. Eight of the 13 plants reported in favor of using a distillate creosote oil. Three plants recommended paving oil similar to that quite generally used for wood block street paving. One recommended water-gas-tar; one carbolineum; one a mixture of half water-gas-tar and half zinc chloride solution; and one a mixture of half water-gas-tar and half coal-tar creosote. The last mentioned product was, however, recommended only for wet situations, this plant recommending creosote injected by the Rueping process for dry situations. The consensus of opinion was to use a distillate creosote, especially for dry situations, and a heavier paving oil for wet conditions.

In general, the plants were not very specific as to the absorption of preservative that they recommended for the two classes of blocks. The inference to be drawn, however, was that comparatively light absorptions (from 5 to 8 or 10 lbs. per cubic foot) would prove satisfactory for dry situations. Heavier absorptions, ranging from 8 to 16 lbs. per cubic foot, were recommended for alternately wet and dry or for wet situations. In general, the absorption to be given would appear to depend to a considerable extent upon the conditions met with in each individual problem, the more severe conditions especially as to the chance of the water coming in contact with the blocks, requiring heavier absorptions of oil. In the case of plants recommending paving oil and water-gas-tar, heavier absorptions were specified than when creosote was recommended.

*Abstract of paper read before the American Wood Preservers' Association.

Letters were written to a large number of users of wood block flooring, to obtain information on the character of the floors being laid and the results obtained. One hundred and sixty replies were received. About 75% of the replies describe floors laid in 1912 or later, while only three records were received of floors laid prior to 1909. This indicates the comparatively recent development of this type of flooring. For this reason, also, the time of service of these floors has been so short that not much information can be given upon durability.

The depth of block used varied from 2 to 6 ins., but 3-in. was used in 50% of the floors concerning which replies were received. Southern yellow pine was used in 72% of the cases, while 15% did not reply to the question, the remaining 13% being divided between eight other species of wood.

Concrete foundation was reported in 80% of the replies, the remainder being plank, dirt, tamped earth, etc., or not answering the question. Seventy-one per cent. reported the use of sand cushion, 12% cement grout cushion, and 3% bituminous cushions. Bituminous fillers were reported by 44%, and sand by 25%. Thirty-nine per cent. reported that expansion joints were used, while 41% did not use them, and 20% did not reply to the question.

Summing up, the general practice was to use 3-in. southern yellow pine blocks treated with 15 lbs. or more of creosote per cubic foot by the Bethell process. These were laid with a concrete foundation, sand cushion, bituminous filler, and the question of using expansion joints depended on the local conditions in each case.

Repairs have been reported in 32% of the records, while 62% reported no repairs. In most cases the repairs made were of a minor character, and as a rule, were caused by swelling or shrinking of the wood. In a few cases blocks were badly worn where heavy castings were thrown upon them.

Bleeding of the blocks was reported in 9% of the records, but was said to be objectionable in only 2.5% of the cases. Swelling was reported in 29% and shrinking in 27% of the records, (in some cases both swelling and shrinking were reported), and these troubles were the cause of most of the dissatisfaction reported. Swelling occurred when the blocks became accidentally wet, because of leaky roofs, bursting water pipes, near drinking fountains, and other accidental causes. Shrinking occurred in very warm or hot situations, and resulted in the blocks becoming loose and producing an uneven floor.

An interesting relation may be shown between the kind of filler used, and swelling and shrinking reported. Thirty-three per cent. of those using bituminous filler reported this trouble, compared with 55% of those using sand filler, 75% where cement grout was used, and 55% where no filler was used.

Eighty-nine per cent. replied that the blocks were satisfactory, while 5.6% did not reply to the question, and 5.6, or nine records, stated that the flooring was not satisfactory. Of the nine unsatisfactory floors, shrinkage of the blocks was responsible for dissatisfaction in three cases, swelling in two cases, in two cases the blocks wore out rapidly, poor foundation in one case and improper laying in one case.

In a large proportion of cases it was reported that wood block was easy on the feet of the workmen and that they like to work on it. Noiselessness, ease of repairs, low upkeep cost, good trucking surface, saving of breakage in tools and fragile metal parts dropped on the floor, warmth, and cleanliness were all reported as advantages of wood block flooring in 10 or more of the records. Durability was reported as an advantage in 77 cases, though it is doubtful if many of the floors had been in service sufficiently long to warrant a statement as to durability.

In 14 records swelling was given as a disadvantage and shrinking in 12 records. Roughness, reported in 11 records, was mostly caused by shrinkage. High cost was given as a disadvantage in 11 cases.

The results of this investigation indicate that treated wood block makes a desirable type of flooring for many purposes, and it is likely that its use for interior work will increase. Since its large use for these purposes is just beginning, one might expect that unforeseen trouble would develop. The records of 160 floors given in this report indicate, however, that serious trouble has developed in a very low percentage of cases.

Most of the trouble has come from shrinkage or expansion of the blocks. To prevent these troubles it is essential to study each case where blocks are to be laid, and to treat the blocks accordingly. For dry situations, the blocks should be well seasoned before treatment and laid in the floor while thoroughly dry. In wet or alternately wet and dry situations, dry blocks would give expansion trouble and, hence, the timber should be green or only semi-air-dried when laid. Even dry interiors are liable to be accidentally subjected to water, however; hence, it would seem desirable as a rule to use bituminous fillers instead of sand filler.

Sand cushions were probably a source of trouble in several cases. If there is any vibration, or if the sand is at all liable to shift, a bituminous or cement grout cushion is to be preferred. Sand cushions are also liable to cause uneven floors if the blocks shrink, and it seems likely that many cases of shrinking would not give serious trouble where bituminous filler and bituminous or cement grout cushions are used.

Bleeding caused very little trouble. In dry and very warm situations, where it is most likely to occur, it would be desirable to carefully consider the method of treating and handling the blocks in order to avoid objectionable bleeding.

In a few cases it seems likely that wood block should not be used. For example, it should not be used where butter or tobacco products are stored. In some foundries, where hot castings are thrown upon the floor, the blocks have burned through to the foundation. Wood blocks may be objectionable where the soiling or staining of certain classes of merchandise would lower the value, and in one case where used in a tennis court wood blocks were a failure and had to be removed.

Wood block was found to be very satisfactory in many cases where heavy castings are thrown about, where heavy trucks are moved, and is liked by workmen because it is warm and is easy on their feet.

The replies from the users of wood block flooring indicate quite strongly that when new wood block floors are to be laid, a careful investigation of all the conditions existing or likely to develop should be made by the manufacturer. The method of treatment and construction of the floor should then be adapted to the special conditions found.

Electrification of steam railroads in the United States last year brought the total of such equipment up to about 2,500 miles.

The British Columbia Electric Railway Company are proceeding with the completion of a large sub-station in Burnaby, B.C., the work on which has been suspended for the past two years.

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BOOK REVIEWS.

Hydraulics. By R. L. Daugherty, A.B., M.E., Assistant Professor of Hydraulics, Sibley College, Cornell University. Published by McGraw-Hill Book Co. (Inc.), New York. First edition. 264 pages, 243 illustrations and diagrams, 12 tables, 6 x 9 ins., cloth. Price, $2.50. (Reviewed by H. G. Acres, Hydraulic Engineer, Ontario Hydro-Electric Commission.)

This is the third hydraulic treatise so far published by Mr. Daugherty, the other two being entitled "Hydraulic Turbines," and "Centrifugal Pumps." After having published two text-books involving the application of rather advanced hydraulic theory, the author has possibly found that the elucidation of this theory to his classes could be more satisfactorily accomplished with the assistance of an elementary text-book of his own devising. Hence the volume under review which should therefore be considered as introductory to the two previous volumes, although as a matter of fact, the three volumes overlap to a considerable extent.

The volume is divided into sixteen chapters, nine of which are devoted to theoretical discussion and the derivation of general formulae. Chapters ten to sixteen deal with the simple theory of impulse wheels, reaction turbines and centrifugal pumps and their characteristics. This section also contains well-chosen descriptive matter, profusely illustrated, in connection with the installation and operation of the most modern hydraulic machinery and the layout of modern hydraulic developments.

In the first nine chapters there are three general subdivisions of the text. The first four chapters cover the theory of hydrostatics, chapter four being devoted to a concise but comprehensive discussion on the practical application of hydrostatic principles to the design of dams.

Chapters five to eight inclusive deal with water in motion, including the ordinary treatment of flow over weirs, flow through orifices, short tubes, pipes and in open channels. Of special interest is the derivation of the general equation for steady flow by the application of Bernoulli's theorem, and the subsequent discussion of its significance and limitations.

Chapter nine deals with the dynamic characteristics of water in motion, the argument leading up to the explanation and derivation of the general torque equations for turbines and pumps. This chapter also includes a brief discussion of water-hammer and surges in long pipes.

The remainder of the volume, with the exception of chapters thirteen, fourteen and sixteen, is largely descriptive matter. In the three chapters above mentioned, the theory of the impulse wheel, the reaction turbine and the centrifugal pump is covered suggestively, but as the treatment is intentionally academic, the general expressions derived are not directly applicable to practical design.

This little volume is a model of terse treatment, which is at the same time adequate by reason of the discriminating judgment with which fundamental principles have been seized upon and elucidated. On this account, while designedly a student's text-book, it is also an extremely useful reference book for any practicing engineer, whose work brings him in contact, more or less intermittently, with the simpler hydraulic problems.

Waterworks and Sewerage Systems of Canada. Compiled by Leo. G. Denis, B.Sc., Hydro-Electric Engineer, Commission of Conservation. Published by the Commission of Conservation of Canada. Contains 176 pages and 28 illustrations. (Reviewed by S. Harvey, A.M.Can.Soc.C.E., Sewer Department, City Hall, Toronto.)

In 1912 a report was published by the Commission of Conservation on the "Waterworks of Canada," being the principal physical data regarding waterworks systems in existence in the Dominion at that time. The great demand for that report proved its value and it was decided to compile another report which would revise that of 1912, and also embody a report on the sewerage systems of Canada.

This book is of a very useful character, setting forth in a condensed form the salient points connected with the numerous waterworks and sewerage systems of the Dominion.

Engineers have oftentimes occasion to refer to other towns and cities for statistics which may be readily gathered from this report.

As there are new systems and extensions to existing systems being constructed continually, this book will require to be revised every year in order to retain its value as a book of reference.

Irrigation Practice and Engineering, Vol. II., Conveyance of Water. By B. A. Etcheverry, Head of the Department of Irrigation, University of California. Published by McGraw-Hill Book Co. (Inc.), New York. First edition, 1915. 364 pages, 82 illustrations, 9 x 6¼ ins., cloth. Price, $3.50 net. (Reviewed by Lieut. T. W. J. Lynch.)

This volume is devoted to the design and construction of the conveying channels that bring water to the farms, including flumes, pipes, syphons and tunnels.

It opens with a chapter on the general features and investigations precedent to design, followed by a chapter dealing with the planning and location of the system.

The hydraulics of design of canals, flumes, pipes, etc., are next considered. As usual in American texts, Kutter's formula for the flow in open channels is given to the practical exclusion of all others, and as a consequence there is the usual presentation of another new diagram for the solution of this complicated and cumbersome equation.

The silt problem, losses from canals and the design of canal sections are next taken up. The seventh chapter is a very complete presentation of the subject of canal linings and prevention of losses. Numerous examples are cited by description and illustration, and the question of methods and costs is very fully dealt with. This is a subject which most text-books on irrigation seem to fight shy of or ignore and this chapter is a refreshing change. The material presented is drawn from a wide range of examples covering all conditions. Chapter 8 elaborates on tunnels, retaining walls, sections and bench flumes.

Chapter 9 deals with flumes and Chapter 10 with pipes and syphons. The latter, which is by far the longest chapter in the volume, is the only one in which design is treated from any other point of view than that of carrying capacity. In this chapter the design of pipes is handled from the hydrostatic point of view as well as the hydraulic.

To summarize, Volume II. contains abundance of valuable information for the young engineer engaged in irrigation practice when his professional experience should be augmented by some valuable treatise on irrigation.

Masonry Dam Design. By C. E. Morrison and O. L. Brodie. Published by Wiley & Sons, New York. Second edition, revised and enlarged, 1916. 276 pages. Price, $2.50 net. (Reviewed by G. R. G. Conway, Mem.Can.Soc.C.E.)

The authors of "Masonry Dam Design" are to be congratulated upon this second and enlarged edition of what, in its earlier form, as published in 1910, was a somewhat inadequate treatment of the subject. In this edition they have grouped in convenient form the latest investigations into the theory of masonry dams that have been discussed so fully during the last few years. In England, much careful investigation has been made in connection with this subject by such well-known authorities as Professor Unwin, Professor Karl Pearson, L. W. Atcherly, Sir John Ottley, Dr. A. W. Brightmore, E. P. Hill, and others, and probably the best record of their work is contained in the very valuable discussion published in Volume 172 of the proceedings of the Institution of Civil Engineers. On this continent very valuable studies have been made by the engineers of the New York Water Supply, and the subject was very fully discussed by leading American authorities in Volume 75 of the Transactions of the American Society of Civil Engineers. Read together with these two discussions, Messrs. Morrison and Brodie's book will prove of great interest to all students of masonry dam design.

The subject of uplift pressure and ice thrust is of great importance to engineers in this country; and, as the authors point out, for probably the first time it received due prominence in the design of the Wachussett dam in Massachusetts. Much space has therefore been given to the consideration of uplift and ice thrust, and in our opinion, in the authors' treatment of this branch of the subject lies the chief value of the book now before us. The book is essentially one for the student, but to the engineer looking for the latest summary of the various theories in connection with masonry dam design the book will be of interest.

Chapter VIII. is a discussion on recent considerations of the condition of stress in masonry dams, but the authors appear to have overlooked the work of Dr. Karl Pearson, who is largely responsible in England for the initiation of the experimental work done by later investigators, particularly those who have been utilizing models of dams composed of jelly and other plastic substances for experimental purposes. The practical engineer in reading this book might ask what value it has for him. He might turn to the very interesting appendix which contains profiles of a large number of notable dams, and point out that many of these dams were built years ago, and are not essentially different in profile from recent designs, and yet are to-day standing among the finest structures of their class—such, for example, as the Furens and Chartrain dams in France, the Villar dam in Spain, the Periyar dam in India, and many others which have caused no anxiety to their designers, while he might point out that the known failures have all been due to faulty foundations, and no matter how theoretically correct the design may be, the real problem of masonry design lies in the careful selection of site, the construction methods adopted to prevent the permeability of the structure, and the proper construction of cut-off trenches and outlet drains to prevent uplift pressures.

We believe that although the real problems of masonry design can be solved only by mature experience and judgment and the special consideration of each individual case, the authors' book is of real value to the practical engineer engaged in dam design, and is a welcome addition to the all too few books upon the subject.

In Appendix No. 3, which gives the cross-sections of many notable dams, we miss the profiles of several famous English examples, *e.g.*, Pen-y-Gareg and Craig Goch dams of the Birmingham Water Supply, and also those constructed in recent years by the Derwent Valley Water Board, all of which are among the finest examples of high masonry dams yet constructed.

A System of Physical Chemistry. Two volumes.. By William C. McC. Lewis, M.A., D.Sc. Published by Longmans, Green & Co., New York and London. Canadian selling agents, Renouf Publishing Co., Montreal. 523 pages, illustrated, 5 x 7½ ins., cloth. Price, $5 for set of two volumes. (Reviewed by J. W. Scott, Health Department, City Hall, Toronto.)

This book is intended for use as a general text book of physical chemistry for those who have a grounding in the subject.

It is not an elementary physical chemistry, the author aiming to make the book fairly comprehensive by including accounts of recent investigations, such, for example, as the structure of the atom, the theory of concentrated solutions, capillary chemistry, Nernst's theorem of heat, and so on. Besides these recently examined problems, the fundamental principles and their applications have been incorporated here. At the same time, the author suggests that the reader becomes fully familiarized with the broad outlines of the subject, which may be found in more elementary works.

Volume I. contains 510 pages divided into 10 chapters, and deals with or may be entitled the "Kinetic Theory." Volume II. contains 542 pages divided into 14 chapters and may be entitled "Thermodynamics and Statistical Mechanics."

This book covers the ground of advanced physical chemistry to perfection, but as a book for students the use of it is not to be recommended.

Maintenance of Way and Structures. By William C. Willard, C.E., M.S., Assistant Professor of Railway Engineering, McGill University. Published by the McGraw-Hill Book Co., New York. First edition, 1915. 450 pages, 225 illustrations, 6 x 9 ins., cloth. Price, $4. (Reviewed by J. R. W. Ambrose, M.Can.Soc.C.E., M.A.R.E.A.)

Of all the volumes published on engineering, very few have been devoted to railroad engineering as a whole. This edition has long been wanted, particularly as a text in universities where there has been a maximum of theory and a minimum of practical information.

The chapters, no doubt, are modelled after the Committees of the American Railway Engineering Association, the greatest of its kind in existence, which controls the railway engineering practice of this continent at least.

The chapter on Rules and Organization is excellent information for the student, but of no practical value to the railroad man, as each company has its own characteristics and the standardization of all would be impossible.

The impression given of track labor is wrong. This class of labor is becoming more important each year, and railway companies are beginning to recognize the possible economy and efficiency through this department.

The chapters on Roadway, Ballast, Ties, Wood Preservation, Rails, etc., are very good and profusely illustrated.

The article on rail anchors is descriptive, but later anchors, such as the "McCooe," might be added, which overcome the difficulties mentioned.

The chapter on Stresses in Track is excellent. This is a new subject and valuable to the engineer as well as the student.

The chapter on Bridges does not go into the design, but the illustrations are valuable to the practical man and particularly so to the student. The statement that ballast floor bridges are not generally waterproofed is incorrect. The author probably meant that special materials are not always used, but some method of waterproofing is always intended.

The remaining chapters give the recommended practice in a concise way, making a convenient reference for the engineer and an excellent text for the student.

The directions for railway drafting are exceptionally good.

As a railway engineering text book, the writer has not seen its equal. The illustrations are clear, instructive and numerous.

Engineering Office Systems and Methods. By John P. Davies, M.E. Published by McGraw-Hill Book Co., Inc., New York. First edition, 1915. 544 pages, 244 diagrams, forms and illustrations, 6 x 9½ ins., cloth. Price, $5.00 net. (Reviewed by H. G. Acres, hydraulic engineer, Ontario Hydro-Electric Power Commission, Toronto.)

The sub-title of this volume indicates its scope more effectively than the general title—"Schedules and instructions for the collection of preliminary data for engineering projects; sampling, inspecting and testing engineering materials; conducting domestic and export shipping operations, etc."

The text is divided into thirteen chapters, ten of which are devoted to engineering subjects. Chapters 5, 8 and 9, entitled respectively, "Purchasing—Office Methods and Forms," "Domestic Shipping," and "Export Shipping," have a much more general scope, as their titles indicate. Chapter 9 contains a well-handled description of procedure and routine formalities in connection with export shipping which could be most opportunely studied by many Canadian manufacturers who plan to invade foreign markets at the close of the war.

Chapters 10 and 11 are devoted to "Progress Charts, Scheduling Systems" and "Indexing and Filing Systems." While these subjects are treated from an engineering viewpoint, an intelligent reader could study these two chapters with profit and adapt the principles outlined to any class of heavy manufacturing. The description of the Dewey decimal system and the discussion of its manifold applications is particularly interesting.

The remaining chapters are more or less directly related to engineering office system and methods or "reminders," and the data required for (*a*) preparing specifications, (*b*) obtaining manufacturers' designs and quotations, (*c*) preparing engineering designs, (*d*) reporting on engineering projects, etc. Chapter 6 deals with cost keeping and estimating and Chapter 7 with sampling, inspection and testing of engineering material. With the exception of the chapter on cost keeping and estimating, these remaining chapters are of doubtful value. The information is not given in sufficient detail to be safely used by an inexperienced engineer, while on the other hand, it is of such a fundamental nature that it must obviously be part of the stock in trade of any competent engineer or inspector. The volume as a whole, however, is a very useful work of reference as related to heavy manufacturing, and should find a market not only among engineers, shop superintendents, etc., but among executives and officers having to do with the purely commercial phases of manufacturing.

Mechanical Engineers' Handbook. Lionel S. Marks, Editor-in-Chief. Published by McGraw-Hill Book Co., Inc., New York. First edition, 1916. 1,836 pages, 4½ x 7¼ ins. About 1,000 illustrations and diagrams. Flexible leather. Price, $5 net.

This handbook brings into the mechanical engineering field the principle of specialization which was introduced into the civil engineering field by the American Civil Engineers' Pocket Book. Prof. Marks, who is professor of mechanical engineering at the Massachusetts Institute of Technology, is the chief editor, but each of the fifteen main sections of the book was written by a specialist.

The book is based upon the German, "Hütte." The German book includes civil and electrical engineering, however, and those portions are not included, arrangements having been made with the Germans for the use of only such portions of their handbook as were required. The greater part of the book must be regarded as new, although the subjects of friction and hydraulic turbines follow "Hütte" closely, while a few of the more theoretical topics, such as heat and mechanics of materials, follow "Hütte" in a general way, with important departures, however.

The specialists who contributed to the book have furnished new data on machine tools and machine shop practice, hoisting and conveying, pipe and pipe fittings, heat, lubricants, paints, weights and measures, refrigeration, fractory accounts and costs, industrial buildings, air conditioning, illumination, fans, hydraulic turbines, air compressors, pumps, measuring instruments, gas engines, steam turbines, fire protection, aeronautics, automobiles, and a large number of other mechanical subjects.

The book is a very useful and welcome addition to mechanical engineering literature.

PUBLICATIONS RECEIVED.

Department of Mines.—Summary report for 1915 of the Geological Survey, Department of Mines, Ottawa. Price, 15 cents.

Canal Statistics.—1915 report of the Department of Railways and Canals, Ottawa, containing 103 pages. Price, 10 cents.

Financial Report, 1915, of the J. G. White Companies, New York, giving annual returns and balance sheet of these companies.

Ore Deposits of the Beaverdell Map Area.—By Leopold Reinecke. Memoir 79, No. 65, Geological Series, Department of Mines, Ottawa.

Report of Nelson P. Lewis, chief engineer, Board of Estimate and Apportionment, City of New York, for the year 1914. 235 pages, 42 tables.

Geology and Ore Deposits of Rossland, B.C.—Memoir 77, No. 64, Geological Series, Department of Mines, Ottawa. By Charles Wales Drysdale.

Geology of Field Map—Area, British Columbia and Alberta.—Memoir 55, No. 46, Geological Series, Department of Mines, Ottawa. By John A. Allen.

Gas Plant Construction.—Published by the Stone and Webster Engineering Corp., Boston, Mass. Contains 24 illustrations of various gas and power plants.

Sewage Disposal.—Tenth and eleventh semi-annual reports, 1915, of the Sewage Disposal Commission of the city of Fitchburg, Mass. Published by the Fitchburg H. M. Downs Printing Co.

Highway Improvement in Ontario.—Annual Report, Department of Highways, Toronto, 1915, by W. A. McLean, commissioner of highways. 223 pages, well illustrated by charts and photographs.

The Strength and Stiffness of Steel Under Biaxial Loading.—Bulletin No. 85, Engineering Experiment Station, University of Illinois, Urbana, Ill. By Albert J. Becker. 65 pages, illustrated. Price, 35 cents.

Experiments on the Economical Use of Irrigation Water in Idaho.—Bulletin No. 339, U.S. Department of Agriculture, Washington, D.C. By Don H. Bark, irrigation engineer, Division of Irrigation Investigations.

Tests of Reinforced Concrete Flat Slab Structures.—Bulletin No. 84, Engineering Experiment Station, University of Illinois, Urbana, Ill. By Arthur N. Talbot and Willis A. Slater. 128 pages, 85 illustrations. Price, 65c.

Good Roads Year Book, 1916.—The fifth annual edition of this useful publication has been issued. It contains a great deal of information regarding road improvement, historical notes, road materials and road machinery. W. A. McLean, Deputy Minister of Highways of Ontario, has an article in it dealing with highway improvements in Canada, and the Hon. B. Michaud, Deputy Minister of Highways of the Province of Quebec, contributes an article dealing with the roadway organization of that province. It contains 440 6 x 9-in. pages.

Annual Report on the Mineral Production of Canada.—Issued by the Department of Mines, compiled by John McLeish, B.A., chief of the division of mineral resources and statistics. This report contains 366 6 x 9-in. pages. It is divided into three sections: First, metallic ores; second, non-metallic production; third, structural materials and clay products. A great many comparative statements are presented showing the production of each important product during the past two years, the production which each contributes to the total production and the increase or decrease, as the case may be, of the production in 1914 as compared with that of 1913.

CATALOGUES RECEIVED.

Steel.—1916 stock list of the steel department of Factory Products, Limited, 220 King Street W., Toronto.

Protecting the Water Supply of Greater New York.—An illustrated booklet issued by the Wallace & Tiernan Co., Inc., New York.

Microscopes.—A 129-page, illustrated booklet issued by the Bausch & Lomb Optical Co., Rochester, N.Y., describing their microscopes and accessories.

Small Motors.—Folder No. 25 issued by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., describing, with illustrations, Westinghouse motors for washing-machine service.

Trill Indicators.—A 56-page, illustrated booklet issued by the Trill Indicator Co., Corry, Pa., describing the latest types of engine indicators and accessories, with information on taking and reading of indicator cards.

William Bryce, Lothian Street, Edinburgh.—Catalogue of chemical and technical books comprising works in agriculture, chemistry, metallurgy, etc. Catalogue is very well classified and contains 56 5½ x 8½-inch pages.

Milburn Oxy-Acetylene Welding and Cutting Apparatus.—A 6-page, illustrated folder issued by the Alexander Milburn Co., Baltimore, Md., describing their welding torch, regulators, cutting torch, welding generator and portable plant.

Manganese Chains.—Bulletin No. 171, issued by the Jeffrey Manufacturing Co. Contains full details and prices of "manganese" chains. Copy of the bulletin can be secured by addressing the Montreal office of the company, Power Building, Montreal.

Small Electrically Driven Centrifugal Pumps.—Bulletin No. S-1000, issued by Yeomans Brothers Co., Chicago, describing their centrifugal pumps for house supply and general service in office buildings, apartment buildings, power plants, etc. 11 pages, illustrated.

Yeomans Duplex Electric Centrifugal Sewage Ejectors.—Bulletin No. E-2000 of Yeomans Brothers Co., 231 Institute Place, Chicago, describing their sewage ejectors for automatically raising sewage and drainage in basements below street sewer level, municipal sewage systems, etc. 11 pages, illustrated.

Oil Filters.—Bulletin No. 5, recently issued by the Richardson-Phenix Co., Milwaukee, Wis., describing a complete line of filters for purifying lubricating oil, having capacities of from 25 gallons per day to 50,000 gallons per hour. The catalogue is well illustrated and contains prices on the various size filters.

Wagon and Truck Loaders.—Bulletin No. 177 of the Jeffrey Manufacturing Co., Columbus, Ohio, featuring their self-propelling wagon and truck loaders for handling crushed stone, sand, gravel, etc. Contains 23 pages and illustrations of many interesting installations, specifications, prices and complete details of their different types of loaders.

Editorial

INDUSTRIAL RESEARCH.

It seems to be a pretty well fixed belief that knowledge should be pursued for its own sake, and that the quest for truth should be unhampered by anything that even has the semblance of utilitarianism about it.

Since the outbreak of war much has been written concerning the necessity for greater activity in the realm of industrial research in Canada. This is a subject which should not be left altogether to universities and scientific bodies. Manufacturers, if they are to maintain their superiority, must recognize that they, too, have responsibilities in connection with the development of industrial research in this country.

Certain large individual industries, as well as groups of industries, have spent large sums of money for research work. Monies have been and are now being spent in this country for this kind of work, but it is very spasmodic. It is a question as to whether we are as a people, and especially as manufacturers, attaching sufficient importance to this matter, and whether we are dealing with it in a corporate and national spirit.

While application and genius are necessary if research work is to be carried to a successful conclusion, money also is called for.

Many men are conducting research work, but are very much handicapped by the lack of apparatus which is absolutely necessary if the best work is to be done. Would it not be possible to gather up these loose ends of disconnected effort by greater co-operation between scientific and industrial groups and seek to approach the problem in a more intelligent, broader and really national sense?

THE ENGINEERS' LIBRARY.

For several years *The Canadian Engineer* has made a practice of publishing in the last issue of each month a department known as the Engineers' Library. In this department are to be found reviews of the new engineering books of the month, these reviews being written by engineers who have made a special study of the subjects with which the books deal. Under the heading of "Publications Received" there is given a review of reports issued by various public bodies which are more or less related to the engineering profession, while under the heading of "Catalogues Received" appear brief summaries of the trade literature of the month.

Every engineer, no matter in what particular branch of the profession he is interested, must feel, in view of the rapidity with which engineering practice changes and the speed with which one development follows another, the need of keeping himself posted, and has a more or less complete selection of text and reference books of his own.

The Engineers' Library as found in *The Canadian Engineer* can be made of great service to the man who recognizes the importance of having beside him at least a few standard general engineering books as well as others which deal more specifically with the phase of engineering with which he is especially interested for reference purposes. Such a collection of books will be found a tool by no means the least useful.

Reports of public officials, publications of engineering societies contain information of value to all engineers, while trade literature, though primarily advertising, very frequently contain data that will be found serviceable to the engineer in his work.

Two things usually limit the extent to which an engineer will build up a library: the demands of his everyday work, and the time and facilities at his disposal for collecting and filing information.

It is in order to render our subscribers the greatest possible assistance in selecting such material as they think should rightly find a place in their collection, that this department was established and is being maintained.

ECONOMIC VALUE OF THE GOOD ROADS MOVEMENT.

The development of the good roads movement will unquestionably help to solve many economic and social problems with which we are confronted to-day. Slowly, but none the less surely, people are beginning to realize the great importance of permanent road construction and to recognize the real significance of the movement.

While a great deal has been done in highway engineering in Canada, there is yet a great deal to be accomplished.

Those who cry "back to the land" will never get very far unless simultaneously with it they lend their practical support to the efforts which various bodies are making, looking to a betterment in the design, construction and maintenance of highways throughout the country.

Many farms that to-day are deserted would never have been so treated had the good roads idea come into service touch with them, and thus made it possible for the tenants to get and keep in more intimate contact with the communities immediately beyond their own borders.

The public highway is, after all, more generally used than any other means of communication, and is free and open to all classes of the community. It is well known that where a community passes from a condition in which poor roads are a rule to one in which good roads dominate, land values advance. The redistribution of a considerable portion of the population in such a way as to remove congestion in the cities and add them to the dwellers in rural communities has been given a great stimulus and will continue to be greatly stimulated by the good roads movement.

There are many districts all over Canada, rich in agricultural products but poor in roads. Such a community is under an enormous handicap. The incoming shipments greatly exceed the outgoing, whereas with improved road condition, these same communities could not only be self-supporting, but could ship products to other markets.

In very many quarters, at least, the real significance of highway improvement is not appreciated and objections to the development of the movement are made largely because of a lack of understanding and a real appreciation of its value from a social and economic point of view.

PERSONAL:

W. A. MAHONEY has been appointed water commissioner at Guelph, Ont.

CHARLES L. MARBLE has been appointed manager of the Wayne Oil Tank & Pump Co., of Woodstock, Ont.

PATRICK LYONS has been appointed general superintendent of the waterworks department of Quebec City.

L. T. WALLS, formerly of the Steel Co. of Canada, has been appointed general sales manager of the Manitoba Rolling Mill Co., Limited.

P. Z. CAVERHILL, forester for the Province of New Brunswick, has begun a survey and inventory of the provincial Crown lands.

D. O. LESPERANCE has been appointed chairman of the Quebec Harbor Board, to succeed Sir William Price, who recently resigned.

ALEX. WILSON, distribution engineer of the Montreal Light, Heat and Power Company, has been appointed Lieutenant in the 244th Battalion now being raised.

J. D. McMILLAN has been appointed superintendent of the Belleville Division (Districts 5, 6, 7, 8, 9 and 10), Grand Trunk Railway System, with headquarters at Belleville, Ont., to succeed H. F. Coyle, deceased.

J. R. BOOTH, the veteran lumberman, of Ottawa and Hull, recently celebrated his ninetieth birthday. Despite his age, Mr. Booth continues to take a very active interest in all of his companies' activities, and even helps around the mills.

E. L. COUSINS, chief engineer of the Toronto Harbor Commission, has just been appointed general manager, a reorganization of the office staff having been made necessary by the enlistment of Major Alex. Lewis, who had acted as secretary since the inception of the commission.

JAMES M. NELSON, who recently resigned as superintendent of the open-hearth department of the Carnegie Steel Co. works at Youngstown, Ohio, has been appointed superintendent of the open-hearth and duplex steel departments of the Algoma Steel Corporation at Sault Ste. Marie, Ont.

E. R. GRAY, assistant city engineer of Hamilton, Ont., has been recommended by the Board of Control for the position of chief engineer, to succeed A. F. Macallum, and A. P. KAPPELE, the present secretary of the works department, has been recommended for the position of manager of that department.

Capt. ALBERT PETER MILLER, Glen Miller, Ont., 21st Battalion 2nd Division, A.M.Can.Soc.C.E., graduate Royal Military College, Kingston, has been awarded the Military Cross for bravery at the battle of St. Eloi. Capt. Miller was formerly resident engineer of the National Transcontinental Railway, Vermilion Bay, Ontario.

J. W. B. BLACKMAN, city engineer of New Westminster, B.C., has been awarded first prize by the Institute of Municipal and County Engineers for an article on the construction of the 25-inch water main which supplies water to New Westminster, and of the 13-inch submerged main leading to Richmond.

Col. G. S. MAUNSELL, Director-General, will shortly leave for overseas to take an important position in the Canadian Engineers at the front. It is understood that Lieut.-Col. A. P. DEROCHE will be Acting Director-General during the absence of Col. Maunsell. Lieut.-Col. Deroche has been in charge of the construction work of the engineering service since the war broke out.

Capt. FRANK P. ADAMS, of the 186th overseas battalion, who for several years has been city engineer of Chatham, Ont., was recently honored, on the occasion of his departure for the training camp at London, by the city councils of 1913-14-15-16, under whose direction he served. He was presented with a purse of gold, and members of the respective councils made brief addresses complimenting him upon the efficiency and courtesy which he had always shown and the very satisfactory service he had rendered the city.

OBITUARY.

Lieut.-Col. F. A. CREIGHTON, Mem.Can.Soc.C.E., has, according to a private message received in Winnipeg, died of wounds. He was City Engineer of Prince Albert before the war.

Company Sergeant-Major ARMSTRONG has been killed in the recent fighting. He was a graduate in science of McGill University. Prior to joining the forces he was on the engineering staff of the city of Montreal.

Col. HERBERT J. BOWMAN, M.Can.Soc.C.E., died June 19th at the Berlin, Ont., Hospital. Col. Bowman was a well-known consulting engineer, having handled many important works during the past thirty years. He was born in Berlin, Ont., June 18th, 1865. He graduated from S.P.S., Toronto, in 1885 and became assistant to P. S. Gibson, the engineer of York Township. In 1887 he qualified as provincial land surveyor for Ontario, and became transit man for the Berlin and Pacific Junction Railway. In 1888 he was engineer for Berlin on waterworks construction, and from the completion of the work to 1892 was superintendent of waterworks. He was then appointed town engineer, and for the following three years was engaged in the design and construction of a sewerage system under the direction of consulting engineers C. H. Rust and Willis Chipman. In September, 1896, he succeeded his father as clerk and treasurer of Waterloo County, and this position he held until death. About 1903 he carried out special survey work in Saskatchewan for the Dominion Government, and in 1908 he joined with A. W. Connor in the consulting engineering firm of Bowman & Connor. Among the work which Col. Bowman did as a member of this firm were waterworks systems for Hespeler, Preston, Fergus, Elmira, Chesley, Gravenhurst, Penetang, and other Ontario towns; the reconstruction of the Berlin waterworks, including the erection of one of the largest concrete water towers in the world; and bridges for Wellington, Waterloo, and other Ontario counties. While attending college, Col. Bowman became a member of the Queen's Own Rifles, and when he returned to Berlin he joined the 29th Regiment and was its commanding officer for some years. Upon the outbreak of the present war he organized the 108th Regiment in Berlin, and was its commanding officer at the time of death. He had been a member of the Berlin Water Commission for nearly twenty years, and was ex-president of the Waterloo County Canadian Club. He is survived by his wife, two daughters and two sons.