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WATER POWERS ON THE WINNIPEG RIVER

FROM A REPORT TO HIS HONOR, JUDGE H. A. ROBSON, PUBLIC UTILITIES COMMISSION, WINNIPEG, PREPARED BY THE WATER POWER BRANCH, DEPARTMENT OF THE INTERIOR; J. B. CHALLIES, B.A Sc., SUPERINTENDENT. J. T. JOHNSTON, HYDRAULIC ENGINEER

It has long been recognized that there is an enormous reserve of potential water power on the Winnipeg River within the province of Manitoba. The rapidity with which the existing developments on the river have been, and are being increased to their capacity, and

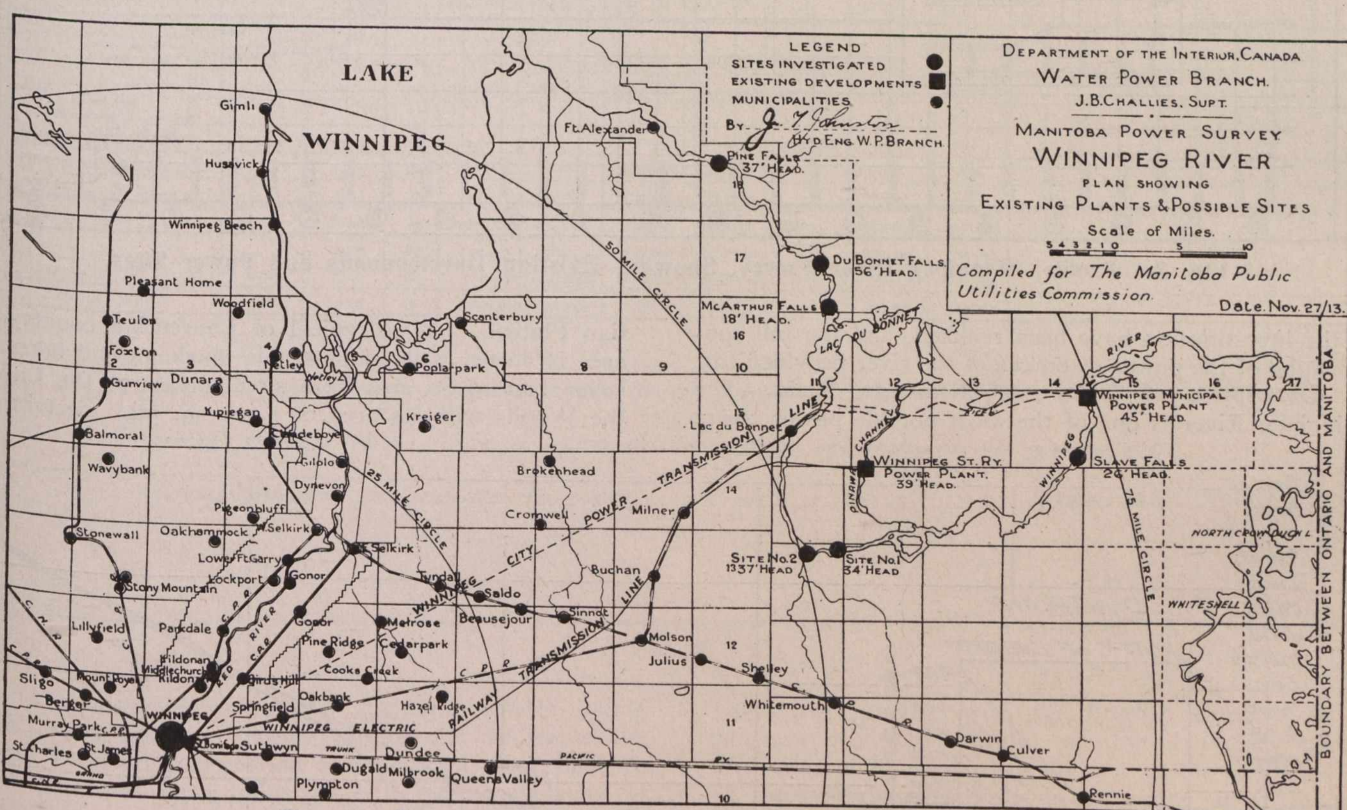


Fig. 1.—Existing Plants and Possible Sights Around Winnipeg.

the active interest that has been taken in the undeveloped power sites of the river, have compelled the Dominion Government to give the water power resources on this river careful and full consideration. Within the last few years there have been presented to the Dominion Government many applications for power privileges on this river; schemes have been proposed for the utilization of various portions of the natural fall, some contemplating the combination of several falls by the concentration of their respective drops at one power site, and others simply proposing the utilization of the drop at a particular fall. These have been so varied and so conflicting, and at the same time supported by such reputable engineering advice, that the government found it inadvisable to commit itself with respect to any further developments on the river until it had first caused to be made a complete survey and investigation of the whole river, with a view to securing such information as would enable the dictation of developments which would contemplate the maximum possible advantageous utilization of the water power resources of the river. These investigations were started early in the year 1911, under the consulting advice of Mr. J. B. McRae, C.E., of Ottawa, and the field work has proceeded vigorously to completion under charge of Mr. D. L. McLean. For the purpose of this report for the Public Utilities Commission, which had to be completed by December 15th, 1913, plans based on this field work have been rushed to completion, and a preliminary provisional estimate made by the engineers of the Water Power Branch, of the best method of concentrating the various separate falls of the river to enable all the natural fall to be utilized for power purposes, and at the same time have each unit development a component part of the comprehensive scheme for the whole river. These concentrations are indicated in plan and profile on Figs. 1 and 2. A study of this profile will illustrate the completeness with which the objects of the investigation have been realized, and the full conservation of the power resources of the river provided for.

Description of River and Drainage Basin.—The Winnipeg River is one of the most notable power rivers on the continent; it flows in a westerly direction connecting the Lake of the Woods with Lake Winnipeg. The basin drained comprises an immense area of some 55,000 sq. mi., lying at the westerly end of the Laurentian Plateau. As is typical of Laurentian country, the area is dotted with innumerable muskegs and lakes, the latter varying in size from small ponds to the Lake of the Woods with its area of 1,500 sq. mi. Certain gen-

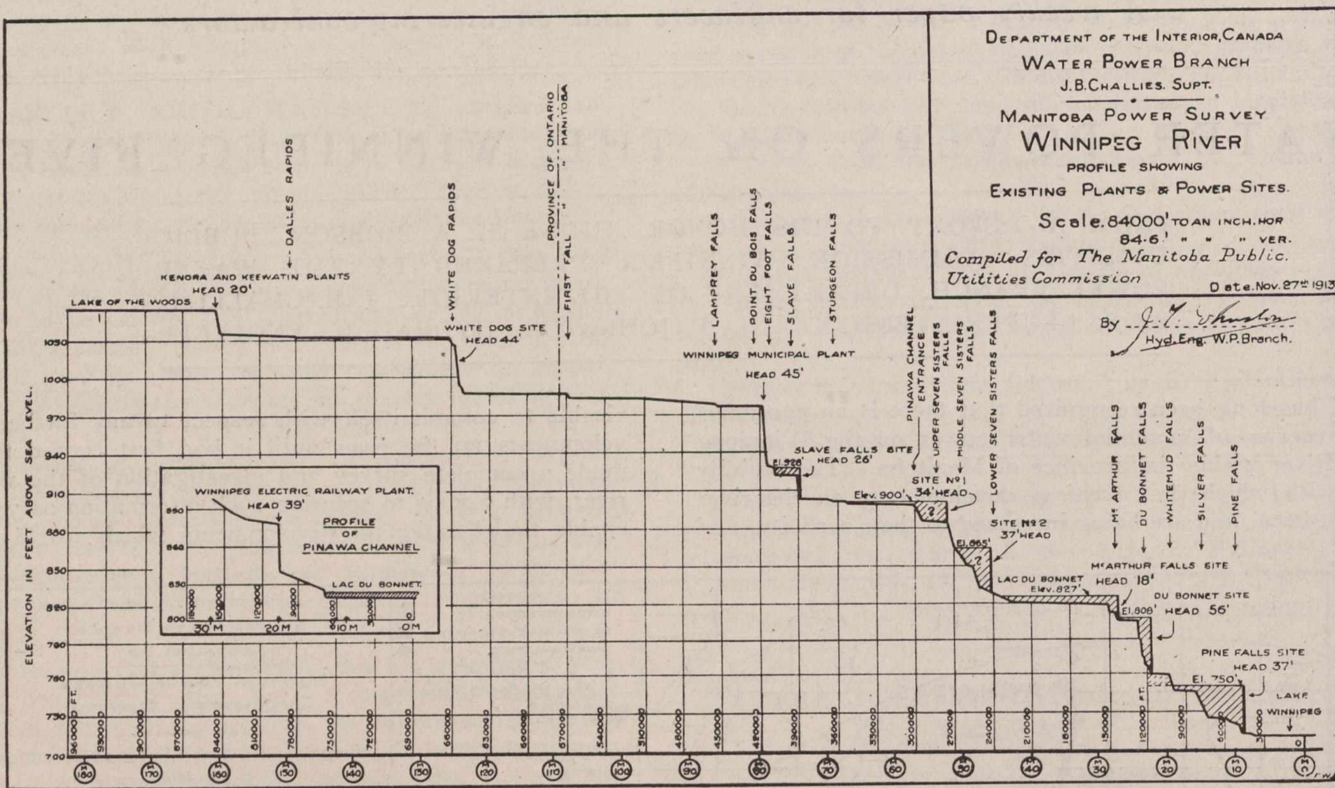


Fig. 2.—Profile, Winnipeg River Survey, Showing Existing Developments and Power Sites.

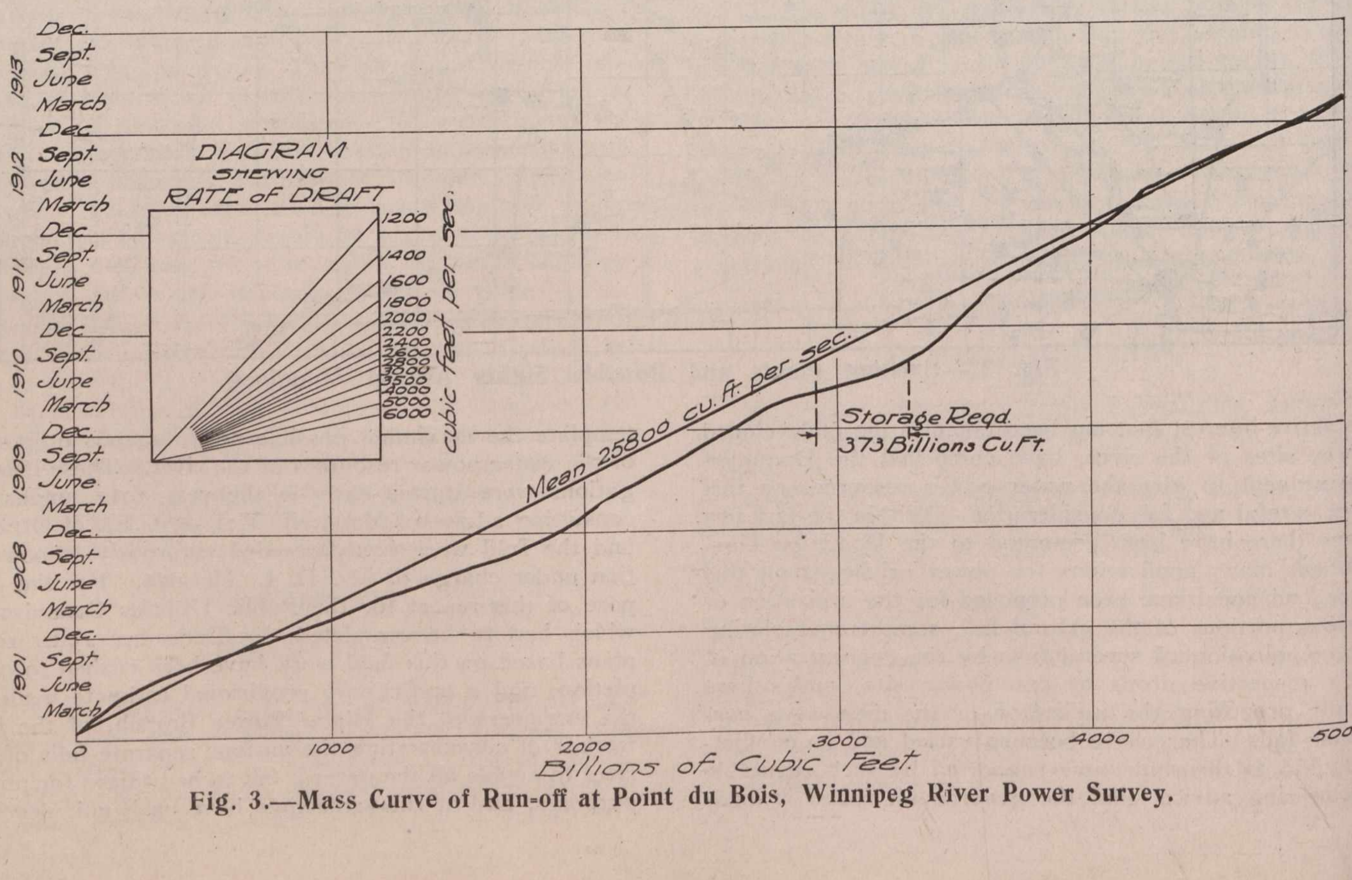


Fig. 3.—Mass Curve of Run-off at Point du Bois, Winnipeg River Power Survey.

eral characteristics apply to the drainage basin as a whole, since practically the entire area is of Laurentian formation with an overlying soil of glacial origin. The country is rough and hilly with large areas of rock outcrop. This latter feature applies in the main throughout the Winnipeg River, and lends itself to a characteristic formation throughout the river channel, which is of exceptional value in the interests of power development. The larger proportion of the river bed in the province of Manitoba, consists of a series of deep cup-like basins, forming small lake-like expanses with little or no current. The river flow finds its way from these basins by falls and rapids over the rock formation which is always in evidence at the outlets, and which forms at once the means of egress from, and the controlling feature of, the basin water level. These falls form the natural power sites along the river.

and finally discharging into Rainy Lake. These upper waters in the main constitute a portion of the International Boundary. Many streams heading in upper lakes and muskegs also contribute to the flow from Rainy Lake. This latter has a surface of 330 sq. mi., and a drainage area of some 14,600 sq. mi. Rainy River, which is the outlet, discharges into the Lake of the Woods. From this latter lake to Lake Winnipeg, the river is known as the Winnipeg. Forty miles down the river from the Lake of the Woods, the flow of the English River enters that of the Winnipeg. This tributary is of almost as large dimensions as the river into which it flows, as it drains an area of 22,000 sq. mi., while the Winnipeg at the Lake of the Woods outlets, has a drainage area of 25,000 sq. mi. From the Lake of the Woods to Lake Winnipeg, there is a total drop of 341 ft., and of this a 70-ft. drop takes place above and a 271-ft. drop

TABLE OF DEVELOPED & UNDEVELOPED POWER ON THE WINNIPEG RIVER.

PLANT OR SITE	HEAD WATER ELEVATION.	TAIL WATER ELEVATION.	HEAD.	TURBINE CAPACITY AT FULL GATE AT GOV. PROPOSALS		HP @ 75% EFF. ON A 24 HR BASIS		H.P. DEVELOPED	CAPITAL COST PER H.P. ON Switchboard.		REMARKS.
				12000 SEC. FT	20000 SEC. FT.	12000 SEC. FT.	20000 SEC. FT.		12000 SEC. FT.	20000 SEC FT.	
WINNIPEG MUNICIPAL PLANT	975.7	930.7	45	—	—	46100	76800	20800	—	—	
SLAVE FALLS SITE	928	902	26	40000	65000	26600	44400	—	$93.45	$83.30	
WINNIPEG ELECTRIC RAILWAY Co PLANT	879.4	840.4	39	—	—	—	—	26500	—	—	
1ST SITE SEVEN SISTERS.	—	—	34	—	—	11.600	34800	—	—	—	
2ND SITE SEVEN SISTERS.	—	—	37	—	—	12600	37900	—	—	—	
McARTHUR SITE.	827.	809	18	27500	42500	18400	30700	—	12300	97.50	
		762	46	70000	120000	47100	78700	—	7940	68.90	
DU BONNET SITE	808	752	56	—	140000	57300	95500	—	—	70.70	
PINE SITE	750	713	37	55000	96000	37900	63100	—	8030	70.70	

TOTAL POWER WITH UNREGULATED RIVER (12,000 SEC FT MIN FLOW) — 237,000. H.P.

TOTAL POWER WITH REGULATED RIVER 20,000 SEC FT. REG. FLOW) — 409,700. H.P.

TOTAL POWER DEVELOPED TO DATE...47,300 H.P.

Ottawa Ont Dec 12th 1913. F.H.B.

Fig. 4.

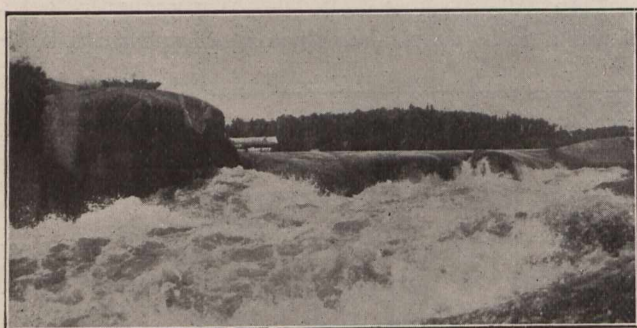
A valuable timber growth including spruce, tamarack, birch and pine, occurs throughout the whole district. Lumbering is carried on extensively, and in addition, pulp and paper industries have been established at Fort Frances and Dryden. Notwithstanding the great extent of rock outcrop, considerable area is available for farming, this applying more especially to the Whitemouth and Rainy River districts. While there are several prosperous towns such as Fort Frances, Rainy River and Kenora in the basin, yet the greater portion of the country has not been settled and is still in the state of nature.

The upper watershed reaches to the height of land separating the Atlantic drainage from that of Hudson Bay into which the waters of the Winnipeg River eventually flow. North Lake, which is situated on the International Boundary, some 45 miles west of Lake Superior, is the headwater of the drainage basin. From North Lake the stream flows westward, passing through many small lakes, collecting the flow of numerous tributaries

below the junction with the English River. As this junction occurs practically at the boundary between Ontario and Manitoba, it follows that the combined flow of the two rivers and the greater drop as noted above are available for power purposes in Manitoba. Of this head a considerable portion is already being utilized by existing developments on the river.

Flow Records.—Estimates of the daily flow of the Winnipeg River have been compiled by the Manitoba Hydrographic Survey, based on discharge measurements secured by them, together with results of measurements supplied by Col. Ruttan, D. A. Ross, and the City of Winnipeg power engineers. These estimated discharges are referred to the flow of the river at Point du Bois and extend over a period of six years. For this period a maximum flow of 53,400 sec.-ft. and a minimum flow of 11,700 sec.-ft. have been recorded. The high-water marks along the shore would indicate that floods of 100,000 sec.-ft. have occurred in the past. Such floods must, however, take place at rare intervals.

Storage on the Upper Waters.—The question of storage on the upper waters of the Winnipeg River is at present somewhat involved, in that the regulation of the Lake of the Woods has become an international question and is now before the International Joint Commission. Considering that the lake has a tributary drainage area of 25,000 sq. mi., and a surface area of 1,500 sq. mi., offering unexcelled storage facilities, it is of vital importance to the powers of the Winnipeg River, that storage should be had on this lake. Partial regulation of the drainage tributary to Rainy Lake is now controlled on Rainy Lake by the dam of the Ontario and Minnesota Power Company at Fort Frances.



Second of the Seven Sisters Falls Sites, Winnipeg River.

By the establishment of storage reservoirs on the English River, the flow of the latter can be regulated; and in conjunction with storage on the Lake of the Woods drainage basin, practically a complete regulation of the flow of the Winnipeg River in Manitoba can be attained.

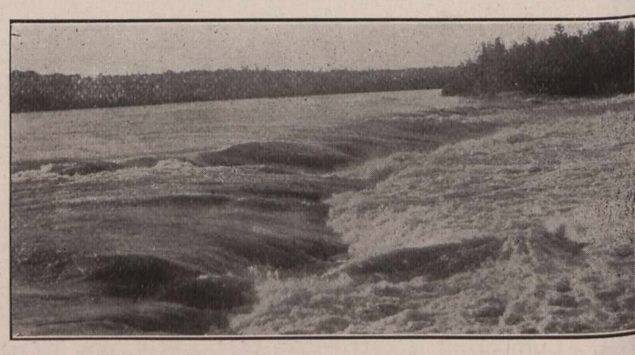
During the period of the last six years, over which records of the flow of the Winnipeg River extend, a minimum flow of 11,700 sec.-ft. has been recorded, as stated above, while the maximum flow in the same period is 53,400 sec.-ft., a range of only 1 to 4, which is illustrative of the extremely low fluctuation under practically natural conditions. Yet, by an adequate system of storage this flow can be so regulated that the minimum flow will be increased from about 12,000 sec.-ft. to some 20,000 sec.-ft. In Fig. 3 is shown a mass curve of the flow of the river at Point du Bois for the period from January 23rd, 1906, to December 31st, 1912. For this period a storage of 373 billion cu. ft. would have been necessary for a complete regulation.

Existing Power Plants.—(a) Winnipeg Electric Railway Co.—The Winnipeg Electric Railway Company's development is situated some sixty miles from Winnipeg on the Pinawa or Lee Channel. This channel was not the main river bed, but was an old high-water channel, of some 25 miles length which has been improved and is being further enlarged. The water for the plant is turned into the Pinawa Channel by three diversion dams, the main of which consists of 1,332 ft. of concrete capped rock fill across the main channel, connected with the banks on either side by concrete spillways bringing the total length to 1,650 feet. Two small weirs of timber crib type span secondary channels. The water thus diverted flows down the improved canal to a central dam which is capable of shutting off the flow and returning a portion or all of it to the main river over the waste or diversion weir. From this point the water flows through the tortuous bed of the old high-water channel, the same having been deepened and partially strengthened by excavation. This waterway, while at present capable of carrying in summer some 10,000 sec.-ft., is only able in winter, on account of the ice, to deliver about two-thirds of this amount. Below the power house the tail-race has been improved by much dredging and excavation. The power house is situated at a bend in the river where a concrete dam with arched spillway creates a thirty-nine-foot head. These headworks are equipped with debris boom, ice-run, spillway, trash-ranks and head gates. The electrical units of this plant consist of five 1,000-kw. and four 2,000-kw. revolving field, 60-cycle, two 300-volt, 3-phase generators, together with two 125-kw., 125-volt d.c. exciters. The generators are capable of carrying a 50% overload, giving in all a total output of 19,500 kw. or 26,140 h.p. While 19,500 kw. are available at this plant for peak loads, an additional 9,000 can be obtained from an auxiliary steam turbine station at Winnipeg operated by the company. The electric energy is transmitted to the City of Winnipeg at 60,000 volts over a 65-mi. transmission line.

(b) City of Winnipeg Municipal Plant.—The muninipal power development of the City of Winnipeg is situated some 77 mi. northeast from Winnipeg at Point du Bois on the Winnipeg River. This plant consists essentially of a large concrete power station, with retaining walls and spillways, forming the forebay, the entrance to which is controlled by a stop-log sluiceway type of headgate. Two concrete weirs or spill dams control the elevation of the headwaters, and together with a rock-fill dam divert the water to the forebay for use at the power house.

This power concentration has created a head varying from 44 to 48 ft., with a pondage of 7 sq. mi. above the plant. This pondage is a great asset during periods of peak loads.

The development is designed for an ultimate installation of 16 units, each consisting of two-runner high



Main Drop of Second McArthur Falls, Winnipeg River.

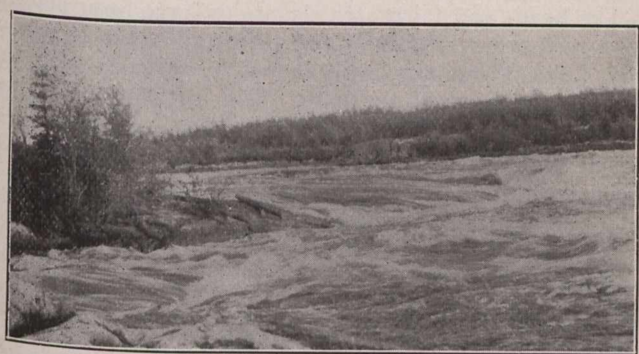
specific speed turbines rated at 5,200 h.p. for 46-ft. head and a 3-phase 3,000-kw. generator. The first installation would give 48,000 kw., with turbines of a maximum capacity of 83,200 h.p. As each turbine unit requires 1,250 sec.-ft. under maximum output at a net head of 45 ft. and running at 164 r.p.m., the total water required would be 20,000 sec.-ft., plus the water for the two small extra units.

The present installation consists of 5 generators of 3,000 kw. each and two exciters of 250 kw. each, making a total of 15,500 kw., and at maximum load requires 7,800 sec.-ft.

The electric energy is transmitted to the City of Winnipeg at 66,000 volts over a 77-mile transmission line, built on a municipally owned 100-ft. right-of way.

The conductors are of aluminum, supported on steel towers throughout. A duplicate line is now under consideration.

Basis of Discussion on Government Power Proposals.—The cost estimate for the government power proposals on the Winnipeg River refer in all cases to the capital cost of installation and are based on both an initial and final development. The initial development is designed to utilize at each site the present minimum flow of the river, i.e., 12,000 sec.-ft., or such portion of it as may be available at the particular site in question. The final development is designed to utilize at each site,



Main Drop of Pine Falls, Winnipeg River.

a regulated flow of 20,000 sec.-ft., or such portion of it as may be available at the site. After the diversion of sufficient water in the Pinawa Channel to operate the plant of the Winnipeg Electric Railway Company under normal peak load conditions, there would remain for use at Seven Sisters in the main river about 4,000 and 12,000 sec.-ft. under unregulated and regulated conditions of the river respectively. It is important to note that it is on this basis that the available power at the Seven Sisters sites is discussed.

In order that the power sites could be compared on a rational and equitable basis, all the layouts and designs have been standardized in so far as possible, giving full consideration to the varying heads, and to the local physical conditions at each individual site. No allowance has been made in the estimate for transmission, the costs being in all cases the capital cost for power on the switchboard in the power house, and the power being considered as straight 24-hour power at 75% efficiency, based on the flow. This forms a very conservative basis. Transmission costs are omitted from the estimates as it is impossible to foretell the use to which the power at the various sites may be applied when developed, and a straight comparison of the sites as they stand is desired. The costs given herewith may be slightly altered upon final revision.

In all cases the dams are designed in solid concrete, with ample discharging capacity to pass the severest floods to be anticipated. The power stations have been developed on single-runner vertical turbine installations, varied for the different heads and to meet local conditions.

A continuous profile of the river to sea level datum was run at the beginning of the field work, and forms the groundwork upon which the whole survey was developed. Recognition of the future needs of navigation has been given and provision in the permanent work for the accommodation, if necessary, of future lockage facilities at the different sites has been made.

Government Power Proposals.—(a) Slave Falls Site.—The proposed development at Slave Falls concentrates a head of 26 ft. formed by the combination of the Slave and Eight Foot Falls. The dam runs along the crest of the falls and curving downstream through an arc of about 90°, connects with the power station on the right bank of the river. Provision has been made for the future installation of a lock on the left bank.

The head and tail water elevations as at present proposed, are 928 and 902 respectively. The initial installation on which the estimate is made provides for eight 5,000-h.p. turbines, sufficient to provide for a flow of 12,000 sec.-ft. at 8/10 gate, with a spare machine for emergencies. On a 75% efficiency, 24-hour basis, 26,600 h.p. will be available at a capital cost of $93.45 per h.p. at the switchboard. The final installation provides thirteen 5,000-h.p. turbines, sufficient for a flow of 20,000 sec.-ft. at 8/10 gate with a spare machine. On a 75% efficiency, 24-hour basis, 44,400 h.p. will be available at a cost of $83.30 per h.p. at the switchboard.

(b) Seven Sisters Sites.—No detail work has as yet been possible covering the best method of development of this reach of the river. However, it is considered that it can ultimately be developed at two sites of about 34 and 37 ft. head respectively. After providing sufficient water for the plant of the Winnipeg Electric Railway Company on the Pinawa Channel, it is doubtful whether any development of the Seven Sisters Falls will be feasible until the flow of the river can be regulated to at least 20,000 sec.-ft., by means of storage in the upper waters. The power available at the 34-ft. site, under unregulated conditions, is about 11,600 h.p. and under regulated conditions, 34,800 h.p. Similarly the 37-ft. site will render available 12,600 h.p. and 30,700 h.p. respectively.

(c) McArthur Site.—At the lower of the two McArthur Falls, a head of 18 ft. awaits development. The river is here divided into two channels by a large island. The

Silver Falls, Winnipeg River.

general layout consists of a solid concrete spillway along the crest of the fall on the right or main channel, and a long spillway and embankment, including sluiceway provision, running diagonally across the island, and connecting with the power station spanning the left channel. Provision is made on the island for the future construction of a lock.

The head water elevation is at present fixed at 827, i.e., about one foot above the recorded highest water level of Lac du Bonnet. The tail-water is proposed at 809, giving a head of 18 ft.

The initial installation provides for eleven 2,500-h.p. turbines, sufficient to provide for 12,000 sec.-ft. at 8/10 gate, with a spare machine for emergency. On a 75% efficiency, 24-hr. basis, 18,400 h.p. will be available at a capital cost of $123 per h.p. at the switchboard. The final installation provides for seventeen 2,500-h.p. units on a basis of a 20,000 sec.-ft. flow, and 75% efficiency, 24-hr. power, i.e., of 30,700 h.p. The cost per h.p. on the switchboard is $97.50. This site can be given a much more favorable aspect, when the local storage available in Lac du Bonnet (whose 32 square miles form the head-waters) is taken into consideration.

(d) Du Bonnet Site.—The proposed scheme of development at the Du Bonnet Falls will ultimately concentrate there a head of 56 ft., made up of the Grand and Little du Bonnet Falls, and the Whitemud Falls. The latter will be added by blasting out the rock bridge over which the present fall takes place. The dam, consisting of embankment, spillway and sluiceway sections, leaves the left bank and crosses the river on the brink of the Little du Bonnet Falls, connecting with the power station which parallels the right shore line below the pitch. Ice sluices and embankment connect the power station with the high land on the right bank. Provision is made for future lockage facilities on this bank.

The head-water elevation has been fixed at 808, with the tail-water at 762 previous to the blasting out of the Whitemud Falls, and 752 subsequent thereto. This secures a head of 46 ft. for the preliminary, and 56 ft. for the final installation.

The initial installation is figured on seven 10,000-h.p. turbine units, utilizing 12,000 sec.-ft. at 8/10 gate and 46-ft. head. This, on the same basis as set out above, will render available 47,100 h.p. at a capital cost of $79.40 per h.p. at the switchboard. An intermediate installation, comprising 12 units and providing capacity for 20,000 sec.-ft. at 46-ft. head, and producing 78,700 h.p., has also been estimated. The cost of the power at the switchboard for this intermediate installation is $68.90 per h.p. The final installation consists of fourteen 10,000-h.p. units, for the development of 20,000 sec.-ft. at 56-ft. head, the extra 10 ft. being secured by the removal of the Whitemud Falls. On the same basis as set out above, 95,500 24-hr. h.p. will be available at a cost of $70.70 per h.p. on the switchboard.

(e) Pine Falls Site.—The Pine Falls development will concentrate the natural drop of the Pine and Silver Falls, giving a head of 37 ft. The dam runs diagonally across the river from the right bank, and joins directly to the power station, which forms a continuation of the dam. The power station is connected with the high ground on the left bank, by sluices and embankment. Provision is made for lockage facilities on this bank.

The head- and tail-water elevations have been placed at 750 and 713 respectively. As the tail-water is practically Lake Winnipeg level, it will vary from year to year with the level of the lake. The installation in the power station has not been finally determined, but the following estimates of the capital cost of the power are considered to be fairly close. The initial installation will provide for the development of 12,000 sec.-ft. at 37-ft. head, i.e., 37,900 h.p. on the 75% efficiency, 24-hr. basis, at a cost of $80.30 per h.p. on the switchboard. The final installation provides for 20,000 sec.-ft., and renders available, on the above basis, 63,100 h.p. at a cost of $70.70 per h.p. on the switchboard.

Diagrams Showing the Developed and Undeveloped Powers at the Various Sites on the Winnipeg River. (Undeveloped Sites Considered at 75% Efficiency with 24-hour Power.)

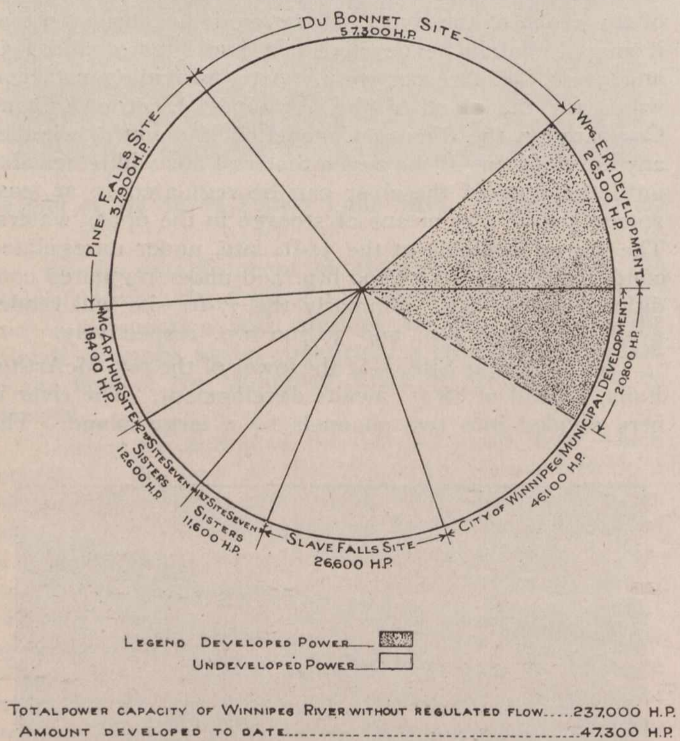


Fig. 5.—Based on the Unregulated Flow of 12,000 Sec.-ft.

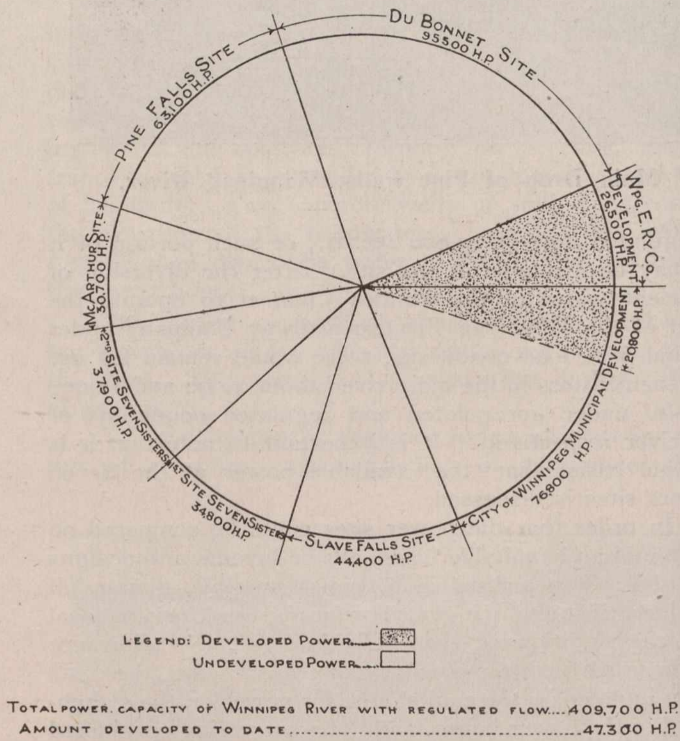


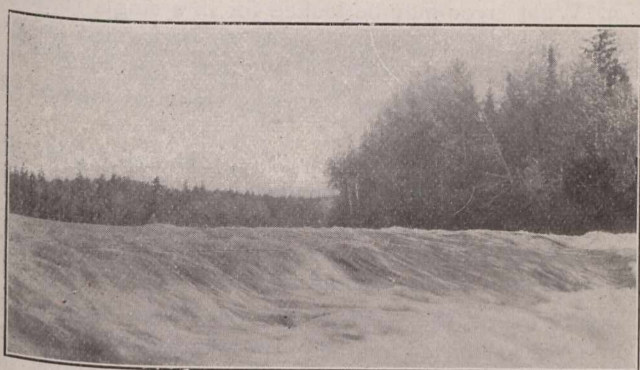
Fig. 6.—Based on a Regulated Flow of 20,000 Sec.-ft.

Summary of the Power Possibilities of the Winnipeg River.—Fig. 4 is a tabulation of the powers, developed and undeveloped, of the Winnipeg River, under regulated and unregulated conditions. The undeveloped power is considered on a 75% efficiency, 24-hr. basis, and the capital cost per h.p. is given in terms of this power, estimated to the switchboard in the power house.

Attention is called to the circular diagrams on Figs. 5 and 6 as illustrating, in a graphical manner, the developed and undeveloped power conditions along the river under unregulated and regulated river flow.

Future Economic Value of the Winnipeg River Powers.—With regard to the future economic value of the powers of the Winnipeg River, a report was made to the Department of the Interior in September, 1911, by Mr. J. R. Freeman, one of the consulting engineers retained by the Department for advice in connection with water power matters. Mr. Freeman says:—

"**Economy and Conservation.**—While water power opportunities on the Winnipeg River may have a very few years ago appeared so far beyond possible use that ordinary economics were unnecessary, it is, I believe, plain to-day beyond serious question that all of the remaining opportunities for power should be carefully conserved and only developed under such conditions as will not necessitate any great waste or the impairment of remaining opportunities.



Second Pitch of Grand du Bonnet Falls, Winnipeg River.

"Sundry remarkable electro-chemical processes have been very recently invented, which promise to be of great future benefit to agriculture and other arts. Fertilizer for farmers' use is now being successfully made by electricity from the nitrogen of the air, and great water powers in Norway are now being developed for these purposes in addition to those already in use, and recent developments have also been made of similar processes not far from the southern boundary of Canada.

"The great uses of hydro-electric power at Niagara Falls and at the Sault, for making aluminum, carbide for gas lighting, bleaching powders, and caustic soda and sundry other important products, were unknown only a few years ago. Indeed, it may be said that every one of the electro-chemical processes now located at Niagara Falls has been invented since the first of the large hydro-electric power stations was built at that point. It is idle to say that the era of important electro-chemical invention is yet more than begun and with the many able investigators now earnestly working on these lines in many parts of the world, great additional discoveries and commercial developments in the application of cheap electric power are almost sure to come, particularly in metallurgy or the reduction of ores.

"**The Winnipeg Market Now Fully Supplied.**—The City of Winnipeg will soon have all the power that it needs for public service corporation and for any conceivable manufacturing purposes likely to locate in or near the city for perhaps a score of years to come, from the railway company's plant already in use and to-day understood to be delivering about 22,000 horse-power and from the new municipal hydro-electric power plant at Point du Bois, now nearing completion, with a first installation of 26,000 horse-power and with works planned to be extended to more than three times that capacity.

"Thus these two plants will be capable of delivering to Winnipeg more than 100,000 h.p. of 24-hour electrical energy, a quantity which can be best appreciated by a statement that it is far greater than the total water power at Lowell, Lawrence, Manchester and Holyoke combined.

"**A Possible Field for Use.**—The best use that I can foresee for the vast water powers now remaining untouched upon the Winnipeg River is as the basis for founding three or four new industrial cities based upon electro-chemical industry, very much as water power was the basis for creating, years ago, the cities of Lowell, Lawrence, Manchester, Holyoke, Bellowa Falls, and as in recent years it has brought together hundreds of new homes at Niagara Falls, Shawinigan Falls and at the Sault.

"We cannot to-day say what the line of manufacture may be, for the electro-chemical arts are still in a state of ferment and creation. It has already been demonstrated that by electric smelting, steel for the manufacture of tools can be made having a quality and value difficult to obtain otherwise. Fertilizer in the form of artificial saltpetre is being produced commercially in large quantities under German processes, while carbide, carborundum, aluminum and numerous other useful products are being made by electro-chemical means in great quantity at Niagara and elsewhere, and sooner or later the time will come when fertilizer will not be scorned by the farmers of the Canadian Northwest. There is promise of new metallurgical processes for which cheap electricity is a necessity and the price per pound of several of these products is such that they could stand a considerable cost of freighting to their markets and such that a power capable of being developed in so vast quantity at one point and at so low a cost per horse-power as appears practicable at three of the sites along the Winnipeg River, will surely be very attractive.

"**These New Industries Must Locate Close to the Water Fall.**—These electro-chemical processes, when carried on in the large commercial way, demand that the work be done close to the point where the power is generated, for two reasons: First, because although the air-saltpetre process uses alternating current at low voltage which cannot be transmitted to great distance with anything like the facility of alternating current; and second, because in order to attract these processes it is necessary that the cost per horse-power be the very lowest and not overloaded by the cost of long transmission lines or the percentage of power necessarily lost in such transmission.

"Wherever a new industrial centre with some hundred of homes can be established in the wilderness within a hundred miles of Winnipeg, it will add to Winnipeg's prosperity in a degree but little less than if located within its borders and will add to the prosperity of the province by the new opportunities that it brings for employment, the diversity that it adds to its business interests and by the money that it will put into circulation. It is plain that many of the recent power developments made in various parts of America, from which the power is transmitted long distances, to displace steam power in populous centres results in putting a much larger number of men out of work than it sets at work. Such a development is of less benefit to the country than the early water power developments which were used locally in erecting the cities already named, in building hundreds of new homes and in setting thousands of men working at new opportunities."

THE SIEVING OF CEMENT.

THE determination of the degree of fineness of a sample of cement, usually a part of the specification and contract upon which the material is purchased, is an operation where accuracy of the results is often in dispute. The U.S. Bureau of Standards has recently carried out tests to ascertain what order of discrepancy may be expected when made by the standard routine method of sieving. A paper by Rudolph J. Wig and J. C. Pearson, just published by the Bureau, gives the following conclusions as conservative estimates deduced from the results of these tests:

1. Employing the present standard method of sieving, the greatest attainable accuracy in single fineness determinations of normal Portland cement on a standard No. 200 sieve, that is, the greatest attainable accuracy in checking uniformity of samples, is about 0.2 per cent.

2. "Standard" No. 200 sieves may differ in their sieving values by considerable amounts, such that their corrections to the ideal No. 200 sieve may be at least as great as 0.7 per cent.

3. Errors of at least 0.5 per cent. may be looked for in single fineness determinations of normal cements on a standard No. 200 sieve when made in the usual routine manner.

4. Deviations exist in the sieving values of "standard" No. 100 sieves, of a magnitude, roughly, one-half the corresponding values for No. 200 sieves as given above.

5. "Personal equation" appears to be appreciable in hand sieving, as in most laboratory operations, the observed values being as great as 0.3 per cent.

6. The rating of a sieve by some system of demerits assigned from direct measurements appears to be an interesting possibility, and worthy of further study. Should a system be worked out to give reliable indications, say, within 0.2 per cent. or 0.3 per cent. of the observed sieving value of a sieve, it will add greatly to the value of the certificate now furnished with standard sieves.

It seems evident that both sieving tests and the interpretation of measurements on sieves are subject to considerable discrepancies, and the question arises as to whether some other more reliable method of determining fineness can not be made available. The sieve at best is a measure of the coarseness of finely ground material rather than the fineness, and experiments now in progress at the Bureau of Standards indicate that air separation will offer a more satisfactory means of determining fineness than mechanical sieving.

It may be stated that a tolerance of 1 per cent. from the specification should be allowed with the No. 200 sieve and 0.5 per cent. from the specification with the No. 100 sieve, every care being taken to conduct the test in strict accordance with standard methods. These tolerances should be considered as minimum values since they are based upon the results obtained by careful and experienced observers; therefore it should be emphasized that greater differences are possible in ordinary routine testing.

Scope of the Tests.—Discrepancies in determinations of fineness may be attributed to: (*a*) Differences in the standard sieves; (*b*) the "personal equation" of the observer; (*c*) lack of uniformity in the samples; (*d*) the residual differences when the three foregoing sources of error are, as far as possible, eliminated.

Considering the last mentioned first, it is evident that the experienced and careful worker, using a high-grade sieve and sieving samples of a well-dried and thoroughly mixed cement according to a fixed program, can by repeated trials determine a maximum limit of tolerance for residual differences. When this has been established, the same observer is in a position to check uniformity of samples of other cements—that is, he may check their uniformity only with an accuracy not greater than his own maximum limit of tolerance. There is at present, so far as we know, no simpler method of detecting lack of uniformity in finely ground material.

Following the results reported below, an attempt has been made to establish:—

1. What variations in fineness determinations are permissible under the most favorable conditions.

2. What variations may arise from differences in the "standard" sieves themselves.

3. What error may be looked for in a single fineness determination on a standard sieve as performed by an ordinary laboratory worker of average experience.

4. Whether variations from the standard method of sieving are appreciable.

5. Whether "personal equation" is appreciable in the limited number of tests made.

6. Whether an arbitrary system of "demerits" determined from careful measurements of a sieve is a reliable indication of its sieving value.

Features of the Tests.—The tests were made on a lot of sieves submitted for the purpose by two well-known firms. Four men made independent determinations of fineness on 24 of the sieves, while two men made the majority of determinations on the remaining sieves. The cement used was a good brand of normal grade Portland, which was first thoroughly dried, screened through a No. 20 sieve, and finally mixed by long-continued rolling on a large sheet of stout manilla wrapping paper. The determinations were made according to the standard method of sieving described in the United States Government Specification for Portland Cement, as follows:

The determination of fineness should be made on a 50-gram sample, which may be dried at a temperature of 100° C. (212° F.) prior to sifting. The coarsely screened sample (cement is ordinarily screened through a No. 20 sieve before mixing for routine tests) should be weighed and placed on the No. 200 sieve, which, with the pan and cover attached, should be held in one hand in a slightly inclined position and moved forward and backward in the plane of inclination, at the same time striking the side gently about two hundred times per minute against the palm of the other hand on the upstroke. The operation is to be continued until not more than 0.05 grams will pass through in one minute.

While the experienced worker always develops some peculiarity in his method of sifting, which contributes to or determines his "personal equation," undoubtedly the chief factor to be guarded against is carelessness. This factor may explain to some extent the rather wide variations observed, but it may be safely assumed that the sum total of carelessness on the part of those who participated in the tests is less, rather than greater, than that made in normal routine work, and it is believed that the average results represent what may be expected from experienced routine workers in similar laboratories.

In the following tables the observers are designated by letters and the sieves by numbers:

Table I.—Results of Sieving Tests Made by Four Observers on 12 Standard No. 200 Sieves.

Sieve.	Observers. A	B	C	D	E	Average.	Max. var. from average
1	80.30	79.72	80.40	80.24	.....	80.16	0.44
2	79.88	80.66	80.20	80.46	.....	80.30	.42
3	79.78	80.44	80.44 80.44	.....	80.51	80.32	.54
4	80.62	80.00	80.44	80.76	.....	80.46	.46
5	80.50	80.72	80.18	80.56	.....	80.49	.31
6	80.24	80.84	80.66	80.36	.....	80.52	.32
7	80.40	80.57	80.44	80.80	.....	80.55	.25
8	80.30	80.82	80.26	81.14	.....	80.63	.51
9	80.34	80.90	80.72	81.04	.....	80.75	.41
10	80.56	80.76	80.90	81.50	.....	80.93	.57
11	80.42	80.40	81.36	81.60	.....	80.94	.66
12	81.04	81.00	80.76	81.34	.....	81.03	.31
Average.	80.36	80.57	80.55	80.89	.....	80.59	.43
Personal equation.	+.23	+.02	+.04	—.29	.....	.....	...

Table II.—Results of Sieving Tests Made by One Observer on One Standard Sieve Using Five Different Methods.

Trial	1 (200 strokes)	2 (250 strokes)	3 (150 strokes)	4 (Single washer)	5 (6 steel balls)
1	80.30	80.06	80.44	79.76	80.36
2	80.44	80.08	80.36	79.46	79.98
3	80.16	80.02	80.24	80.08	80.18
Average....	80.30	80.05	80.35	79.77	80.17

Table I. shows the results obtained by four observers using the same cement on 12 standard No. 200 sieves. The figures are percentages of total cement passing the sieves.

An approximate value of the range that may be expected due to differences in the sieves may be obtained from the averages for each sieve, which are taken as the most probable sieving values. The highest is seen to be 81.03 per cent., the lowest 80.16 per cent., range 0.87 per cent. A "standard" sieve according to these results, may therefore differ from the mean value of a number of good sieves by nearly 0.5 per cent. It is to be borne in mind, however, that the mean value of a number of good sieves will generally be greater than the amount passed by an ideal No. 200 sieve, since the prescribed limits of tolerance allow greater latitude below 200 meshes than above. Thus, careful measurements of cloth on sieve No. 1 showed this to be the nearest of the lot to the ideal No. 200 sieve, and repeated fineness determinations with this sieve showed that its most probable sieving value was about 80.30 per cent., which is 0.3 per cent. less than the observed average value for all the sieves. It follows, therefore, that a "standard" sieve may have a true correction to the ideal sieve of as much as 0.7 per cent.

The last column of Table I. shows that the error to be looked for in a single fineness determination is likely to be at least 0.5 per cent., a figure which will, of course, vary with the reliability of the observer. A search through Table I, however, will show that all the observers have missed the average value on one or more sieves by more than 0.4 per cent.

A roughly approximate value of personal equation may be obtained by averaging all the determinations made by each observer and comparing this with the mean value of all observers. The values are given in the last line of Table I. The number of observers is too small to establish this factor with any certainty, but for observers A and D, whose averages show appreciable deviations from the others, it may be noted that 8 times out of 12 A's value is less than the mean value for the sieves, and 8 times out of 12 D's value is greater than the mean value for the sieves.

Table 2 represents the results obtained by a single observer on sieve No. 1, using five slightly varying methods of sieving, each method being given three careful trials. These methods include the deviations from the standard method of sieving which are sometimes permitted in fineness determinations. Col. 1 contains the results obtained by moving the sieve back and forth 200 times per minute, that is, according to the standard specifications. Col. 2 contains the results obtained from sieving at the rate of 250 strokes per minute, this rate requiring, of course, short quick strokes. Similarly Col. 3 contains the results obtained by sieving at the rate of 150 strokes per min., the strokes being relatively long and slow. Col. 4 contains the results obtained by sieving according to standard specifications, using, however, a single brass washer about ¾ in. in diam. to aid in breaking up the small lumps of fine material. Col. 5 shows the effect of using six 3/16-in. steel balls in place of the washer.

While the determinations are too few in number to show decided differences, the order in which the results actually occur is interesting. From the lowest to the highest amounts passing the sieve, the order is as follows:—

1. Sieving with a washer on the sieve.
2. Sieving with steel balls on the sieve.
3. Sieving at 250 strokes per min.
4. Sieving at 200 strokes per min.
5. Sieving at 150 strokes per min.

Thus the trials indicate that the simplest and easiest method—that is, sieving at the moderate rate of about 150 strokes per minute—gives the maximum percentage of cement passing the sieve. The somewhat erratic results obtained by the use of the washer and the balls, which might have been anticipated to give the highest values, are seen to be the lowest; and the variations are to be accounted for by the uncertainty of the stopping point. The use of washer and balls seems to increase the irregularity of the amounts obtained in successive minutes toward the end of the sieving, so that one may naturally stop somewhat earlier than he would if the amounts were decreasing regularly. It is evident, of course, that for every minute over or under sieving, the error introduced is approximately 0.1 per cent. On this basis the maximum limit of tolerance for the best work can hardly be less than 0.2 per cent., since the most careful observer may readily be one minute short or one minute over.

The fact that appreciably more cement passes the sieve at 150 strokes per minute than at 250 strokes per minute is no doubt due to the more rapid horizontal motion of the sieve in the latter case, whereby particles just under the smallest size retained have less opportunity to fall through the sieve openings than when the sieve is moving at the slower rate.

In all sieving tests it is tacitly assumed that the specifications need not be closely followed until the greater part of the fine material has already been sieved through, that is, the final result is assumed to be independent of the manner in which the first part of the sieving has been performed. This is no doubt justified in hand sieving when no washers or balls are used to hasten the process, but one may well question the assumption when vigorous methods are used, as in most routine work. In all trials reported in Table 2, the specifications were followed throughout the entire time of sieving.

It may, of course, be possible to form an estimate of the relative sieving value of a sieve from the direct measurements made upon it of the number and diameters of the warp and shoot wires, and the uniformity of spacing of the wires. The establishment, however, of a hard and fast demerit system for calculating the sieving value involves much guesswork, and the attempts thus far made at the Bureau of Standards to devise such a system have been only partially successful. It is not, therefore, worth while to go into the details of the manner in which the demerits have been assigned other than to state that consideration was given to all factors which affect the variations in size and distribution of the openings.

Table III.—Relation Between Value of Sieves as Actually Tested and Estimated Value Based on Sieve Measurements.

Sieve.	Sieve value.	Demerits.	Sieve.	Sieve value.	Demerits.
1....	80.16	— 408	7....	80.55	— 548
2....	80.30	+ 1312	8....	80.63	—1386
3....	80.32	+ 1304	9....	80.75	— 188
4....	80.46	—2363	10....	80.93	—1573
5....	80.49	—1101	11....	80.94	—2340
6....	80.52	—1150	12....	81.03	—3135

Table III. gives the average sieving values of the sieves listed in Table I., together with their demerits arbitrarily assigned from analysis of direct cloth measurements on the sieves.

Table IV.—Results of Sieving Tests Made by Four Observers on 12 Standard No. 100 Sieves.

Sieve.	Observers. A	B	C	D	E	Average	Max. var. from average.
1	96.28	96.48	96.44	96.64	.....	96.46	0.18
2	96.24	96.50	96.58	96.70	.....	96.50	.26
3	96,22	96.48	96.44	.....	96.86	96.50	.36
4	96.46	96.50	96.42	96.70	.....	96.52	.18
5	96.32	96.58	96.48	96.72	.....	96.52	.20
6	96.30	96.74	96.50	96.68	.....	96.56	.26
7	96.52	96.68	96.52	96.44	96.74	96.58	.14
8	96.48	96.56	96.58	96.74	....	96.59	.15
9	96.54	96.60	96.56	96.66	.....	96.59	.07
10	96.54	96.48	96.42	96.90	.....	96.59	.31
11	96.64	96.64	96.72	96.64	.....	96.66	.06
12	96.59	96.68	96.68	96.96	.....	96.73	.23
Average..	96.43	96.58	96.53	96.71	.....	96.56	.20
Personal equation ..	+.13	—.02	+.03	—.15	.....	.....	...

Table IV. is similar to Table I., containing the results obtained by four observers using 12 "standard" No. 100 sieves. The same method of examination enables us to state that a single determination of fineness on the No. 100 sieve is likely to be at least 0.2 of 1 per cent. in error. This value is, of course, less than the corresponding value for the No. 200 sieve, owing to the smaller quantity of material of this grade, which therefore gives a more definite stopping point in the sieving. Similarly, the range of differences that may be expected between standard sieves is less than that for the No. 200 sieves, being in this case from 96.46 per cent. to 96.73 per cent., of 0.27 per cent. The maximum correction of a "standard" No. 100 sieve to the ideal No. 100 sieve therefore appears to be of the order of 0.2 per cent.

A striking agreement is also noted between the "personal equations" as given in Tables I. and IV., the operators being the same in each case.

SUPPORTING TRACKS DURING CONSTRUCTION WORK.

The bearing on the total cost of work which is had by the design and construction of temporary structures supporting railway tracks under traffic, while work proceeds underneath—for instance, in the building of street or highway undercrossings—was shown at the recent convention of the American Railway Bridge and Building Association. Work was described at various points on the lines of the Lake Shore and Michigan Southern Railway, where three systems of support were successively required as the work proceeded.

At Sandusky, Ohio, a street crossing seven tracks at grade was to be carried under without altering the track profile. The solid rock surface was about halfway down and above this were boulders and hardpan. Pile bents were built, the piles being driven to a stop. In the floor system supporting the tracks were incorporated two sets of stringers, one spanning from bent to bent and the other balanced on the bents. As the excavation proceeded ridges were left to protect the piles, the intervening spaces being taken out to solid rock. Some of the piles were found broken, and in such cases short posts on sills were pushed in to replace them. When the rock surface between bents had been reached frame bents were erected in the middle of the spaces, catching the ends of the secondary system of stringers, which, like the primary system, were designed to carry the full load. The pile bents were then removed, except the caps, which were left bolted to the stringers; then the remainder of the loose material was cleaned away and trenches cut to the full depth required for the excavation, the trenches being directly in the line of the original pile bents and the whole system being so spaced as to avoid the permanent abutments and the intermediate piers. New frame bents were then constructed in the trenches and the load transferred to them, after which the bents on the higher level were in turn removed.

A somewhat different treatment was required at Cleveland, where a street crossed six tracks at grade on a sharp skew. There, as at Sandusky, it was proposed to cut the street under without changing the track profile, but the rock surface was only about 4 ft. below subgrade. Of the four main tracks the two inferior ones were temporarily put out of service and the soil underneath excavated to rock. Two sets of stringers were used as at Sandusky, the secondary set, however, being placed on top of instead of alongside the primary set. The stringer system thus filled most of the space between subgrade and rock, and the first system of supports consisted of sills and blocks spaced 20 ft. apart. Afterwards the procedure was similar to that at Sanduskv, the second set of bents being carried in trenches about halfway down and the third set resting on the bottom of the finished excavation.

The cost of the Panama Canal to May 30, 1913, was $295,587,418.41. For the sanitation of the Canal Zone $16,-132,056 was expended.

EXPERIMENTS IN PRE-HEATING CLAYS.

In Memoir No. 25, Geological Survey, Department of Mines, Canada, Dr. Heinrich Reis and Mr. Joseph Keele have submitted Part II. of their report on the clay and shale deposits of the Western Provinces. The 108-page book is well illustrated, and has an abundance of new data concerning the properties and characteristics of the formations to be found throughout the West. One chapter, by Mr. Keele, deals entirely with experiments in pre-heating clays, from which we make the following extracts:—

Among 120 samples of clay and shales collected during the seasons of 1910-11 in the Great Plains region, 28 of them, or about 23%, cracked in air drying after being moulded. These defective clays occur principally in the Belly River and Edmonton formations, and in the upper part of the Cretaceous, but some of the Laramie clays have the same fault.

They are frequently found in localities well situated for transportation; they are easily worked, and occur in great abundance. They would, therefore, be of great economic importance if they could be utilized, as many of them will make fireproofing, and some even can, we believe, be manufactured into sewer-pipe if their tendency to crack while drying can be overcome.

Several beds of these clays and shales could be manufactured into facing bricks by the dry-press method, but it is impossible to use them for the many important structural wares which involve the use of the wet-moulded processes.

During the progress of the laboratory work on the samples of these clays collected in the field, the writer was confronted with the difficulty of preparing test pieces from them for the purpose of observing their behavior under fire. The clays absorbed a great deal of water in tempering, afterwards forming a stiff pasty mass which was tough and sticky and hard to work. Shortly after being set to dry the moulded shapes cracked, even small test pieces splitting badly in the ordinary laboratory temperature. The surface of a full-sized brick readily became dry, and developed a perfect network of cracks, which deepened and widened as drying progressed, while the inside remained moist for several days. The use of substances which would coagulate the clay was tried to cure this cracking, being careful to use materials which were cheap and readily available, so that if the remedy were successful it could be used on a commercial scale. Of the various acids and alkalis tried, common salt to the amount of 1% added to the clay seemed to give the best results. The salt kept the surface of the bricklets moist while the water was working its way out of the body.

Full-sized bricks made from some clays thus treated would dry safely in the ordinary room temperature, but many clays would not, and few of the salted clays would stand even moderately fast drying. Furthermore, the stickiness and soap-like qualities of the clays were not ameliorated to any appreciable extent by the mixture.

The next method which suggests itself was the use of non-plastic materials like sand or grog. River sand, ground quartz, and calcined clay were successively used. These were added to the clays in varying amounts up to 50%.

The mixtures with sand failed in every respect, and although the grogged clay could be safely dried in some instances, and burned to a good body, the bad-working qualities of the raw clay were still in evidence.

Professor Orton,* who was experimenting on some clays of the Edmonton series at the same time as the writer, was unsuccessful in overcoming their drying defects by the use of either chemical coagulants, or additions of non-plastic materials. There remained then the method described by Professor A. V. Bleininger for treating clays that cracked in drying, by pre-heating them at various temperatures.

Pre-heating experiments were done on several of our clays, and the results arrived at seem to prove that this is the best method so far, for dealing with the difficulty. The data for six samples of clay from localities widely apart are here given. Clays of these types may be expected to recur frequently in other localities throughout the region we are dealing with. Numbers 1644 and 1755 are used for making dry-pressed bricks, but the other samples are from unused deposits.

1644—Dark grey massive clay, underlying a lignite seam, Estevan, Sask.

1755—Light grey massive clay, Coleridge, Alta.

1765—Dark grey soft shale, underlying a lignite seam, Tofield, Alta.

1675—Light grey hard shale, overlying coal seam, Oldman River, Alta.

1800—Soft olive shale, Gwynne, Alta.

1796—Soft shales interbedded with streaks of sand, Camrose, Alta.

The clays were heated in a small rotary drum, made of sheet iron, and having baffles projecting from the inside to keep the clay well stirred up and evenly heated.

A stationary sheet iron hood enveloped the drum except where openings were left for the gas flames to enter. The drum, which was revolved by hand, was provided with a hollow axle, through which a pyrometer tube was inserted. About ½ to ¾ hr. was generally taken to bring the clay to the required temperature, the latter being easily kept constant during the time allotted for treatment.

The length of time allowed at each temperature was 15 min., each clay being kept for this period at successively higher temperatures until it yielded to the treatment. Other trials were made of 30 min. duration at certain temperatures, to show the effect of time.

The latter results show that it is possible to obtain effects at lower temperatures with increased time, similar to those given in the shorter time at higher temperatures, but this appears to be true only within certain limits, as Professor Orton's experiments show that some of these clays were not improved by exposure for 1½ hrs. to a temperature of 400° C. Steam was given off freely from the heated clay at all temperatures up to 500° C. The fumes evolved at higher temperatures smelled strongly of sulphur and hydrocarbons, which was probably due to the dissociation of particles of pyrite and driving off of bituminous matter.

When the heating was completed all the clays except No. 2 were much darker in color than in the raw state, being dark grey to almost black.

Clay No. 1755 yielded at a comparatively low degree of heat treatment, probably due to its containing a relatively larger amount of grains larger than clay substance than any other of the samples tested.

The tenacity with which clay No. 1765 clings to its plasticity under the action of heat is remarkable, as that property was not affected to any great extent even at the

*Edward Orton, Jr., Experiments on the drying of certain Tertiary clays, Trans. Am. Cer. Soc., Vol. XIII.

highest limits of the experiment. It would no doubt succumb to a more prolonged exposure at 550°. or it might be successfully treated at 600° for 15 min. The latter was not tried, however, as it is possible that the amount of preliminary heating that could be economically applied to this or similar clays in practice was already exceeded.

Clays Heated in Rotary Drum.

No.	——	400° C. 15 min.	450° C. 15 min.	500° C. 15 min.	500° C. 30 min.	550° C. 15 min.	550° C. 30 min.
1644	Drying at 65°C.				Bad	Improved	Good.
	" 30°C.				Bad	Good	Good.
	Plasticity				Good	Fair	Low.
1755	Drying at 65°C.	Good					
	" 30°C.	Good					
	Plasticity	Fair					
1765	Drying at 65°C.					Bad	Bad.
	" 30°C.					Bad	Good.
	Plasticity					Good	Fair.
1765	Drying at 65°C.					Bad	
	" 30°C.					Bad	
	Plasticity					Good	None.
1800	Drying at 65°C.				Bad	Improved	
	" 30°C.				Bad	Good	
	Plasticity				Good	Fair	None.
1796	Drying at 65°C.		Bad				
	" 30°C.		Bad				
	Plasticity		Good	None			

The results given by sample 1675 show the slight margin in time that exists between the proper and unsuccessful handling of some clays.

After the 30-min. treatment at 550° this clay was sandy in texture, and could not be moulded into shape, while after the 15-min. treatment its defective qualities were quite unimpaired.

The precise time, then, for the clay at this temperature appears to be either 20 or 25 min., but. as will be explained later, the 30-min. treatment was not fatal.

The results of previous experience without any special apparatus, showed that the clays would require a high degree of heat treatment, but to avoid mistakes all the clays were heated to 350° C.; however, since no change occurred in any sample at this temperature it is unnecessary to include it in the table.

The test pieces made up for the drying tests were 2½-in. cubes, as there was not a sufficient quantity of the various clays in stock to make full-sized bricks. The cube, however, has a greater volume for the amount of surface than any of the brick shapes.

The driers used in the experiment consisted of small chambers attached to the steam heating apparatus of the building. The maximum temperature that could be obtained in this way was about 65° C., the pieces being dried in from 24 to 36 hrs. Although faster driers are used for some clays in practice, it was decided that if the clays can be worked and afterwards dried safely at the above temperature, that the object of the experiments had been attained.

The pre-heating causes marked changes in the character of the clay, the most important for practical purposes being the change from a tough sticky mass, having undue shrinkage and abnormal cracking in drying, to an open granular body which can be easily worked and rapidly dried.

The pre-heated clays require considerably less water for mixing than the raw clays, consequently the air shrinkage in the clays thus treated is greatly reduced, as shown in the following table:

No.	Average per cent. air shrinkage. Raw clay.	Pre-heated clay.
1644	9.6	4.0
1755	7.0	6.0
1765	8.7	5.0
1675	8.9	5.0
1800	8.5	3.6
1796	8.8	4.0

Another striking advantage gained in pre-heating is seen when burning the test pieces. Those clays which were subject to black coring and swelling were completely cured of this trouble by the pre-heating treatment. This is probably due to the change in texture which the clay undergoes when pre-heated, giving a more open body from which the gases evolved in burning can escape freely, and also to the driving off of some of the carbonaceous and sulphurous components.

The effects obtained by pre-heating to the above temperatures are not permanent.

The plasticity of the clays Nos. 1675 and 1800, apparently destroyed during the course of the experiments, was restored again by allowing those clays to remain in an excess of water for 24 hrs. Sufficient water was then evaporated, so that the clay could be remoulded, and set to dry. No. 1675 would still stand fast drying, but No. 6 cracked both in the fast and slow drier.

Again, when the cubes made from No. 6 were dried, reground and wetted for the third time it was found that this clay had regained all its pristine plasticity and stickiness, and small bricklets then made from it cracked while air drying at room temperature quite as badly as the raw clay did.

Analyses of Clays Which Cracked in Drying.

	No. 1755.	No. 1765.	Bentonite from Camrose.
Total silica (SiO_2)	74.25	65.23	69.14
Alumina (Al_2O_3)	14.29	18.60	14.50
Oxide of iron (Fe_2O_3)	2.89	2.97	2.56
Lime (CaO)	0.37	0.66	2.45
Magnesia (MgO)	Trace	0.64	1.14
Potash (K_2O)	2.52	2.40	0.19
Soda (Na_2O)	1.19	2.23	1.25
Loss on ignition	4.21	7.30	7.71
	99.72	100.03	98.95
Supplemental determinations—			
Organic carbon	not determ'ed	1.44	not determ'ed
Carbon dioxide (CO_2)	none	0.42	0.52
Sulphur trioxide (SO_3)	none	none	1.70
Hydrous silica	0.43	0.51	21.03
Sulphur	none	none	not determ'ed

In the table given above will be found analyses of several of the clays described in this chapter. They were made by G. E. F. Lundell.

The greater part of these clays is made up of quartz grains of varying degrees of fineness, as many clays are, and the chemical analysis furnished no clue to their erratic behavior.

About 20 ft. below the beds from which sample No. 1796 was taken a seam of about 2 ft. in thickness of the clay known as bentonite occurs. This variety of clay is of yellow color when fresh from the bank, but assumes a dirty white color on exposure. It is fine in texture, exceedingly smooth, and forms a very soft soapy mass when mixed with an excess of water. It has an extraordinary capacity for absorbing moisture, being capable of taking up three times its weight in water.

The clay possesses marked detergent properties, and was used in the early days of the North-West by Indians and Hudson's Bay Co. employees as a substitute for soap.

This material was rejected as unfit for any burned clay wares, but an attempt was made to dry some bricklets made from it, in a moist atmosphere. After three weeks of gradual drying the bricklets showed abnormal cracking and very high shrinkage. Although none were observed on the outcrop, it is possible that some thin streaks of bentonite were included in the beds sampled for No. 1800. Certain of the sand beds of the vicinity were found to possess plasticity, and some decidedly silty beds will crack in slow drying.

As a good deal of the material which composes these beds is derived from the erosion of the lower Cretaceous which contains bentonite beds, it may be assumed that this material, being part of the product of erosion, was re-deposited and distributed through many of the later beds.

It occurred to the writer that some simple scheme of washing might be adopted to separate out the pasty constituent from these clays.

As an experiment, one pound of ground shales from sample No. 1675 was well stirred up in about a gallon of water and allowed to settle for two hours, the water and suspended matter being then drawn off. This operation was repeated, and the residue allowed to dry. When the residue had dried, it was found to consist of a badly cracked yellow paste about half an inch in thickness, forming a crust on top of dark grey sand and silt. The yellow paste had all the appearance and characteristics of bentonite or soap clay.

The shale, when dry, was found to have lost 25% of its weight, presumably all of it being pasty matter held in suspension and drawn off with the water.

The plasticity of the shale was much reduced by the washing, but it cracked almost as badly as ever in the 65° drier. It would dry intact though, in room temperature.

That the presence of bentonite is a potent factor in producing air cracks, was proved by the following experiment. Ten per cent. of bentonite from Camrose was added to a coarsely ground paving brick shale from Elmira, N.Y. The cube made from this mixture cracked badly in the 65° drier. The Elmira shale will stand fast drying at 85° C.

Between bentonite as an extreme case and clay No. 1755 as a mild example we have clays containing varying amounts of gelatinous paste, which allows the water to escape with difficulty from the body, and causes cracking while retarding drying.

The chemical analysis of bentonite (see table) showed that it possessed a large amount of hydrous silica; which probably causes that sticky type of plasticity and the trouble in drying.

Pre-heating has the effect of driving out the water from the hydrous silica, and causing the caking together of the dehydrated particles, which gives the granular texture seen in the clays thus treated.

Clay No. 1765 was washed in a similar way to No. 1675, but lost 75% of its weight and the residue cracked in drying.

The chemical analysis made of it shows only a small amount of hydrous silica, but this clay, notwithstanding the low amount of that ingredient, possesses all the pastiness of bentonite, and its tendency to crack is almost as pronounced.

A large percentage of this clay is in a very finely divided state, and much of it may be colloidal matter; perhaps organic colloids are also present. Then, in this case, pre-heating to sufficient temperatures has the effect of driving the water from the infinitesimal pore spaces between the minute grains, and the chemically combined water from the colloids. The minute particles, when deprived of their water envelope appear to adhere in sufficient numbers to form sizable grains.

The subsequent safe drying after pre-heating seems to depend on the fact that the water with which the clay was tempered escapes by evaporation in the driers before it has time to permeate the microscopic pores again and hydrate the colloid or siliceous content.

Clays which retain or regain their plasticity after the expulsion of chemically combined water have been recorded at various times.

H. E. Kramm* found that test pieces made from mixtures of kaolin and gypsum, kept for 8 hrs. at a temperature of 790° C. slaked down in water, and had lost little or none of their original plasticity.

Most of the clays can be made workable by the preheating process if commercial conditions allow of its use. This process involves the use of a suitable type of rotary kiln, a cheap fuel to supply the high temperatures at which these clays must be treated, a proper superintendence in controlling the process and the cost of extra labor. The samples on which the experiments were made have been selected from localities in which either coal, lignite, or natural gas is abundant.

Clay No. 1644 undergoes a slight pre-heating through a rotary drier in the brickworks at Estevan. This is done primarily to prepare the clay for dry pressing by getting rid of the superfluous moisture which it contains in the bank, but the treatment was also found to stop much of the fire checking to which the raw clay was liable. The losses from fire checking are still great, but a higher degree of heat treatment would probably do away with it entirely.

It is doubtful if the kind of apparatus in use at Estevan would give a sufficiently high temperature to drive off combined water and render the clay fit for wet-moulded processes.

*Trans. Am. Cer. Soc., Vol. XIII., p. 698.

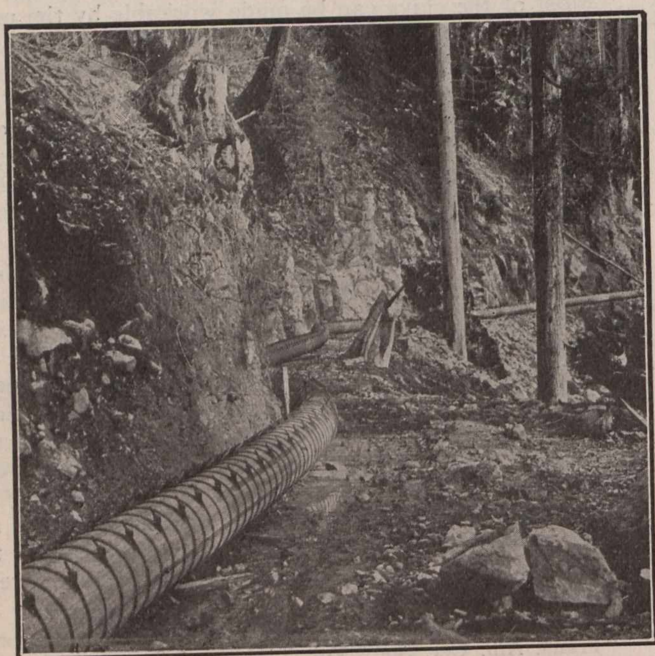
The annual report of the mines branch of the Department of Mines, issued last November, makes the statement that Canada possesses gas and oil fields of considerable value, which, if developed, may rival those of the United States. Hitherto, oil as liquid fuel has been used in North America only in the United States, and the report states that there is no reason why Canadians should not also avail themselves of its advantages. It also points out that an increasing demand for liquid fuel has of late constituted one of the outstanding features in power development; and observes that, while the oil business has generally been viewed as a gambling enterprise, and many companies have conducted it as such, the days of taking great chances are past. Dealing with the possibilities of the different Canadian provinces, the experts in the employ of the mines branch, who have compiled the report, say that in Alberta deposits are considerable, but the cost of drilling is high. Of the Northern Alberta field, they point out, that it has as yet produced no oil in commercial quantities. The same is true of British Columbia and Manitoba. The district between Regina and Moose Jaw and the Alberta border in Saskatchewan is reported to offer chances for oil operators. The province of Quebec gives no indication at the present time of developing fields of either petroleum or natural gas. New Brunswick oil fields, however, show considerable promise, and of Ontario, the statement is made that "the production both of petroleum and natural gas is on the decline and the total depletion of the underground supply is approaching."

SOME WATERWORKS SYSTEMS IN BRITISH COLUMBIA.

Construction of the Port Alberni Plant.

IN August, 1913, the Vancouver Wood Pipe and Tank Company completed the construction of a waterworks system for the city of Port Alberni, B.C., a contract begun in the fall of 1912. This contract was awarded in September, 1912, to the Municipal Construction Company, Limited, as the company was then known, and was for a lump sum approximating $108,000. The work was to have been completed in eight months, but owing to delays in arrival of shipments of steel for banding the continuous stave pipe, the plant was not finally ready for operation until August.

The principal features of the Port Alberni waterworks system, which is a municipally-owned enterprise, are an intake dam of crib-work and rock construction, a supply main some 7¼ miles long, and a distribution



Port Alberni Waterworks—16-in. Continuous Stave Pipe Line.

service throughout the business and residential portions of the city of some 4½ miles of 6-in. mains. The intake dam was constructed on China Creek, the source of supply, and is about 200 feet in length. A difficulty which first had to be overcome was the construction of a road for the entire distance of over seven miles from Port Alberni to the dam along the pipe line. This was through a rough, heavily timbered country, where trees 6 ft. in diameter had to be cleared away. In some parts, too, rock work of heavy character had to be undertaken, and the nature and extent of this may be learned from the fact that the amount removed in the construction of the road totalled 6,000 yards of rock and over 22,000 yards of earth.

In building this road the line was brought to grade, as the pipe was laid at one side, next the bank, so that it was readily covered with earth turned down from the slope of the bank. One important part of the work was providing for six inverted syphons, necessary because of the contour of the pipe line, which crosses several deep ravines, almost canyons in one or two cases. Here the roadway constructed had to be raised up by cribbing and filling-in—in some places to a height of 20 feet, so that the extreme curvature of the pipe might not be exceeded. To accomplish this about 30,000 lineal feet of cribbing timber was used.

The continuous stave type of construction was used in the first 26,000 feet of the supply main, the diameter being 16 inches. A portion of the line is illustrated in Fig. 1. This pipe was made of Douglas fir staves, from seasoned, clear stock, 2 x 4 in., dressed in radial section to a thickness of 1⅝ in.

One of the most important features of continuous stave pipe construction is the connecting of the ends of the staves. This is done by means of a flat metal tongue, about 2 in. wide and 1-16 in. thick, inserted in a slot sawed in the ends of the staves, and projecting at each edge just far enough to engage the side of each adjoining stave. To ensure absolute uniformity in this work the company has perfected and patented a machine by means of which the work of slotting is done with perfect accuracy. Thus the pipe goes together in such a manner that a uniformly smooth bore is secured throughout, which is the object to be most desired in construction. In assembling this pipe, steel bands ½-in. in diam. were used, and the average spacing was 2½ in. The pipe line was marked by a great many curves as well as by the six syphons referred to, and the result of the construction is a striking demonstration of the adaptability of the continuous stave type of construction for such a water main.

Steel pipe was used for the remainder of the 7-mile main, the first 7,300 ft. from the end of the continuous stave pipe being 12 in. in diameter, and the next 5,800 ft. being 10 in. As the total head due to the elevation of the intake dam, 614 ft. above sea level, would have been too great a working pressure for the system, reducing valves were installed on the 12-in. and 10-in. portions of the main, bringing the pressure down to an average of about 110 lbs. in the city.

For the 6-in. distribution mains, wire-wound wood stave pipe, made from selected Douglas fir, was used. House services from these were installed at the time of laying the mains, under the supervision of the city engineer. Fire protection and other needs have been very adequately looked after, and Port Alberni, one of the most westerly ports in Canada, and one with an optimistic future, now that railway connection to Victoria has been completed, is well supplied with water for a population of fully 20,000 people. It is a curious bit of British Columbia history that this new port on the west coast of Vancouver Island, was the site of the first saw-mill, and really the first industry located in the province. The mill, long since removed, was erected by Capt. Stamp, of Boston.

Salmon Arm and other Water Systems.—The activities of the Vancouver Wood Pipe and Tank Company have included another water system for a British Columbia city, Salmon Arm, in the interior of the province. Here, during 1913, the company installed a complete system several miles in length.

Supply was taken from Canoe Creek, under a head of 700 feet, which was broken with a 50,000 gallon stave tank. This tank was housed in a frost-proof octagonal building. It forms the direct supply for the city service, which is designed to be extended as the needs of population demand.

In 1912, just prior to commencing the Port Alberni waterworks, the company completed a large contract for installing over 55 miles of steel distribution mains for the waterworks system of Burnaby municipality, adjoining the city of Vancouver. In the years 1910 and

1911 the same company undertook, and successfully carried out, the contract for installing the new supply main for the city of New Westminster, some 74,000 feet of steel pipe, 25 inches in diameter. This pipe was laid from a new dam built by the Vancouver Power Company at Lake Coquitlam, in the mountains just east of Burrard Inlet. (See *The Canadian Engineer*, Jan. 13th, 1914.)

Last year the company secured three patents for use in connection with the making of pipe. One of these was on a new and improved coupling, the other two on machines used in turning out the staves and pipe. In the new coupling for wire-wound wood pipe, the features are a machine-turned interior bore, to match the turned tenon on the end of each section of pipe where it is inserted; and a galvanized flat band of steel on each end, covering a portion of the sleeve coupling, which is in other makes left bare, as the winding of the wire cannot be carried to the extreme end of the sleeve. The flat band is sunk flush with the surface of the couplings, which are greatly strengthened by it. This band is an added strength to the end of each joint of pipe, which necessarily has no wire on the tenons where they are driven into the couplings. The machining of the interior of the coupling is a very important improvement, as it does away with any lack of uniformity of the staves when assembled in the work of winding, and thus it allows of a much more perfect fit in connecting up the pipe.

MICROMETER METHOD OF SURVEYING WATER ROUTES.

By Robert B. Sinclair.

FOR the purpose of pushing ahead their various enterprises, some governments and many private companies are now mapping their watercourses, not hitherto covered by the land surveyors. The work must be carried on with a considerable degree of accuracy; but the speed with which it is carried through is not by any means the least important factor, and sometimes becomes an important problem.

In obtaining the required data for the mapping, the micrometer survey has been found to produce results which compare very favorably with the triangulation method and the traverse method in accuracy, and the time which is gained is often invaluable to the parties concerned.

Established Methods.—This class of surveying can be carried on by several different methods, e.g., triangulation, the traverse and the stadia. All of these methods lack what is frequently a great essential, namely, speed. The first two of them have been tried out on numerous occasions where they have been found to be impracticable. The enormous amount of work in the making of the traverse survey may be readily apparent to anyone conversant with it. Lines must frequently be cut through the bush and the traverse carried along the shore.

The triangulation method suggests something more feasible, but to one familiar with this class of work, it can be seen that great difficulty may be encountered in obtaining points which could be sighted on, owing to the numerous bays and overhanging trees.

The stadia survey is much more adaptable than either of the other methods, but it is lacking in one necessity, viz., the accurate reading of distances of 400 ft. or over. On account of this the triangulation method must frequently be applied to the survey in order to take in the longer readings.

Hence, the advisability of using an instrument which will eliminate the possibility of error in long sights, and will read the shorter sights with the same degree of accuracy, appears obvious. Such an instrument we have in the micrometer. It has been tried out by the governments and also by the surveying departments of the different railways, and has been pronounced a most suitable instrument for this class of surveying.

In order to obtain the readings, a target is used, composed of two discs mounted on a light rod and set at varying distances apart, according to the length of the sights taken. The ordinary distances to be sighted are from 300 ft. to 1 mile. The space between targets used for these readings is about 10 ft. Nevertheless, sights of 5 miles have been read with a very fair degree of accuracy. For these sights a base line of perhaps 100 ft. is chained and the targets mounted at this distance apart.

The telescope of the micrometer is equipped with a double glass which throws two objects on the plane of the diaphragm of the instrument. The two glasses are worked in the vertical plane by a micrometer screw. When the objects coincide the vernier of the instrument reads zero. In turning the screw the glasses slide along, focusing the target at different points on the diaphragm. When the two of the target faces coincide, forming only three target faces in all, then the glasses have slid along a certain set distance, which varies each time with the increase or decrease in the space separating the instrument from the target. We see then the relation which obtains between the turning of the micrometer screw and the distance to be measured.

In order to compile a table which gives the distances in relation to the micrometer screw, a base line of perhaps one mile is chained out previous to entering the field. Distances are laid off every 100 ft. up to about 500 ft., and then at every 300 ft. or so. At these points the readings of the micrometer are noted. The screw is turned first to the left and then to the right, and the mean of the readings deduced. By this means the table of readings is taken in relation to the distances measured by the chain. Any number between the distances not noted can then be obtained by interpolation.

When this means of determining the distance is resorted to, the survey resolves itself into a very simple operation. The engineer in charge may use two targets. The main line of the traverse is kept intact and readings, spiralling in different bearings from the station points, is perhaps the more advantageous method of procedure. It might be stated in conclusion that the method is approximately 14 times as swift as the triangulation method, and compares very favorably in accuracy with any of them.

Governor Glynn announced recently at Albany, N.Y., a plan which he has formulated to increase the revenue of the state from $1,200,000 to $1,800,000 per annum. The scheme is based upon the state taking absolute charge of the 4,400 cubic feet of water per second now available at Niagara Falls under the treaty between the United States and Great Britain. It is claimed by electrical experts that this water will produce 75,000 horse-power. Mr. Glynn's policy is that the state should either develop this power itself and sell it to consumers, or sell the water to companies for generating electricity. If sold at the present wholesale price of electricity in Buffalo, $16 per horse-power, 75,000 horse-power will bring a revenue of $1,200,000 a year. If sold at the present retail prices of electricity at Buffalo, $26.50 per horse-power, 75,000 horse-power will bring a revenue of $1,800,000 a year. Governor Glynn contends also that, inasmuch as the state owns the water to be diverted from the Niagara river, the state and not the federation should receive the profit from its use.

CITY WATER WASTE.

"CONSERVATION," published by the Commission of Conservation, Ottawa, draws a comparison between the cities of Europe and North America with respect to consumption per capita of water, and presents some remarkable figures tending to emphasize the inordinately high waste of water in American cities.

The tables below give figures taken from representative cities on both sides of the Atlantic, and furnish a good basis for such a comparison.

	Imp. gals. per head per day.
St. John, N.B.	200
Vancouver,	160
Montreal	120
Ottawa	190
Toronto	95
Hamilton	98
New York	100
Buffalo	270
Chicago	190
Philadelphia	175
Average	159.8
Vienna, Austria	14
Ascher, Germany	24
Basel, Switzerland	40
Copenhagen, Denmark	26
Hamburg, Germany	40
London, England	36
Liverpool, England	36
Glasgow, Scotland	72
Newcastle-on-Tyne, England	33
Hull, England	38
Nuneaton, England	18
Stirling, Scotland	53
Riga, Russia	21
Manchester, England	42
Devonport, England	40
Average	35.5

It will be seen from the above that the average consumption per head in America is between three and four times what it is in Europe. This tremendous difference can only be accounted for by assuming that the greater portion of the water consumed in New World cities is simply wasted. A consumption of 50 gallons per head per day ought to be ample for all purposes, and would still be about 43 per cent. greater than the European average. Taking the American average as 150 gallons, we see that cities on this side of the Atlantic are using 100 gallons per head per day more than is necessary.

This unnecessary waste increases the cities' financial burdens in many ways. The pumping and filtration plants must be of needlessly large capacity; far more power must be employed to force a large quantity of useless water through the mains; and the distribution pipes and also the sewers that carry the water away, must both be bigger than necessary. Mr. R. O. Wynne-Roberts, M. Inst. C.E., estimates that in a city of 250,000 population, the extra cost of water delivered would amount to $560,000, or $2,24 per inhabitant. Further, the difference in cost of sewerage and sewage disposal would be $420,000, or $1.67 per inhabitant. This means that the city's water rates are increased by $3.91 for every man, woman and child of the population, without any appreciable benefit being gained for the extra outlay.

Undoubtedly some of this waste could be eliminated by placing meters on all house services, and, indeed, this is a common practice in England, and has already been adopted by some United States cities. To avoid the cost of installing meters on each service and to detect leaks in the mains, Mr. Wynne-Roberts suggests that meters be placed on the mains in different parts of the city, so that the quantity consumed in various districts could be ascertained. This would localize waste, and, if combined with an efficient system of inspection, would materially reduce useless consumption at a less cost than metering all house services. For a city of 250,000, he considers that about twenty district meters would suffice, the estimates the cost as follows:—

15 per cent. interest and depreciation on meters	$ 7,500
20 inspectors at $1,200	24,000
1 superintendent	2,400
2 clerks	1,920
Rent, light, stationery and miscellaneous	2,000
	$37.820

or approximately $40,000 per annum.

Certainly some means should be taken to check the present reckless waste. If some cities would conserve their present water supply, there would be no necessity of new reservoirs and additional water supply for many years to come.

CANADIAN STEEL MANUFACTURING.

Engineering, London, England, contained an article recently on the steel situation in Canada, and a short history of its growth. To quote, the writer says:—

"It would almost appear that, if the present rate of progress in steel manufacture continues, Canada will be able soon, not only to supply her own wants as regards steel, but also be able to enter the markets of the world.

"Prior to 1902, Canada made very little steel. The output advanced from 26,084 gross tons in 1901 to 182,037 gross tons in 1902. Five years later, in 1907, it had reached 646,754 tons, and five years later still, in 1912, it increased to 853,031 tons, the largest output in its history. It is quite probable that in the present year Canada will make nearly 1,000,000 tons of steel, or more than the United States made in 1879. The steel output of Canada is largely in the form of ingots, over 96% of the total in 1912 being in this form, and less than 4% in the form of direct castings.

"The largest two centres for steel in the Dominion are Ontario and Nova Scotia. In 1909 Nova Scotia led Ontario by 28,201 tons, in 1910 by 11,943 tons, and in 1911 by 20,623 tons. In 1912, however, Ontario forged ahead by 1321 tons. Nova Scotia has within its borders the new and modern plant of the Dominion Steel Corporation, while Ontario has within its boundaries the large and modern plant of the Algoma Steel Corporation.

"Naturally, the output of finished rolled forms of iron and steel in Canada increased in the same ratio as steel ingots and castings. In 1902 the total rolled output was 161,485 tons. In 1907 it had increased to 600,179 tons, and in 1912 to 861,224 tons, the maximum. Much the larger part of the total was steel—about 87.5% in 1912. Rails formed almost one-half of the total rolled output of the Dominion in 1912—over 49.2%.

"It was not till 1902 that Canada began to manufacture steel rails on a large scale. In that year it made 33,950 tons. Its output in previous years had seldom exceeded 800 or 900 tons. In 1912 the rail output reached 423,885 tons, its best yearly record."

The Canadian Engineer

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CONTENTS OF THIS ISSUE.

WATER POTENTIALITIES OF BRITISH COLUMBIA.

The investigation of the Commission of Conservation into the power possibilities of the rivers and lakes of British Columbia was dealt with to some length at the fifth annual meeting of the Commission in Ottawa last month. The chairman, Hon. Clifford Sifton, in his address outlined the progressive steps from the beginning of the work in the Kootenay district in 1911, to the present. It was announced that the amount already done covers that portion of the Province between the Grand Trunk Pacific line and the International Boundary, including Vancouver Island. The assembled data on this part are being prepared for publication and will be issued during the present year.

British Columbia has contributed the most difficult problems with which the Commission has yet had to contend in its water-power study. Physical difficulties, causing unavoidably slow progress in survey work, have prolonged operations. Brevity of season during which profitable advancement can be made in reconnaissance investigation, lack of facilities for rapid movement over routes or from one route to another, and heavy expenses throughout, have also been factors occasioning more labor than one is apt to credit to such a great undertaking. One of the serious difficulties encountered, for instance, is that it is almost impossible for observers to avoid over-recording power possibilities of streams observed during high stages, and the flood stages in this province frequently occur much later in the year than in eastern Canada. The conditions affecting powers in this province are unique and do not closely correspond to those existent in other portions of the country. Glaciers, melting snow, and heavy rainfall abound, especially on the north mainland coast. Many storage possibilities, known and unknown, exist. While such factors contribute to enhance the value of powers, these conditions require special and very careful engineering investigation and expert handling in order to avoid encouraging developments that might not prove economical.

British Columbia has a number of streams which cross, and some of which recross, the International Boundary, and in connection with the utilization of these waters, there may be questions requiring consideration by the International Joint Commission. Some of these streams have large power potentialities.

The construction of railways in the lower portions of valleys debars development of many of what would otherwise have been fine water-powers, and, in some instances, highways have been constructed in locations which also tend to prevent development.

Incidentally, the protection of great fisheries dependent upon inland waters arises in this connection. An instance, witnessed last summer, of great numbers of salmon dying in the Fraser river, because of artificial blocking through railway blasting, has shown how carefully matters must be considered which may possibly affect the ingress and egress of valuable fish.

The report will also include references to the British Columbia law relating to waters, to various procedures under the law, and other cognate matters. The water legislation of British Columbia is quite advanced and has attracted international attention. *The Canadian Engineer* for January 8th, 1914, outlined the scope of a proposed bill for the formation of water municipalities for the conservation and distribution of water for irrigation purposes.

BUSINESS TRAINING FOR ENGINEERS.

It is not often that engineers are afforded such a clear analysis of the status of the profession in the public mind as Mr. Porter gives in his paper on page 320 of this issue. It is a subject about which much has been written. Engineers are constantly being offered opportunities for making introspective diagnoses of their professional qualifications.

There should be no resentment, however. There has never been an age when capable engineering talent was more in demand than the one in which we live. Present day problems in rural and urban development are not as simple of solution as they used to be. Besides the increase of necessities, the insistent demand for more rapid growth, greater undertakings and more costly enterprises, there is an entanglement of vested rights and powers associated with every problem. Its working out requires a talent that possesses much greater attributes than a panoramic view of engineering practice itself.

Compared with the older professions, engineering and engineering training are subjects of much controversy, and naturally so. The former are the product of old-established courses—the product of age itself, lacking which the engineering courses of to-day are without a certain coherence. This will come, but none too speedily if the criticisms which Mr. Porter cites are to be spared by the interested public.

The practical business sense, claimed to be one of the absent qualities, is undoubtedly as much the result of insufficient training as are any of the other discrepancies. Dr. Humphreys, President of Stevens Institute of Technology, a prominent engineer, and a high authority on the value of business training as a part of technical education, in one of his numerous writings, treats the subject in the following way:—

"Self-evident should be the truth of the proposition that the engineer ought to be a man of business, or at least informed of, and prepared to conform to, business conditions and business methods. When this proposition is squarely laid before them, it is self-evident to the majority of successful engineers and men of business. Business men, bankers, and manufacturers not infrequently refuse their confidence to engineers and experts as a class, because, under trial, some individuals have demonstrated their incapacity to meet business conditions; from the standpoint of the man of business their reports, advice, conclusions have required interpretation and readjustment or amendment.

"The man so far somewhat exceptional, who is able to bring to the service of his clients or associates a sound technical training, and the ability to meet business conditions proves by his comparative success the material value of this dual capacity. For the sake of the profession and the country at large it is important that this broader capacity should no longer be exceptional.

"To this end the professional educator and the engineer-student must better recognize the conditions to be met in practice. A general and definite demand on the part of the business world for engineers of such broader capacity would ensure the necessary reform in the separate schools of engineering and the university departments of applied science."

ONTARIO LAND SURVEYORS.

The Association of Ontario Land Surveyors will hold its annual dinner at the Engineers' Club, Toronto, on Wednesday evening, February 18th.

LETTER TO THE EDITOR.

Paving Streets With Creosoted Wood Block.

Sir,—Creosoted wood block paving, while comparatively new in many Canadian cities, is, in reality, not a new idea nor a new pavement. It is the result of combining two ideas, both of which in themselves had proved successful long before the first creosoted wood block pavement was laid. The ideas are: first, that of using wood as a paving material, and second, that of chemically preserving wood from decay.

For many decades wood was used as a paving material, sometimes in the form of cylindrical blocks cut from poles, best represented by the cedar block pavement. Both of these pavements gave great satisfaction because of their noiselessness and their adaptability to all kinds of traffic. But they were short-lived owing to the attacks of decay. Even in the face of this, many cities persisted in laying them because their many merits recommended them despite their lack of durability.

While wood block pavements were decaying and many cities were being forced to abandon their use for that reason alone, there was being developed a science which was destined to remove this objection to wood paving. This was the science of wood preservation. Railroads were preserving their cross ties and bridge timbers, while preserved piling, driven in the tepid waters of the Gulf of Mexico, where it was subject to the attack of the sea worm, was found to last almost indefinitely.

Many chemicals have been used to preserve wood, but only two seem to meet all requirements. They are creosote oil and chloride of zinc. Creosote oil, alone, is adapted to the preservation of wood paving blocks as, in addition to preventing decay, it also seals the pores of the wood, prevents the absorption of water, and does not leach out the blocks.

The application of timber preservation to the use of wood as a paving material has developed a street pavement which possesses more points of merit than any other material.

Many standards of excellence for a street paving material have been offered by writers upon this subject. The following is believed to be a fair standard by which to measure any material:—

(1) Its initial cost must not be so high as to make it unreasonable to the abutting property.

(2) Its durability must be sufficient to make its maintenance and ultimate cost low.

(3) Its surface must be smooth and hard and yet afford sufficient foothold to horses.

(4) It must be as nearly noiseless as possible, neither producing noise under traffic nor echoing other sounds.

(5) It must be so constructed as to be quickly laid and easily replaced when cuts are made.

(6) It must be of such material as to give off no dust or mud of its own creation.

(7) It must present no obstructions to cleansing, such as crevices, and be easily flushed and scrubbed.

(8) It must present a surface which offers no resistance to wheel traffic passing over it.

(9) It must not injure horses' legs and hoofs nor be injured by horses' calks or motor car traffic.

The initial cost of a pavement is an important item and yet not always as important as one might be lead to believe. In purchasing a street pavement, as in buying merchandise, the nature and length of service should be taken into consideration. The initial cost of a creosoted wood block pavement is so low as to make it reasonable for any street and the service it will give makes it the best possible investment for the property owner.

Durability is one of the prime requisites of a street pavement. Once a street is paved it is always to be a paved street. If the pavement is not durable the time will soon come when a new pavement must be paid for. The only test for durability is experience. In this regard, creosoted wood blocks have an enviable record. It is probably the only form of pavement that has never worn out or been replaced by another. Streets paved 12 or 14 years ago with this material are in as good condition to-day as they were the day they were opened to traffic. The splendid durability of the pavement makes its ultimate cost lower than that of any other form of pavement known.

In addition, the quality of service given by the creosoted wood block pavement is so much higher than that of any other form as to increase the advantage of the material over all others.

For that reason many cities have adopted the policy of paving down-town business streets, where traffic is tremendously heavy, with creosoted wood block. The practice was the result of the experience of London, Paris, and other European cities, and the results obtained in American cities have been fully up to expectations. The service given by the Broadway pavement in New York and several heavy traffic streets in Chicago proves the truth of this assertion. The peculiar quality to resist the effects of traffic possessed by creosoted wood blocks, placed with the grain vertical, gives the pavement first rank in point of durability.

Street pavements are laid to be travelled upon. Their chief object is to present a smooth surface for traffic and one which will bear the wheels of passing vehicles with little or no obstruction. The very purpose in view should preclude the use of any material which is not smooth and hard. Creosoted wood blocks possess this quality to a higher degree than any other material and yet afford a sufficient foothold for horses.

Every modern city is experiencing a laudable crusade against unnecessary noises within its limits. Everyone commends legislation preventing needless blowing of whistles and ringing of bells. Creosoted wood blocks make practically a noiseless pavement, frequently called the "silent pavement." Their adoption on many busy streets has resulted in increased rents for space in abutting buildings owing to the decreased noise by the traffic.

Yet, this success of a creosoted wood block pavement depends upon the way it is laid. If the blocks are laid on a solid foundation with ½ to 1 in. sand cushion and the pavement given plenty of room for expansion and pitched to prevent water getting under it, no trouble will be experienced and the pavement will be ideal. But when the pavement is laid crudely by men who are not familiar with it, trouble must always result.

When trouble of this kind does occur, it is published throughout the country by knockers, but if the actual fact, viz., that it was the crude way the pavement was laid, were known, it would be different, and people would understand why trouble has occurred. Every time a pavement heaves it is caused by the crude way the pavement was laid. Such is the case with the creosoted wood blocks laid on the Bank Street bridge at Ottawa, an account of which was published throughout Canada. It was a certainty that the pavement on the Bank Street bridge would expand and heave and that the blocks laid near the street car rail would either be loosened and come up or break. No expansion joints had been put in the sides at each curb; the blocks had been laid too closely and instead of the blocks next to the rail having been bevelled and set right against the rail, strips of untreated timber merely had been put alongside of each rail. These strips would absorb water, expand, rot and disintegrate. The blocks were laid up tight against the strips, leaving a space of 1½ in. wide and 2 in. deep between the rail and the edge of the pavement between the tracks. During a heavy rain-storm the water would run down alongside the rail and get under the pavement, causing it to expand and heave.

The space between the pavement and the rail permits the wheels of carriages and light wagons to get into this space and loosen or tear up the blocks.

When properly laid, great success has been experienced with wood block pavements. In the large cities on this continent, each having laid hundreds of thousands of yards during the past 13 or 14 years, most of them are without any repair bills whatsoever to date. For instance, Hamilton, Ontario, has laid since 1908 over 285,000 sq. yds. and has had absolutely no repair bills. Compare this, for instantce, with the maintenance charges in Ottawa on the Bank Street pavement, from Wellington Street to Gladstone Avenue; and on the St. Patrick Street pavement from Dalhousie Street to the St. Patrick Street bridge. On the Bank Street pavement $49,848.66 was spent by the city since 1907, in addition to the maintenance expenditures made by the contractors. On the St. Patrick Street pavement, which was completed in 1911, the city spent $344.90 in 1912, and $1,696.88 in 1913; these amounts being in addition to the maintenance expenditures of the contractors.

A minor portion of these expenditures was on account of cuts for water and gas service, etc., but the cost of such cuts in dealing with a block pavement is greatly less than in dealing with a sheet asphalt pavement, such as was laid on the two streets above mentioned.

There has been considerable objection against creosoted wood block on account of Canadian climatic conditions, but when our pavements have been excellently successful in Moose Jaw, Denver, Minneapolis, Duluth and St. Paul, with a temperature running from top summer heat to from 30 to 60 deg. below zero in the winter, this point would seem to be answered by practical experience. In Ottawa, there is a properly laid pavement constructed of blocks that were merely dipped—not even properly creosoted—which has withstood Ottawa's climate for 8 or 9 years and it is in fairly good condition to-day. Several streets in Montreal have been properly laid with the dipped creosote wood blocks and these streets have been in fairly good condition with the exception of the blocks decaying on account of moisture getting beyond the point of oil.

In the city engineer's report to the council of Ottawa, he recommends the expenditure of over $3,000,000 for pavements, including merely $900,000 for permanent roads, namely, asphalt and stone blocks. In the light of statistics throughout Canada and United States, the repair bills on the remainder of the paving recommended would be enormous. Taking statistics in these countries, creosoted wood block pavements show no cost for maintenance with the exception of a few cities, and these few cities' statistics show maintenance cost almost nil. With the large amount of creosoted pavement laid on the principal streets in all of the larger cities in the United States, without having one pavement to show much of a wear over ⅛ in., should cause the engineers in the large cities of Canada to study carefully the qualities of creosote wood block pavements.

E. S. CLEMENTS,
Canada Creosoting Company.

Toronto, February 5, 1914.

THE CIVIL ENGINEER AND HIS RELATIONS TO SOCIETY.*

By Sam. G. Porter, B.A., B.S., M.Am.Soc.C.E.
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THE engineering profession is constantly meeting with these criticisms with regard to its members: 1st, That they are narrow in their mental training and habits. 2nd, That they are lacking in practical business sense. 3rd, That they are too little interested in the welfare of the community, or of society.

Let us ascertain what justification there is for these criticisms and how they should be met.

Narrowness.—Most engineering students confine their energies to strictly technical topics and take under protest what few subjects of general culture are forced upon them. As a consequence, they graduate and enter upon their work with little knowledge of what is termed the humanities. Having chosen a work that calls for technical skill, they naturally give their attention to the questions which will advance their usefulness and professional standing. Furthermore, their work, especially in their early years, usually leads them away from, rather than into, contact with social and commercial influences. They are pioneers, they are on the firing line, always advancing before they are permitted to enjoy the civilizing results of their own conquests. How natural it is, then, that they should acquire habits of thought and action out of sympathy with the social problems of the day—not in the sense that they are antagonistic to social and political progress, but are merely negligent and apathetic towards them.

To the extent that this habit predominates is the criticism of narrowness justified. Our profession is worthy of the highest possible respect; the possibilities of attainments in it are unlimited; a devotion to its ideals is to be encouraged; but to put it on a pedestal and overestimate its value to the exclusion of an appreciation of other things is undoubtedly a sympton of narrowness.

Lack of Business Sense.—If the first criticism is established, the second and third will naturally follow as corollaries.

Some of the qualities and conditions which have been pointed out above as tending towards narrowness, should, if properly applied, bring about the opposite result. The engineer is trained to be exact, to be accurate, to consider all the elements of a problem before arriving at a conclusion. He is in daily contact with inexorable laws. He must study nature's forces and combat or utilize them.

If, however, the exercise of these duties appeals to and develops only the technical side of his nature, a big part of the lesson is lost.

The failure of engineers to reach a high rank in practical matters and in influence is not always through want of technical attainments. More often it is through a lack of a broad outlook, an appreciation of the true proportions of things, a right perspective of practical values. The man who keeps his eyes too closely riveted to the technical problems is too apt to lose sight of the practical ones. He will not be trusted, and in fact, is not qualified to be trusted with the broader, practical questions which are usually the dominating ones. The man who solves them is the man who becomes boss.

*Read before the Calgary Branch of the Canadian Society of Civil Engineers, January 23rd, 1914.

In addition, then, to technical attainments, honesty and energy, which we will assume that most engineers have and which we will not here discuss, he must have (a) a broad outlook, (b) a right perspective of practical values, and (c) a well developed sense of personal responsibility. Without these qualities he may make a useful man, even a necessary man, but not a great man; not a leader. But if he has these qualities in addition to the first and is trained, as we presume he is, in the accurate observation and application of the laws of cause and effect, he should forge well to the front as a leader of affairs.

A Broad Outlook.—Too seldom is it the engineer who can be credited with the conception of the plans for big enterprises. Or, if he conceives them he seems to lack the leadership necessary for putting them into effect, and some trained intellect, with executive ability and a comprehensive grasp becomes the controlling brain of the head. Then the engineer is hired to work out the details of projects which others direct and benefit from.

A man of broad experience who knew whereof he spoke, said: "It is far easier to hire engineers than to hire men." Why is this true? Why do so many engineers allow themselves to be mere units in a system or cogs in a machine to be used by other men? Why, unless this second criticism is justified, have they not enough personality, enough force of character to direct and to control affairs instead of always being the hired man? Why do they not hire lawyers and financiers instead of always being hired?

It is estimated that more than 90% of the skilled labor of the world is directed by engineers. And yet the engineers are not in many cases actually the bosses. They are only hired superintendents taking their orders from the men who are blessed with this broad grasp of practical affairs and with ability for leadership.

A Right Perspective of Practical Values.—As used here "perspective" means placing things in their proper relations to each other; giving them their proper relative values. Some men never arrive at an appreciation of this essential element. They can never distinguish between the essential and the non-essential; between the fundamental and the ornamental. Unfortunately, some engineers have this failing in respect to practical, or business matters. They have no business judgment. They have no appreciation of values. They are the ones that bring upon the profession the criticism that its members are lacking in practical business sense. Of course, the same accusation is true of members of all other professions. But we are engaged here in self analysis and will not permit ourselves the satisfaction of hiding behind the faults of others.

Even if the engineer does not aim to be a commercial manager, but confines himself as a specialist strictly to the engineering branch of his profession, still his practice must be in harmony with the commercial conditions of his specialty.

Someone has defined engineering as a "compound of common sense and mathematics." This is a good definition to bear in mind.

A Sense of Personal Responsibility.—A general fault of the times, not restricted by any means to engineers, but one of which they are also guilty, is the lack of a feeling of responsibility on the part of the individual. It is an entirely too common a procedure to shift responsibility from one shoulder to another, and to get into the habit of looking upon all mistakes as being the other fellow's fault. More effort is frequently expended finding reasons why one is entitled to be excused from doing his full duty or bearing the responsibility for a failure than in an honest effort to meet his obligations. The mental habit of self-justification for mistakes committed is an evidence of weakness of character.

Such a tendency is an outgrowth of a lack of discipline which is manifest in our modern institutions of all kinds—commercial, educational, and political. It, in turn, has grown out of an abuse of the principle of personal liberty. An extreme example is seen in the socialistic idea that has been advanced in many of our cities that one is not personally responsible for making an honest living, but is entitled to be supported by the community.

Responsibility is a cumulative quality. Coupled with discipline it makes the individual responsible to his chief, and his chief responsible not only for himself but for those under him. Thus it extends from the lowest to the highest rank, no one being excused from its operation. Without it, efficient organization is impossible.

One who is lacking in this particular quality of honesty, which has here been called the sense of personal responsibility, is not likely to acquire the full confidence of his associates. Business organization makes it necessary that one in an important executive position see most of the facts regarding the work for which he is responsible through the eyes and the brains of other men—his subordinates. The subordinate, then, must be not only accurate in his observations, but honest and loyal in his mental attitude with respect to the obligations and responsibilities which rest upon him.

Present Tendencies.—A study of the present day activities of the business world shows that the place filled by engineers is rapidly enlarging. The engineering professor is passing from the period in which mere design and construction are its sole duties, into a much broader field—and the engineer's influence will broaden accordingly. He is essentially an economist, an adjuster of business relations and investments. Commissions for appraisals, valuations and public management are calling more and more for engineering services, and in turn making the engineer more of an economist and business manager.

It is gratifying to note this tendency on the part of engineers to qualify for business administration. It is also gratifying to note that the public is beginning to recognize their worth. Some notable examples have recently occurred of the public confidence in the ability of the engineer to administer big business affairs with surer integrity and greater efficiency than can be expected through the usual political administration. The City of Dayton, Ohio, has recently created the office of City Manager, and offered Col. Goethals, Chief Engineer of the Panama Canal Commission, a salary of $25,000 a year to take the job. He declined their offer, but another engineer was appointed to the position at a salary of $12,500. The City of Ottawa has recently made a contract with Sir Alexander Binnie, the well-known English engineer, whereby it turns over to him for the remarkable fee of $400,000 the entire engineering and administrative control of the design and construction of their proposed $8,000,000 waterworks system. The point to be emphasized here is not the big fee, but the evident inference that the city recognizes the advantage of an engineering administration over a political one. Lethbridge, the first city in Western Canada to adopt the commission form of government, has just elected three commissioners, all of whom are engineers.

"A former mayor of the City of New York, in testifying before a legislative committee, made the statement that if he were to be confined in his selection of heads of departments to men who could assume their duties and be prepared at once to administer the work of the several departments efficiently without devoting a considerable part of their term of office to learning what was expected of them, he would be obliged in a large proportion of cases to name civil engineers."*

Public sentiment is steadily growing more favorable to the engineer in respect to his appointment to responsible public positions. This sentiment is being aided by the various engineering organizations of the country, especially by the American Institute of Consulting Engineers, which has been conducting an active campaign along this line. Evidence of the betterment of conditions affecting the opportunities open to engineers is also seen in the great increase within recent years of the numbers of engineers holding positions of administrative and executive responsibility with railroad companies, and with other big business corporations. A few years ago engineers were not considered practical enough to fill such offices as that of business manager or president. Now, scores of them are held creditably by engineers.

Another fact bearing on this point is the vast increase in the last few years of the amount of construction work done directly under the direction of engineers instead of the old-time "practical" contractor. Notable examples are the Panama Canal and the Los Angeles Aqueduct. The prejudice which formerly existed against engineers and kept them out of the business side of construction has so far disappeared that nearly all the big contracting firms are either entirely controlled by engineers or depend largely upon engineering advice for guidance.

All these are favorable symptoms and tend to broaden the scope of the engineer's opportunities. In recognition of the demands for competent engineer-managers, some of the engineering schools, notably the Massachusetts Institute of Technology, are offering courses in engineering management to prepare engineers for executive positions. Let us hope that a healthy progress in this direction will continue and that engineers will prove themselves able by demonstration to refute the criticism that they are lacking in practical business sense.

Citizenship.—Coming now to the last of the three criticisms—that the engineer is too little interested in the welfare of the community, or of society, there is much to be said.

Modern progress is to a large extent a monument to the engineer. He, more than any other class of men, has been responsible for the marvellous advance made during the past century. Means of transportation and communication and the development of power, are the chief factors in creating modern conditions and these are largely the work of engineers. This being the case, why do engineers occupy a position of so little prominence in the conduct of public affairs? The number of engineers who have become notable for their activities and influence in the political and social affairs of their country is few, deplorably few, in comparison with the importance of the engineer's work in modern civic life.

One reason, of course, is that they are usually employed temporarily for a specific piece of work and when it is completed they move on to something else, thus ob-

*Extract from an address by Dr. N. P. Lewis, M.Am.Soc.C.E., on "The Engineer as a Professional Man."

taining no material footing or interest in a community. This is more generally the case than it should be. It leads to the complaint among engineers that they do not receive due praise and credit for their work. What else is to be expected when they are so quick to fade into the background and leave the lawyer and the politician not only to manage the works they create, but to mould and direct public thought.

The expenditure of public money is an important part of the administration of public affairs. It is notorious that large sums of public money are squandered on great public works because they are done in an inefficient and uneconomical way. Engineers see and recognize this more than other men. I do not mean to convey the idea that it devolves upon them to do routine professional work for the public without compensation, but a lively interest and a properly directed influence may do much to correct the evils. Their judgment should be a much more prominent factor in moulding public affairs. What is needed is a habit of mind among engineers that will cause them to take an active part in all public questions where their knowledge and experience will enable them to contribute to the common good. Let them advise the legal profession and the legislator in forming laws governing public utilities and guarding the public health. Let them become leaders in the affairs of their government and promote the highest efficiency in its work. The influence of the professional man—the man with the right professional spirit—is needed in the direction of public affairs as well as in corporate management. The professional spirit is essentially the sense of trusteeship. The professional man takes in trust the affairs of his client. It is closely akin to what I have called the sense of personal responsibility.

The great problem of the twentieth century is a social problem. The manifest tendency of the times to put more and more power into the hands of the ignorant and uneducated, while being done in the name of personal liberty, is endangering the high standards and efficiency of our institutions—a tendency towards deterioration. The engineer's training should enable him to see things as they are, to see through the shams of socialistic theories that profess to offer a cure for all the ills that society is heir to.

I close with this sentiment: "To look upon politics and public service with contempt and disgust indicates neither intelligence, wisdom, nor patriotism, but rather ingratitude and a low order of citizenship. Your country needs your very best judgment upon public questions. This is not a mere privilege, it is a duty you owe the nation in return for the benefits of citizenship."

The Scottish District of the Institution of Municipal and County Engineers have been discussing the problem of road construction, and considering in particular the question of laying down some experimental stretches with different methods of construction, so as, if possible, to obtain data showing the methods that are best suited to the climate and the traffic. Experimental road sections are to be laid down in ten different places, and in each place eight different forms of construction are to be employed contiguously. So far as possible materials obtainable in the vicinity will be used, the binding materials will be uniform, and the gradients will be practically similar. In addition, the methods of construction will be simple and cheap, and quite applicable, so far as cost is concerned, to the districts in which the experiments will be carried out. Periodical examinations of the road surfaces will be made, the wear and tear noted, and records of the climatic conditions kept.

U.S. IRON AND STEEL INDUSTRY, 1913.

THE quantity of iron ore mined in the United States in 1913 is estimated by E. P. Burchard, of the U.S. Geological Survey, to have been between 58,000,000 and 60,000,000 long tons. This estimate is based on preliminary reports from 25 of the largest iron-mining companies, which represent the principal iron-producing districts and whose combined output is about 81% of the total iron ore mined in 1912.

The average increase in output shown by these 25 companies was 8% over that for 1912, and if this increase should be maintained by all the iron companies in the United States the total output of iron ore for 1913 should reach 59,500,000 long tons. At any rate, it appears almost certain that the former high record of iron ore mined, 57,014,096 long tons in 1910, has been surpassed in 1913. The reports received for 1913 showed considerable variation in the percentage of changes in output compared with 1912, the maximum range being from a decrease of 36% to an increase of 56%. These apparently wide variations were evidently due to conditions affecting particular companies rather than to general or even local conditions of the iron-mining industry; moreover, they concerned, for the most part, the operations of companies whose production is not sufficiently great to affect largely the grand total tonnage.

In Lake Superior district, where 85% of the domestic iron ore is mined, the increase in production corresponded closely with that of the United States in general, or about 8%, thus indicating a total production for that district of about 50,000,000 long tons, compared with 46,368,878 tons in 1912. The year 1913 is therefore a record year for production and shipments in this district also. The preliminary figures indicate that the shipments of Lake Superior ore by water will exceed 49,000,000 long tons, which, together with the all-rail shipments of more than 800,000 tons, brings the figures for total shipments of Lake ore very close to the tonnage of ore mined and indicates that not much change has occurred in the stocks of ore at the mines in the Lake district. These stocks amounted at the close of 1912 to about 9,500,000 long tons of ore.

In the Birmingham district, Alabama, the production of iron ore in 1913 as indicated by the preliminary returns was about 10% greater than that for 1912. In Tennessee there was apparently a slight decrease and in North Carolina a slight increase. New Jersey and New York both showed slight increases, while Pennsylvania showed a slight decrease. In the Rocky Mountain district of Wyoming, Colorado, and New Mexico there was a slight decrease.

The types of iron ore produced commercially consist of red and specular hematite, brown ore, magnetite, and siderite, or spathic ore. Hematite constitutes about 90% of the output. Only a very small fraction of 1% of the output is siderite, the production of brown ore and magnetite together constituting nearly 10% of the total.

ELECTRIC RAILWAYS IN CANADA.

There are in operation 1,308 miles of electric railways of the first class, main track; second class, main track, 295 miles; siding and turnouts, 121 miles. Total single track, 1,724 miles. The capital involved is $122,841,946, according to a Government report. The revenue collected for the year was $23,499,250, while the working expenses for the year were $14,266,674. The additions made to the capital during the last five years approached $50,000,000.

CENTRIFUGAL PUMPING MACHINERY

ABSTRACT OF INTERESTING PAPER ON THE GENERAL CHARACTERISTICS, POSSIBLE SERVICE, METHODS OF OPERATION AND LIMITATIONS OF CENTRIFUGAL PUMPS, READ BEFORE OTTAWA BRANCH CAN. SOC. C.E., FEB. 12, 1914

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IT is not my intention to deal in this paper with the hydraulic design of centrifugal pumps, but rather to endeavor to point out the general characteristics of these machines with reference to the best type of pump to use for a particular duty, to note the services for which these pumps are specially adapted, to give some description of the more general methods of operation, and to describe the limitations of this class of machinery in actual practice.

Characteristics of Centrifugal Pumps.—Centrifugal pumps (and under this heading are included turbine pumps) are regulated by the following general laws:

1. The quantity discharged by a pump, when running at constant speed, varies with the total head against the pump. (By "total head" we mean the head from all causes, including suction lift, delivery head, and head due to friction in the piping.) If the total head be increased (the speed being kept constant) the quantity delivered will be decreased; and conversely, if the head be reduced, a greater quantity of water will be discharged by the pump.

2. The efficiency of a pump running at constant speed varies with the output, and will reach a maximum under a certain condition of head and discharge. A pump which is running at this point is said to be giving normal output. For any given speed, there is a definite maximum possible head which the pump can overcome, and the normal output is nearly always a little below this point.

These general laws have limitations. For instance, the sides of the impeller are revolving in what is generally termed "dead water," and hence if the speed of the impeller is increased, the disc friction is increased until the amount of power absorbed in this manner becomes too large a proportion of the total power absorbed by the pump. When this occurs it is necessary to increase the number of impellers in the pump. One impeller delivers into the next and so on, the head being obtained in a number of stages.

In addition, care must be taken that "cavitation" does not occur. Cavitation may take place either on the suction side or on the delivery side of the impeller. The effect of cavitation is generally overload on the driving machine and unstable delivery by the pump, and in serious cases the pump will stop working altogether. On the suction side, cavitation is caused chiefly by the suction lift being carried beyond the practical limit. On the delivery side, it is most often met with in centrifugal pumps with guide-vanes, (i.e., in that class of pumps generally known as turbine pumps). In these pumps it is generally due to badly designed guide-vanes, or to the pump being used to deliver a quantity of water far in excess of the normal output for which the pump is designed.

Curve No. 1 gives the variation of head and quantity in a pump running at constant speed. This type of curve is generally called the "characteristic curve" of a centrifugal pump, and is the most usually adopted method of showing the performance of a pump graphically. The actual curve shown is one selected at random from a number of test curves, but for convenience we have called the point of normal output 100, so that the quantity delivered, head, efficiency, and brake horse-power for any other point of operation may be read off as a percentage.

Taking, therefore, the normal point of the curve as 100, then at 75% of the normal quantity, the head is 106% of the normal head, the efficiency is 97% of the normal efficiency and the b.h.p. is 84% of the normal b.h.p.

At 75% of the normal head, the quantity is 130% of the normal quantity, the efficiency is 85% of the normal efficiency, and the b.h.p. is 112% of the normal b.h.p.

From this curve, which may be taken as being typical of a well-designed centrifugal pump, it is seen that a good efficiency can be maintained over a wide range. Thus the capacity can be varied from 70% below normal to 120% above normal with a fall of only 5% in the normal efficiency. On looking at the b.h.p. curve, we see that the maximum possible power taken by the pump is only 17% greater than normal. This being so, it follows that a reasonably well-built motor will be capable, running at constant speed, of taking charge of any duty which the pump may be called on to perform at that speed. My firm have frequently built pumps in which there was practically no overload at all, but as a rule all that is necessary is to design the pump so that the maximum overload does not exceed about 10% to 15% or even 20%, as any motor with a good rating will stand this overload without damage.

An important point to notice in connection with centrifugal pumps (and this may also be observed from the curve) is that there is no possibility of damage to the pumps in event of the delivery valve being closed during pumping operations. Thus, on the curve shown, when the valve is closed the pressure is only 92% of the normal.

While the curve shown may be taken as being typical of a well-designed centrifugal pump, it is also possible by suitable modifications in the internal design to alter the features of this curve to suit particular requirements. Thus pumps can be built in which the variation of the quantity with head is large, and others with small variation, but pumps with large variation of quantity are susceptible to a heavier overload than those with small variation. It is not possible to combine maximum quantity variation with minimum overload, but while minimum overload can only be combined with moderate quantity variation, a very fair compromise can be effected in practice. It is often necessary to design pumps with a special characteristic to suit certain specified conditions. Thus, in the case of graving docks, the head generally varies from zero to maximum, while the dock is being pumped out, but by suitable design of the pumps the power can be kept approximately constant throughout the operation with the motor running at constant speed. The driving motor is thus running economically during the whole period of pumping, and the size and cost of the motor reduced to a minimum.

I have confined myself in these remarks on the characteristics of centrifugal pumps chiefly to the question of constant speed operation, because in Canada most of the electric current supplied is alternating, but a few remarks on the operation of centrifugal pumps at variable speeds may not be amiss.

To illustrate these remarks I have plotted curve No. 2 from actual test results. The first point to notice is that the speed of a centrifugal pump varies as the square root of the head and as the quantity delivered. The curve marked "normal," drawn through the points of maximum efficiency at each speed, is a parabola. Similar curves, the points on which all represent equal efficiencies, can also be drawn.

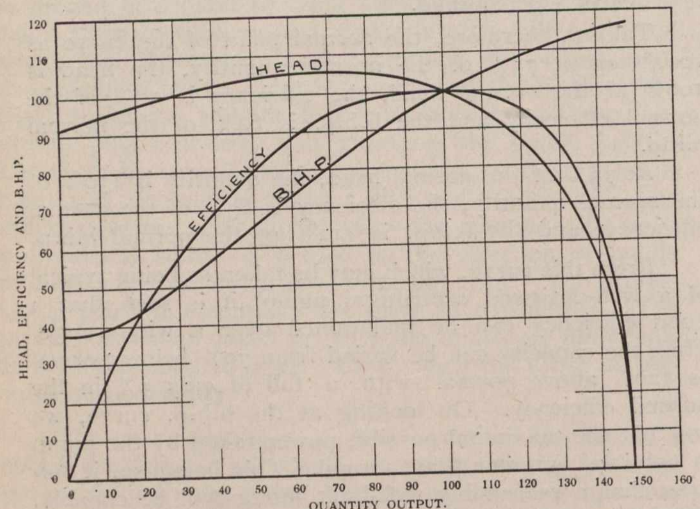

Fig. 1.—Characteristic Curve of Centrifugal Pump at Constant Speed.

Suppose a centrifugal pump is working at the point *G*, i.e., delivering 2,350 gallons per minute against a total head of 37 feet at a speed of 650 r.p.m., the efficiency being 78%. Now, suppose the speed is kept constant and the head is reduced to 30 feet, it will be seen that the quantity is increased to 2,750 gallons per minute and that the efficiency taken on the parabola has dropped to 70%. Now, suppose that instead of keeping the speed constant we reduce it till we get the head required, and we find that in doing so the quantity delivered has become reduced to 2,150 gallons per minute at the point *H*. The efficiency remains the same as it was at *G*. (In cases where the head is very greatly reduced this is qualified by the fact that the blade angles of the impeller are not quite correct for the lower speed.)

Now, suppose we are told that we must have the same quantity of water as before, but with the head reduced to 30 feet. Drawing the constant speed curves through the point *H* (i.e., the point where we had both the head and quantity reduced) and through the point *K* (i.e., the point where the head is reduced and the quantity remains the same as before) we find that we must now increase the speed by an amount, *J K*, or starting from the point *G*, the speed must be reduced by an amount *K L*.

The point *M* was where we got to by reducing the head at constant speed. The point *K* is where we get to by reducing the speed, keeping the quantity constant. It can, therefore, be seen that the most economical way to work under a varying head is to vary the speed, since the point *K* represents a better efficiency than the point *M*. Further, the additional quantity of water obtained at constant speed when the head falls, may not be desired; but if it is, then there is no object in varying the speed; should the additional quantity of water not be required, the balance of head can be made up by partial closing of the sluice valve, but the head taken up in the sluice valve represents that much wasted power.

Range of Application of Centrifugal Pumps.—Centrifugal pumps may be used under almost any conditions where it is necessary to deal with liquid or semi-liquid. There is such a wide range of uses that we will readily recognize that there must necessarily be a considerable variation in design between the various types of pump. Thus, where there is only a small percentage of gritty matter in the liquid to be dealt with, it is only necessary to make certain wearing parts of the pump easily renewable, but when the liquid contains a considerable amount of solid material of an abrasive nature, it is usually necessary to build a pump which is lined either partially or wholly in the interior. There is a good deal of divergence in the design of various makers of dredging pumps, and the designs of dredging pumps by the same maker will also vary according to the nature of the duty to be performed. Sometimes it is only necessary to line the pump at the sides, the volute being unlined, while it is often imperative to fit the whole interior of the pump with liners. There are duties where liners of the best manganese steel become worn through in a few weeks, so that it will be seen how necessary it is for a pump working under these conditions to be totally lined throughout.

Lay-out of Centrifugal Pumps.—An important point to notice in connection with the lay-out of pumping schemes is that hot or gaseous liquids should flow into the pump by gravity. When a pump is working on a suction lift it creates the vacuum necessary to overcome the suction lift. If, therefore, a liquid with temperature approaching the boiling point at atmospheric pressure has the pressure on it reduced on account of the vacuum created by the pump, the liquid will tend to vaporize, and if sufficient vapor gathers the pump will stop working. It should also be noted that the higher a place is above sea level, the less the atmospheric pressure becomes, and consequently the possible suction lift of the pump is reduced in proportion. It should also be noted that the specific gravity of a liquid or mixture does not affect the total head dealt with by a centrifugal pump impeller, but it only affects the power necessary to raise the liquid (and of course the pressure in the pump). Thus a centrifugal pump running at a given speed would raise a liquid having a specific gravity of 1.2 to exactly the same height as it would raise water of unit specific gravity, but the b.h.p. taken would be 1.2 times as great and the pressure in the pump would also be 1.2 times as great.

In connection with these remarks on the lay-out of centrifugal pumps, I am fully aware that some of the matters touched on may seem somewhat elementary to those who are familiar with this class of machinery, but as it has frequently happened that an oversight in what may seem a small and obvious item in the complete design of a pumping plant has been overlooked in the general arrangement, I feel that on this account and for the benefit of those who have not been in touch with this class of work, I am justified in elaborating these matters.

In order to make the suction lift as small as possible, centrifugal pumps should be placed as close to the water as possible. Where there is a suction lift, the pipes should be as short and direct as possible, and should always incline upwards to the pump. If this is not possible they may be horizontal, but they should never dip downwards as this may allow air pockets to be formed with consequent unsatisfactory working. I have come across cases where air pockets have been unavoidable, and it has been necessary to keep the highest point of the suction pipe in communication with a condenser or vacuum pump. As a rule it is not advisable to exceed a suction life of 20 ft. including friction, but where it is necessary to go beyond this, the suction pipe line should be tested to a pressure of 30 lbs. per inch and should be absolutely tight under this pressure. It should be remembered that the effect of air in a centrifugal pump is to reduce the quantity of water delivered.

Suppose a volume of air, Vo, obtains access to the suction pipe, then at a pressure P this volume becomes

$$V = Vo \frac{Po}{P}$$

where Po is the pressure when volume is Vo. As the orifice in the pump is fixed, then when working at constant speed, if solid water is being dealt with, the volume delivered against a given external resistance has a given value, but if air is also present then the volume is reduced by V (the volume of air at the given point of minimum pressure). It follows, also, that as the characteristic is developed from zero quantity to maximum quantity the vacuum will increase so that the result generally is a reduction in the equivalent orifice due to the greater expansion at higher vacuum and increased air quantity. The effect is shown graphically on curve No. 3 and it can be seen how serious this trouble becomes at the larger quantities. The ultimate result of excessive air leakage is that the water column becomes broken on the suction side and the pump will stop delivering. Where the water flows into the pump under a head, if it is impossible to avoid loops or pockets, it is advisable to place an air cock at the highest point of the pocket to release the accumulated air.

The speed of water in delivery pipes should not exceed about 500 ft. per minute unless the pipe line is very short. It frequently happens that the output of a centrifugal pump with a certain size of delivery or suction branch is much too great for the pipes to be made the same size as the branches. In such cases it is advisable to fit taper pipes next the pump branches. The length to make these taper pipes to give the best results is given by the formula

$$\text{Length} = \frac{D - d}{2 \times 0.12}, \text{ approximately equal to } 4 (D - d)$$

Where D = diam. of large end in inches

d = diam. of small end in inches

0.12 = constant representing tan $6° 50'$.

(This angle of about 7° has been found by experiment to be about the best for water.)

Where centrifugal pumps are working on a suction lift it is necessary to charge them (and the suction pipe) with water. There are two methods of doing this:

(1) To withdraw the air from the pump casing and suction pipe, thus causing a vacuum which becomes filled with water from the suction tank or sump.

(2) To place a foot-valve at the bottom of the suction pipe and fill the pump and suction pipe with water.

As examples of the first method we have the steam ejector, compressed air ejector, and ejector operated by water. Any of these ejectors may be used according to the facilities offered. The ejector is generally placed on the top of the pump casing and when the pump and suction pipe have become filled with water the steam, compressed air, or pressure water is shut off and the centrifugal pump started up. The air in the suction pipe and pump may also be withdrawn by means of a vacuum pump. This is operated by hand or power according to size. In the smaller sizes of centrifugal pump, the air pump is often attached to the pump bedplate but in the larger sizes where power is required it is generally made an independent unit. In the case of intermediate sizes, it is sometimes driven from the centrifugal pump spindle by means of a belt or chain.

In the second method, the foot-valve should be placed sufficiently far below the surface of the water to ensure that "solid" water is obtained under all conditions of pumping. Where pumps are charged by means of a foot-valve there is another point which it is important to notice. Suppose a pump is running and the driving motor stops suddenly, due to the blowing out of a fuse or from some other cause, then if the pump is fitted with a foot-valve the column of water in the delivery pipe drops down and closes the valve. It can be readily understood that in cases where the static head is considerable, the pressure caused by this column of water being suddenly brought to rest may become very great, and as the pump casing is generally weaker than the pipes on account of its larger diameter, there is great danger of the pump being burst and destroyed. It is, therefore, necessary where the static head (including suction) is greater than 30 or 40 feet, to fit a check valve on the delivery side of the pump. It is often handy to fit this valve with a by-pass which can be opened for the purpose of charging the pump.

The design of the foot-valve selected should be such that the flap can be easily raised by the centrifugal pump, as if the flap is too heavy the valve does not come fully open and the pump will not deliver its full quantity. In fact, cases have occurred where the centrifugal pump could not open the valve at all on account of the excessive weight of the flap. Foot-valves should always be chosen so as to give a clear area through them at least equal to the area of the suction pipe. In large sizes foot-valves, where used, are generally of the multiple flap type, though it is usual to employ one of the other methods of charging for large centrifugal pumps. Strainers are nearly always fitted to the suction pipes, and these should always be of large area.

Some Types of Centrifugal Pumps.—Centrifugal pumps may be broadly divided into three different classes, according to the head to be pumped against, and I shall give some illustrations showing variations of these classes.

Class I.—Ordinary centrifugal pumps for heads up to about 150 feet.

Class II.—Twin series centrifugal pumps for heads up to about 300 feet.

Class III.—Turbine pumps, i.e., centrifugal pumps having fixed guide blades in the pump casing and suitable for pumping up to the greatest heads.

In cases where the suction lift would be too great for the pump if placed on the ground level, or where on account of the expense of excavating a larger well, or where on account of risk of flooding it would not be advisable to place the motor down along with the pump, vertical spindle pumps are adopted. Thus, where sewage has to be pumped, the liquid should flow into the pump by gravity, as gas is given off more freely in a partial vacuum, such as occurs in a pump working with a suction lift. In these cases the motor is kept on ground level and the pump spindle is connected to the motor spindle by means of vertical shaft fitted with suitable intermediate guide bearings. The weight of the motor spindle and armature is taken by the motor thrust bearing, and a common way to support the vertical shaft is by means of a thrust bearing contained in the cast iron steel supporting the motor. A flexible coupling is generally fitted between the motor spindle and the vertical shaft and sometimes also between the vertical shaft and the pump spindle. Where this is done it is necessary for the pump to be provided with a bearing to take the weight of the pump spindle and impeller, but where the lower flexible

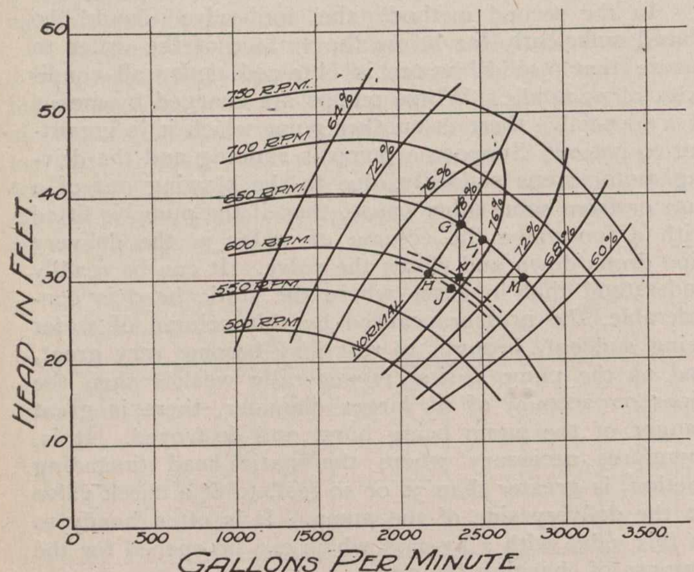

Fig. 2.

coupling is discarded and solid coupling fitted, the weight of the rotating parts of the pump is taken by the thrust bearing in the motor stool.

In cases where there is a very considerable rise and fall in the level of the suction water, say, greater than 20 to 25 feet, where there is a difficulty in charging the pump, or where for the sake of convenience it is advantageous to do so, the vertical spindle pump may be totally submerged. In such cases the pump is fitted with bearings of lignum vitae which are lubricated by the water, and any of the intermediate bearings which are likely to become submerged are also fitted with lignum vitae and arranged with a water service for use when these bearings are not submerged. With submerged pumps, the lower flexible coupling is done away with.

With all vertical spindle pumps, it is most important that the foundations and floor are rigid so as to prevent any possibility of relative movement between the pump and the motor. It is, of course, essential that the shafting be properly aligned. As my firm have built vertical spindle pumps having shafts up to eighty feet long it can be readily understood that there is a considerable range for pumps of this type.

Then, there is also what is termed a "multi-rotor" pump. One of these pumps recently built had six impellers all on the same shaft. When driven by an exhaust turbine at a speed of 2,500 r.p.m. it delivered 8,000 gallons per minute on a total head of 25 feet. Each of the six impellers passes its share of the water against 25 feet head, the water being split up in this manner to enable a high speed to be obtained on low head with a large quantity of water, thus making the turbine drive practicable. The pump casing is horizontally divided so that the whole of the inside of the pump can be inspected by lifting off the top half. Special diffuser pipes are fitted on the suction and delivery in order to maintain a good hydraulic efficiency.

Twin series pumps consist of two centrifugal pump casings bolted together. The first pump delivers into the second and thus for a given speed double the pressure is obtained from a twin series pump as compared with a single pump. In some cases, it is found more convenient to have a motor between two single pumps, one at each end of the bedplate, and by a suitable arrangement of piping and valves, the pumps can be put either in series or in parallel. This is an excellent arrangement where it is desired to have pumps suitable for either domestic or fire service as required.

The pumping plant supplied for the City of Edmonton, Alberta, is an example of twin series pumps. There are two sets of twin series pumps, each driven by an auto-synchronous motor of 850 b.h.p. at 900 r.p.m. Each pump, when working by itself, gives an output for domestic purposes of 10,000,000 gallons per day (say, 7,000 gallons per minute) against a pressure of 110 lbs., and when the two pumps are put in series, the combined output of the plant for fire purposes is 7,000 gallons per minute against a pressure of 160 lbs. The pump casings are fitted with gunmetal liners to prevent corrosion, the pump covers are fitted with impeller bearing rings, the impellers are of phosphor bronze, and the spindles are of nickel steel fitted with gunmetal sleeves.

In ordinary centrifugal and twin series pumps it is most important that the pump volute should be properly designed in order to reduce the speed of the water after it leaves the impeller in such a manner as to get the greatest efficiency from the pump, and, of course, the impeller has to be designed so as to give the water the correct velocity (including the correct direction) both at entry and at exit. In the case of turbine pumps, the water, when it leaves the impellers, is taken charge of by fixed guide vanes. These guide vanes must not only have the correct angle for the water leaving the impeller,

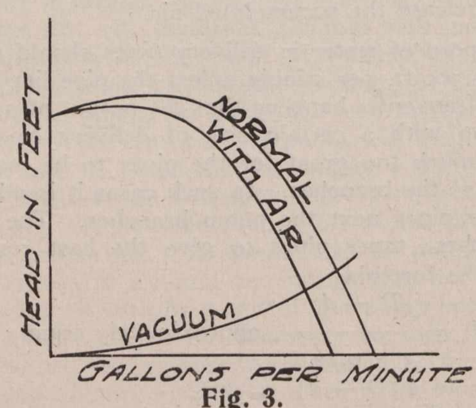

Fig. 3.

but they must also be of sufficient radial depth to ensure that the proper amount of velocity is converted into pressure head. If the guide ring is too short there will be a loss of efficiency due to the water not being sufficiently slowed down before passing from the vanes. If, on the other hand, the guide ring diameter is made very large, the weight of the pump (and hence the price) becomes excessive, and a compromise has to be struck, the practice varying according to the ideas of the respective manufacturers. Guide vanes are generally made of hard phosphor bronze, or some other similar material to prevent corrosion. When guide vanes become worn, the efficiency of the pump falls and as the vanes introduce an additional element of wear in the pump, where the head is not too great twin series pumps may be used with advantage since they have no guide vanes and can be made with practically as good an efficiency as the turbine pumps.

The impellers of multi-stage turbine pumps are generally of the single suction type. The most common ways of taking up the end thrust are by an automatic hydraulic balancing device or by a mechanical thrust bearing. Where the water to be pumped is clean, the hydraulic balancing device works very well, but where the water is gritty a good deal of wear takes place, and it is often found advisable to use the mechanical thrust bearing which very often takes the form of double-acting ball thrust bearing on the end of the pump shaft. Most hydraulic thrust bearings are built on the following lines: A disc which may be termed the piston is attached to the pump shaft inside the casing between the impeller of the last stage and the delivery gland, and this piston has a small chamber behind it. On the side nearest the impeller the disc has a working face corresponding to a similar face on a distance piece attached to the pump casing. If the pressure in the last stage is greater than the pressure behind the piston, the faces tend to move apart and the pressures are equalized and vice versa. This automatic regulation, based on difference of pressure, can, of course, be carried out in a number of different ways, and where the water in the pump is clean it has proved very satisfactory.

An example of this type of pump is the installation at Renfrew, near Ottawa. This pump is a 12-inch one, with four impellers, and is driven by a water turbine. The pump casing is sheathed with bronze, impellers and guide vanes are of phosphor bronze, and the spindle is of nickel steel sheathed with gunmetal. Automatic hydraulic balancer is fitted. Flexible coupling is fitted between the pump shaft and the turbine shaft. Some tests taken on this pump a fortnight ago, after about 18 months' operation, show that at the required speed of 590 r.p.m., the quantity delivered is fully 10% in excess of that called for by the specification, and the head pumped against 4 lbs. higher than the guaranteed figure.

Turbine pumps driven by a compound enclosed forced lubrication engine through double helical gearing, contained in gear box, are coming into greater favor. A two-stage pump of this kind, built recently for a head of 400 feet, runs at a speed of 1,200 r.p.m. The engine runs at 400 r.p.m., the gear ratio being 1 to 3. This is interesting, as showing how a suitable pump speed may be obtained from a slow-running steam engine, or from a water turbine where low head limits the speed. Well-made double helical gears contained in gear boxes have shown themselves to be thoroughly reliable, as indicated by the increasing extent to which they are being taken up for marine propulsion, enabling the turbines and propellers respectively to be run at their most economical speeds, and well-designed gears of this type are wonderfully quiet. So far as I can judge, helical gearing for high-speed machinery does not appear to have been adopted extensively in Canada, but I have no doubt that it will find considerable favor in the future on account of its convenience and adaptability where it is difficult to work in direct-coupled pumps, and particularly in cases where, if direct-driven, the low speed of the driving motor would necessitate the supply of a large and costly pump.

The Canada Cement Company announces that, owing to the dullness of business, they have decided to close down four of their plants for the balance of the year 1914, or until further notice. The plants affected are those at Marlbank, Ont., Lakefield, Ont., Shallow Lake, Ont., and Calgary, Alta.

COAST TO COAST.

Guelph, Ont.—Last year's receipts to Guelph from the Guelph Junction Railway earnings, amounted to $42,000. compared with $34,850 in 1912.

Stratford, Ont.—The annual statement of the Stratford Light and Heat Commission shows a net surplus for 1913 of $10,218.35 on the account of the civic operating plant.

Galt, Ont.—In January, the Galt hydro-electric department made 88 new installations of service. The total number of hydro power consumers in that municipality is now considerably over 1,600.

Stratford, Ont.—The report of the Perth county engineer, Mr. John Roger, for the year 1913 shows an expenditure of $25,592.63 spent in road construction, including draining; on bridges, $5,744.02; for machinery, $3,135.77; for county road superintendent and foreman, $2,133.35, making a total of $36,585.77.

Prince Rupert, B.C.—The floating drydock for the G.T.P. Railway and Steamship Company, upon which construction is commencing at Prince Rupert at a cost of $3,000,000, will have a lifting capacity of 20,000 tons, according to the plan furnished by William T. Donnelly. These also show a structure so designed that it is capable of operating in sections as a number of smaller docks.

Berlin, Ont.—The two electric pumps for the Berlin waterworks system have been installed, and are giving satisfactory service. They have a capacity of 800 gallons per minute, or 1,152,000 gallons per day, and are designed to pump against a head of 200 pounds. The pumps were manufactured in Zurich, Switzerland; and are connected with a gasoline engine to be used in case of emergency.

Vancouver, B.C.—Up to the end of 1913 the expenditure by the Greater Vancouver Joint Sewerage Commission amounted to $48,374.04, according to the statement issued by Mr. Frank Bowser, chairman of the board. It is expected that the expenditure this year will exceed a quarter of a million dollars. Also, steps are being taken to change the name of the board to the Vancouver and District Joint Drainage Board.

Victoria, B.C.—The auditor-general's report for the first six months of the current fiscal year, April 1 to September 30, was presented to the Provincial Legislature on January 22nd. The total expenditure for these months was $10,020,102.10, and included the following as some of its items:—Works and buildings, $1,292,680.28; roads, streets, bridges, and wharves, $3,115,787.19; subsidies to steamboats, ferries, and bridges, $32,077.15.

Ottawa, Ont.—A return tabled in the Dominion House of Parliament on January 28, giving the 7th report of the Commissioners for the demarcation of the 171st Meridian, west longitude, stated that the field work in connection with the whole survey in the Yukon is practically finished. 202 monuments mark the line from the Arctic Ocean to Mount St. Elias, a distance of 645 miles, and a vista 20 feet wide has been opened through all the timber.

Montreal, Que.—The annual report of the Ottawa Electric Railway Company for the year ended December 31, 1913, shows gross earnings of $1,041,282, an increase of $106,885, and net earnings of $412,160, an increase of $12,101. During the year, a large amount has been spent in improving tracks and rolling stock as well as other properties. Four short track extensions were laid, and two sub-power stations built. The record of the company shows an increase in gross receipts from $71,698 in 1892 to $1,041,282 in 1913.

Winnipeg, Man.—The second annual report of the Manitoba Public Utilities Commission shows that in the fiscal year ending November 30, 1913, the commission dealt with 43 formal applications, which devolved into 63 proceedings and orders, covering almost every phase of railway, water, light and power activities and the distribution thereof, and also covering corporate rights and financing such as transfers, increase and issue of stocks. There were also 34 separate proceedings and orders instituted upon the commission's own initiative.

Swift Current, Sask.—With the completion of Swift Current's storage dam, it is believed that the town's water supply should be assured for years to come. At least 80,000,000 gallons are now conserved for city purposes, and in addition a liberal supply is reserved for the use of the C.P.R. amounting to 3,500,000 gallons daily. The supply is obtained from the Swift Current Creek, which rises in the Cypress Hills to the south, and according to Government chemists is of unsurpassed purity and of a degree of softness that makes it especially suitable for manufacturing purposes.

Chilliwack, B.C.—The new concrete sluice has been installed and is in operating order at the Chilliwack pumping plant. Considerable trouble, due to quicksands, was experienced by the contractors for the work, Love Bros. & Shirley; but the difficulty was met by the driving of piles on both sides of the Semiault river, both above and below the gates. The bed of the river below the gates is also to be lowered and widened to the depth of the bottom of the Chilliwack river. This will minimize the danger of the bed of the Semiault filling up and rendering useless the automatic gates.

Ottawa, Ont.—The main estimates of expenditures by the Dominion Government for the coming fiscal year call for a total vote of $190,735,176. When the supplementary estimates have been added to this amount, it is expected that the total will exceed considerably the total estimates of last year, $202,656,166, of which the main estimates amounted to $179,152,183. In main estimates, this year shows an increase of $11,582,993. And it is expected that, with appropriations by special statute to be added, the grand total of expenditures authorized by Parliament will reach the quarter-million mark.

Saanich, B.C.—The report of the engineering department of Saanich has been presented by Municipal Engineer Topp to the Saanich council. It shows surveys and estimates in various branches of public works making a total since March, 1913, of $507,900; while the total cost of the engineering department for the 10 months was $4,193.22, or less than 1 per cent. of the total estimates furnished. Of the various items comprising the amount for estimates, the cost of grading a number of roads totalled $131,095; the cost furnished on plans for water supply in the districts close to Saanich, totalled $77,522; and the cost for drainage schemes, $5,010.

Victoria, B.C.—The public accounts of the province of British Columbia for the fiscal year ending March 31st, 1913, were placed before the legislature on January 15th. From these it is seen that the net revenue of the province for the year was $12,510,215.08, and the net expenditure $15,412,322.02, making a balance of expenditure over revenue of $2,902,106.94. The revenue for the previous fiscal year ending March 31st, 1912, was $10,745,708.82, and the expenditure $11,189,024.35. In the way of expenditure in 1913, among the largest items are: roads, streets, bridges and wharves, $4,790,461.24; works and buildings, $2,815,648.50.

Montreal, Que.—Montreal's 1914 programme of civic development provides for the laying of about 20 miles of permanent pavements, on central streets, and a large amount of macadamizing on suburban streets, at an estimated expenditure of about $1,500,000. The paving law which charged the cost of paving on the proprietors having been repealed, the city will have to take this amount out of the loan fund, unless new legislation is made by the council in the form of a local improvement tax or some other method of financing the work. Besides permanent pavements, the programme provides for an expenditure of $1,091,000 for sidewalks, $1,700,000 for sewers and $760,000 for the aqueduct.

London, Ont.—A surplus of $36,111.14 has been reported for London's electrical department for 1913. However, Chief Engineer Gaby of the Ontario Power Commission claims that 5 per cent. of the capitalization ($439,362.49), or $21,716.32, should be deducted from this surplus for depreciation. Also, equipment consisting of switchboards, converters, transformers and other machinery, costing in the neighborhood of $30,000, is now under order by the department for the purpose of supplying the London Street Railway Company with Niagara energy. When this amount is taken out of the capital account it would appear that the department will show a deficit of some $15,000 instead of the surplus announced.

Sinclair, B.C.—There is under construction between Sinclair and Castle Mountain in British Columbia a link of 60 miles of the great circular highway which forms one of the most important features in the programme of trunk roads for that province and will afford one of the finest scenic highways for motorists on the continent. The completion of the undertaking, for which the Canadian Pacific Railway have undertaken to pay half the cost, will mean more than 500 miles of good roads always within view of the Rockies, running through Cranbrook and the Crow's Nest Pass to Calgary, thence continuing westward over the driveway to Banff recently constructed by the Dominion Government.

Kingston, Ont.—The city of Kingston has in immediate consideration an additional water main capacity. The point of difference lies in the territory to be covered. Two sections have been proposed; one scheme being to replace the old 6-inch pipe on Union Street and to obliterate the dead ends on Clergy Street, opening up a circuit of $3.225 feet of 18-inch cast-iron pipe at an approximate expenditure of $23,638.56; the other also proposing to replace the pipe on Union Street, but coupling up the dead ends on West and Bagot Streets, and replacing the uncoated Kingston foundry pipe, now installed on Union Street, representing a total distance of 5,725 feet and an approximate expenditure of $43,936.30.

Edmonton, Alta.—There were recently in Edmonton, after inspecting the country traversed by the new G.T.P. line, and particularly the section surrounding Willow River, Mr. St. John, manager of the Transcontinental Townsite Company, Mr. George Hartford of the Morning Inter-Ocean, Chicago, and Mr. W. P. Hinton, general passenger agent of the G.T.P. Company. They estimated that on the Willow River there is enough potential electric energy to supply several cities of hundreds of thousands of population each, while 12 miles away from the town are vast beds of coal of good quality, as well as other minerals. On the Willow River alone there is at least 9,000,000 feet of timber, according to Government estimates, of size and quality equalled, only by the giant trees of the coast.

Toronto, Ont.—The concrete work on the bridge being constructed over the Walmer Road Hill ravine on St. Clair Avenue West, is now complete. Mr. E. C. Law, the contractor for this portion of the work states that in the foundation over 800 white oak piles have been used, averaging a length of 45 feet each; that about 6,000 cubic yards of concrete were necessary for the monolithic piers; and that the total weight of material used in this part of the construction was about 10,000 tons. The structure consists of two abutments and 8 piers, in sections of 4 each, arched together at the top. The central span, running north and south, measures 100 feet clear between piers, while on either side is a span of 40 feet. McGregor and McIntyre, the contractors for the steel work, are now busily engaged in placing the smaller girders in position. This work will be continued without interruption to completion.

Regina, Sask.—Steps are being taken here with the view to mining coal at Grand Coulee. Tests have been made as to the usefulness of this coal, and the scientific test by Dr. W. W. Andrews gave 10,800 British thermal units per pound of dry coal. It is believed that the deposits of coal in this vicinity are of considerable extent; and trial tests to discover the probable quantity are being made. At the point where the well was sunk, coal strata was 6 feet thick, and of increasing thickness on the north side. If the deposit is of sufficient extent to warrant mining operations the close proximity of this field to Regina will make it a valuable asset. Recently, a second seam of coal has been struck at Grand Coulee. The thickness of this seam has not yet been tested, but it is claimed that the coal is harder and of better quality than the first find. Its discovery has greatly increased the interest in Grand Coulee coal, and further drilling operations will be carried on with a view to discovering the possibilities of this second field.

Victoria, B.C.—The report of the Inner Harbor Association upon the work completed last year gives the following information:—"In the upper harbor, or basin, a large portion of the bottom has now been dredged to 20 feet deep at low water, with berths at the Canadian Puget Sound Mills of 25 feet. The large rock, about the middle of the basin, will shortly be removed. The lower harbor generally, where dredging can be done, is now 20 feet deep at low water. The rock on the western side of the entrance (off Behren's Island) has been removed; and the rocks off Shoal Point on the eastern side of the channel, have been cut back, thus widening the channel by about 60 feet and, to some extent, straightening out a very difficult turn. To the southeast of Songhees Point, the rocks have been cut back to 16 and 20 feet deep at low water. It is proposed to remove the remainder of the triangle to the railway bridge by contract work and the material utilized for reclamation purposes as originally proposed. The total amount of rock, clay, gravel and sand removed in the harbor has been about 550,000 cubic yards."

Vancouver Island, B.C.—The construction of the initial portion of the substructure of the breakwater at Ogden Point has progressed as far as is possible until more favorable weather conditions will permit of the divers laying the huge granite blocks that will form the base of the concrete structure. In the meantime, the contractors, Sir John Jackson, Limited, are concentrating their efforts upon the first 1,000 feet of the breakwater. Upon the site of this construction, in practically three weeks of the month of December, there were dumped 22,744 tons of rubble. In addition, at the core, there were dumped 9,715 tons. On the first 900 feet the stone has been levelled up to a depth of approximately 20 feet from low water mark; and arrangements have been made by Sir John Jackson, Limited, to have the first shipment of granite blocks brought down from Nelson Island early next month. This granite has been tested at the Government Laboratory and is declared to be of the most excellent quality obtainable anywhere on the coast. All the cement to be used in the construction work on the breakwater will be supplied by the Associated Cement Company, a Canadian firm, and samples of this material have been tested and approved by Government specialists for this kind of work in Canada. Also on the land side at Ogden Point, progress is shown. Already 6,394 cubic yards of rock have been excavated on the site where the giant sea-wall will extend its tentacles of stone seaward. A large area has been levelled off and several miles of steel track have been laid for the operation of the steam-engines hauling the dump-cars to the various parts of the site.

CONCRETE ROAD BUILDING CONVENTION—PROGRAMME.

The following is the programme of the National Conference on Concrete Road Building, which is being held on Thursday, Friday and Saturday of this week at the Auditorium Hotel, Chicago. Professor W. F. M. Goss, dean of the University of Illinois, School of Engineering, is chairman.

Thursday afternoon session, W. F. M. Goss presiding.

Address—"The National Conference on Concrete Road Building." W. F. M. Goss, dean, College of Engineering, University of Illinois, Urbana, Ill.

Address—"Financing Permanent Roads." S. E. Bradt, secretary, Illinois State Highway Commission, Springfield, Ill.

Address—"Can a Rural Community Afford Permanent Roads?" Oliver Dunlap, president, Iowa State Supervisors' Association, chairman, Board of Supervisors, Washington County, Iowa.

Address—"The Concrete Road System of Wayne County, Michigan." Edward N. Hines, chairman Board of County Road Commissioners, Wayne County, Michigan.

Friday morning session, A. N. Johnson presiding.

Address—"Development of Concrete Roads in the United States." Henry C. Shirley, chief engineer, Maryland State Roads Commission, Baltimore, Md.

Reports of committees:—

I.—"Contraction and Expansion of Concrete Roads." Chairman, R. J. Wig, Bureau of Standards, Department of Commerce, Washington, D.C.; N. H. Tunnicliff, civil engineer, Davenport, Iowa; W. A. McIntyre, engineer, Association of American Portland Cement Manufacturers, Philadelphia, Pa.

II.—"Joints for Concrete Roads." Chairman, W. K. Hatt, professor in charge, School of Civil Engineering, Purdue University, Lafayette, Ind.; George W. Cooley, state engineer, St. Paul, Minn.; R. J. Wig, Bureau of Standards, Department of Commerce, Washington, D.C.

III.—"Methods and Cost of Repairing and Maintaining Concrete Roads." Chairman, Edward N. Hines, cnairman, Board of County Road Commissioners, Wayne County, Detroit, Mich.; J. S. McCullough, city engineer, Fond du Lac, Wis.; F. P. Wilson, city engineer, Mason City, Iowa.

IV.—"Preparation and Treatment of Sub-Grade for Concrete Roads." Chairman, Ira O. Baker, professor of civil engineering, University of Illinois, Urbana, Ill.; A. R. Hirst, state highway engineer, Madison, Wis.; A. N. Johnson, state highway engineer, Springfield, Ill.

V.—"Reinforcement of Concrete Roads." Chairman, Thomas H. McDonald, state highway engineer, Ames, Iowa; Henry E. Riggs, professor of civil engineering, University of Michigan, Ann Arbor, Mich.; Richard L. Humphrey, president, American Concrete Institute, Philadelphia, Pa.

Friday afternoon session Ira O. Baker presiding.

Address—"Experiments with Concrete for Roads Conducted by the United States Office of Public Works." Logan Waller Page, director, United States Office of Public Roads, Washington, D.C.

Reports of committees:—

VI.—"Aggregates for Concrete Roads." Chairman, Sanford E. Thompson, consulting engineer, Newton Highlands, Mass.; A. N. Talbot, president, American Society for Testing Materials, Urbana, Ill.; W. M. Kinney, assistant engineer, Universal Portland Cement Company, Pittsburg, Pa.

VII.—"Shoulders for Concrete Roads." Chairman, Maj. W. W. Crosby, Baltimore, Md.; C. A. Kingsley, state highway engineer, Little Rock, Ark.; John H. Mullen, secretary, Minnesota Roadmakers' Association, St. Paul, Minn.

VIII.—"Bituminous Surfaces for Concrete Roads." Chairman, E. J. Mehren, editor-in-chief, Engineering Record, New York City; Henry G. Shirley, chief engineer, State Roads Commission, Baltimore, Md.; James R. Marker, state highway commissioner, Columbus, Ohio.

IX.—"Finishing and Curing Concrete Road Surfaces." Chairman, F. E. Turneaure, dean, College of Engineering, University of Wisconsin, Madison, Wis.; H. J. Kuelling, president, Wisconsin Highway Commissioners' Association, Milwaukee, Wis.; E. D. Boyer, engineer, the Atlas Portland Cement Company, New York City.

X.—"Economic Methods of Handling and Hauling Materials for Concrete Roads." Chairman, Halbert P. Gillette, editor-in-chief, Engineering and Contracting, Chicago; Donald D. Price, state engineer, Lincoln, Neb.; Percy H. Wilson, secretary, Association of American Portland Cement Manufacturers, Philadelphia, Pa.

Saturday morning session W. F. M. Goss presiding.

Address—"Concrete Road Construction by the Ohio State Highway Department." James R. Marker, state highway commissioner, Columbus, Ohio.

Reports of committees:—

XI.—"Mixing and Placing Materials for Concrete Roads." Chairman, Paul D. Sargent, chief engineer, State Highway Commission, Augusta, Maine; Arthur H. Blanchard, professor of highway engineering, Columbia University, New York City; C. W. Boynton, inspecting engineer, Universal Portland Cement Company, Chicago.

XII.—"Cost of Constructing Concrete Roads." Chairman, A. N. Johnson, state highway engineer, Springfield, Ill.; Joseph Hyde Pratt, state engineer, Chapel Hill, N.C.; Albert Reichmann, president, Western Society of Engineers, Chicago.

XIII.—"Thickness, Crown and Grades for Concrete Roads." Chairman, Leonard C. Smith, in charge of roads and pavements, University of Wisconsin, Madison, Wis.; Earle R. Whitmore, city engineer, Port Huron, Mich.; T. R. Agg, assistant professor in civil engineering, Iowa State College, Ames, Iowa.

XIV.—"Proportion and Consistency of Materials for Concrete Roads." Chairman, C. U. Bowley, city engineer, Sheboygan, Wis.; C. C. Widener, city engineer, Bozeman, Mont.; George A. Dingman, engineer, Board of County Road Commissioners, Wayne County, Detroit, Mich.

XV.—"Form of Specifications for Concrete Roads." Chairman, A. Marston, dean and director, Division of Engineering, Iowa State College, Ames, Iowa; A. N. Talbot, president, American Society for Testing Materials, Urbana, Ill.; George W. Cooley, state engineer, St. Paul, Minn.

PERSONAL.

A. J. MacLEAN, formerly one of the commissioners of Edmonton, was appointed Assistant City Engineer of that city and assumed his duties on February 2nd.

D. W. JOHNSON has been appointed engineer for the municipality of Saanich, B.C. For the past five years he has acted in a similar capacity at Point Grey, B.C.

J. M. BEGG, assistant city engineer, in charge of sewers, read a paper before the Edmonton Engineering Society on the 5th inst., entitled "The Tunnel Sewers of Edmonton."

J. W. W. DRYSDALE, Jr., B.Sc., director of Drysdale and Co., Limited, of Yoker, Glasgow, Scotland, manufacturers of centrifugal pumps, is in Canada on a four weeks' business trip.

W. A. McLEAN, Provincial Engineer of Highways for Ontario, and a member of the Public Roads and Highways Commission, has been elected president of the American Road Builders' Association.

J. V. MIMMO, division engineer, C.P.R., between Boston Bar and Lytton, B.C., read a paper before the Vancouver branch of the Canadian Society of Civil Engineers, on February 3rd, on railway construction work in British Columbia.

T. H. KETTLE, until recently in the employ of the Toronto Power Company, as manager of the Transportation Department, left for Minneapolis on February 1st to take a position as Assistant Sales Manager for the Minneapolis General Electric Company.

R. G. G. OMMANNEY, a member of the engineering staff of the Canadian Pacific Railway, has recently been appointed engineer to Sir Thos. Shaughnessy, president of the road. Under this new appointment Mr. Ommanney will devote his time to special work.

A. J. McPHERSON, for several years chairman of the Highway Commission of Saskatchewan, has been appointed to the chairmanship of the Government Finance Commission of that province. Mr. McPherson graduated in 1893 from the School of Practical Science, Toronto. F. J. ROBINSON of Regina, formerly Deputy Minister of Public Works, succeeds him as chairman of the Highway Commission.

W. E. WOODHOUSE has been appointed Superintendent of Motive Power for the eastern division of the Canadian Pacific Railway, his headquarters to be in Montreal. Mr. Woodhouse has been in the employ of the company for 22 years, spending a greater portion of that time in British Columbia, coming back to Winnipeg in 1906, where for the past four years he has been Assistant Superintendent of Motive Power of the western lines.

CANADIAN GOVERNMENT EXHIBIT AT SAN FRANCISCO IN 1915.

The final plans for the Canadian pavilion at the Panama-Pacific International Exposition, to be held in San Francisco in 1915, were accepted January 21, and the process of actual construction has begun, under the supervision of Colonel William Hutchison, of Ottawa, the Canadian Exhibition Commissioner. Colonel Hutchison arrived in San Francisco January 14 to inaugurate the work upon the building, preparatory to the arrival of the Canadian exhibit, part of which is now en route. He was joined here by George Freeman, the London architect, who is designer of the building, and his staff.

The pavilion, which will cost approximately $300,000 will be the largest exposition building ever erected by the Canadian Government. It will be 340 feet long, 240 feet wide and 50 feet high. The whole sum expended upon the building and its contents will amount to $600,000 or more.

"THE ST. LAWRENCE RIVER BRIDGE."

At the regular monthly meeting of the Canadian Society of Civil Engineers held in Montreal on Thursday, February 5th, a paper was read on the St. Lawrence River Bridge by Mr. P. B. Motley, M.Can.Soc.C.E., Engineer of Bridges for the C.P.R. Mr. Motley presented some interesting details concerning the method in which the old C.P.R. bridge over the St. Lawrence River at Lachine, P.Q., erected as a single track structure in 1885, has, in the last two years, practically undergone complete reconstruction as a double track without interference to traffic during operations.

The plan adopted was to build two independent single track bridges, removing the old bridge in sections, and transferring the traffic from side to side during the operations.

While this was being done an average of 18 trains a day passed over the bridge during working hours.

The work was accomplished by cantilevering spans from the piers supporting the old bridge, by the sinking of pneumatic caissons under the direction of the Foundation Company, by employing floating barges, and transferring traffic from the old to the new spans as the latter were completed.

CALGARY BRANCH CAN. SOC. C.E.

Some very interesting meetings have been held by the Calgary branch Canadian Society of Civil Engineers since its inception last summer. These meetings usually take the form of a 6 o'clock dinner with an address and discussion following. Mr. J. S. Dennis, M.Can.Soc.C.E., assistant to the president of the Canadian Pacific Railway Co., gave an interesting address to the meeting held on December 29th. His subject was "Early Surveys and Surveyors of Western Canada." Upon a similar event on January 9th, Mr. Geo. W. Craig, M.Am.Soc.C.E., city engineer of Calgary, read a paper on "Modern Pavements." On January 23rd, Mr. Sam. G. Porter, B.A., B.S., M.Am.Soc.C.E., irrigation inspecting engineer for the Dominion Government, read the paper "The Civil Engineer and his Relation to Society," which appears elsewhere in this issue. On February 6th, Mr. H. A. Moore, M.Can.Soc.C.E., and general manager of the Calgary Power Co., addressed the meeting, describing the company's new power plant at Kananaskis Falls on Bow River.

"Irrigation Engineering" is the subject of an address to be delivered at the February 20th meeting by Mr. W. D. Hays, M.Am.Soc.C.E., chief engineer of the Southern Alberta Land Co. at Medicine Hat. At later dates, not as yet definitely decided upon, the speakers will be Mr. F. H. Peters, A.M.Can.Soc.C.E., Commissioner of Irrigation for the Dominion Government; Mr. H. B. Muckleston, M.Can.Soc.C.E., assistant chief engineer, Department of Natural Resources Canadian Pacific Railway; and Mr. H. J. Duffield, B.E., M.I.C.E.

These dinners are held fortnightly and are being largely attended by the members of the Canadian Society resident in Calgary and vicinity. Mr. P. M. Sauder, P.O. Drawer "V," Calgary, is secretary-treasurer of the branch.

TORONTO BRANCH CAN. SOC. C.E.

The local branch of the Canadian Society of Civil Engineers held a luncheon on Wednesday, February 11th, at which a good representation of the members were present. A short address was given by Prof. C. R. Young, Department of Structural Engineering, University of Toronto, who spoke concerning the library which the Society possesses, making a number of apt suggestions respecting its enlargement and concerning ways in which it might be made of more service to the members. In addition to its monthly meetings the branch contemplates holding a monthly luncheon of this nature during February, March and April. The secretary is John S. Galbraith, 57 Prince Arthur Avenue, Toronto.

CHICAGO CEMENT SHOW.

The Seventh Chicago Cement Show begins on February 12th and will continue to February 21st. During this period the following organizations are also convening in Chicago:—American Concrete Institute, National Builders' Supply Association, Interstate Cement Tile Manufacturers' Association, Illinois Lumber and Builders' Supply Dealers' Association, Illinois Association of Municipal Contractors, National Conference on Concrete Road Building.

CANADIAN MINING INSTITUTE.

Among the papers that have already been arranged for in the programme of the annual meeting to be held in Montreal next month, are the following:—

"Mill and Metallurgical Practice at the Nipissing Mining Co., Cobalt, Ont.," by James Johnston, Cobalt, Ont.; "The Sampling of Cobalt Ores," by C. St. G. Campbell, Cobalt, Ont.; "The Veins of Cobalt District," by Arthur A. Cole, Cobalt, Ont.; "Recent Improvements in Cyanidation," by Herbert A. Megraw, New York; "Some Notes on Mining and Milling Practice at the Alaska Treadwell Mine," by H. C. Meek, South Porcupine, Ont.; "Ore Dressing Improvements," by Robert H. Richards, Boston, Mass.; "Recent Metallurgical Developments," by A. Stansfield, Montreal; "Methods of Excavation in the Mount Royal Tunnel," by S. P. Brown, Montreal; "Factors Influencing the Cost of Power for Mining Purposes," by J. M. Forbes, Montreal; "High Carbon Steel for Sluice Linings in Hydraulic Mining," by Howard W. Dubois, Philadelphia; "Mining in British Columbia" (illustrated by colored lantern slides), by Howard W Dubois, Philadelphia; "Scientific Management," by F. B. Gilbreth, New York; "Efficiency Engineering Applied to Mining, Quarries and Industrial Plants," by H. M. Payne, New York; "The Chisana Gold Field," by D. D. Cairnes, Ottawa; "Coal Resources of the World," by D. B. Dowling, Ottawa; "Asbestos Resources of the Thetford Area," by W. J. Woolsey. Thetford Mines, Quebec; "Safety in Coal Mines" (illustrated by moving pictures), by a representative of the H. C. Frick Coke Co., Pittsburgh.

EDUCATIONAL INVESTIGATION OF INDUSTRIAL METHODS.

A number of students taking the Chemical Engineering course at the University of Toronto, under the direction of Professors Bain and Ardagh and Mr. Rogers of the Faculty of Applied Science and Engineering, spent a week on a tour of investigation to points in Western Ontario. The party visited the plants of the Dominion Sugar Co., the Empire Refining Co., and the Canadian Glass Co., afterwards proceeding to Windsor where the works of the Canadian Felt Co. were visited. The new electrolytic alkali plant of this company at Sandwich was also inspected. The party included men of the second, third and fourth years.

COMING MEETINGS.

AMERICAN CONCRETE INSTITUTE.—Tenth Annual Convention to be held in Chicago, February 16th to 20th, 1914. Secretary, E. E. Krauss, Harrison Building, Philadelphia, Pa.

NATIONAL CONFERENCE ON CONCRETE ROAD BUILDING.—Meeting will be held in Chicago, Ill., February 12th to 14th, 1914. Secretary, J. P. Beck, 72 W. Adams Street, Chicago, Ill.

CANADIAN MINING INSTITUTE.—Sixteenth Annual Meeting to be held at Windsor Hotel, Montreal, March 4, 5 and 6th, 1914. Secretary, H. Mortimer Lamb, Windsor Hotel, Montreal.

AMERICAN WATER WORKS ASSOCIATION.—Thirty-fourth Annual Meeting to be held in Philadelphia, Pa., May 11-15, 1914. Secretary, J. M. Deven, 47 Slate Street, Troy, N.Y.

CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS.—To be held in Montreal. May 18th to 23rd, 1914, Mr. G. A. McNamee, 909 New Birks Building, Montreal, General Secretary.

ORDERS OF THE RAILWAY COMMISSIONERS OF CANADA

Each week on this page may be found summaries of orders passed by the Board of Railway Commissioners, to date. This will facilitate ready reference and easy filing. Copies of these orders may be secured from *The Canadian Engineer* for small fee.

21250—January 26—Authorizing C.P.R. to construct sidings for Fraser, Limited, mileage 20.03, Atlantic Div. Fredericton Sub. Div., at Victoria, New Brunswick.

21251—January 23—Refusing application Corporation Village of Princeville, Que., for Order directing G.T.R. to provide and construct highway over its tracks, about 1050 ft. west of Princeville station.

21252—January 26—Authorizing C.P.R. and Algoma Central and Hudson Bay Ry. Cos. to operate trains over crossing at Hobon, Dist. Algoma, Ont., without their being brought to a stop.

21253—January 24—Relieving C.P.R. from speed limitation of 12 miles an hour on portion of Swift Current Southeasterly Branch Line, from Neville to Vanguard, mileage 27.5 to 43.6.

21254—January 26—Authorizing C.P.R. to construct Two (2) bridges, namely,—mileage 59.8, Kootenay Central Ry., over Findlay Creek, B.C., and mileage 46.62, Kootenay Central Ry., over Skookumchuck Creek, B.C.

21255—January 24—Authorizing, temporarily, City of Toronto, Ont., to operate Danforth Ave. Car Line over G.T.R. Toronto Type Foundry Spur, until June 1st, 1914, pending installation of half-interlocking plant at said crossing.

21256—January 24—Authorizing C.P.R. to construct bridge over Dutch Creek at mileage 75.6 of Kootenay Central Ry., British Columbia.

21257—January 27—Authorizing G.T.R. to construct extension of siding into premises of S. L. Lambert, on Block Y, east side of Burger Street, town of Welland, Ont.

21258—January 24—Extending, until May 1st, 1914, time within which G.T.R. is required to install gates to cover all tracks and sidings as well as main tracks at crossing of the first highway east of Clarkson Station, Ontario.

21259—January 28—Granting leave, temporarily and until further Order of the Board, to city of Montreal, Que., to construct and lay steel water pipe beneath main track and siding of C.P.R. Co.'s Lachine Canal South Bank Branch, subject to certain conditions.

21260—January 28—Authorizing city of Montreal, temporarily and until further Order of Board, to construct and lay 8 feet diameter steel water pipe beneath, along and across right of way of G.T.R. on part Lot 3410, Cadastral plan of Municipality of parish of Montreal, subject to certain conditions.

21261—January 22—Extending, until June 1st, 1914, time within which Cumberland Ry. and Coal Co. equip cars with automatic couplers and air breaks.

21262—January 28—Granting leave to Ottawa Electric Co. to erect, place and maintain wires across track of C.P.R., on road north of Hurdman's Bridge, at mileage 6.64 from Sussex Street Station, Ontario.

21263—January 28—Extending, until May 31st, 1914, time within which C.P.R. complete siding for McCormick Manufacturing Co., Limited, London, Ont., authorized under Order No. 20710.

21264—January 28—Approving plan "A," numbered 52969, showing bridge No. 94.4 on Toronto Subdivision of C.P.R.

21265—January 29—Authorizing the C.L.O. and W. Ry. to construct its line of railway at grade across Front Street, in the city of Belleville, Ont.

21266—January 24—Approving revised location of C.N.O.R. at Grand Lake, Tp. Barron, Dist. of Nipissing, Ont., mileage 126.37 to mileage 129.94 from Ottawa.

21267—January 28—Relieving for the present, the C.P.R. from providing further protection at the crossing of the first highway east of Sheho Station between Secs. 9 and 10, W. 3 M., Sask., at mileage 67.9 on said railway.

21268—January 28—Authorizing the N. St. Catharines and Toronto Ry. Co. and the G.T.R. to operate their cars and trains over Welland Avenue, St. Catharines, Ont., without their first being brought to a stop.

21269—January 28—Postponing the effective dates of the Special Commodity Tariff, C.R.C., No. 217, and the Joint Freight Tariff, C.R.C. No. 221, of the Temiscouata Ry. Co. increasing the rates on pulpwood in carloads and published to become effective on the 1st and 24th days of January, 1914, respectively, until the 15th day of August, 1914; and rescinding Order No. 21105, dated December 23rd, 1913.

21270—January 30—Authorizing the city of Brantford to excavate a new channel across the island immediately below the Homedale District where the L.E. and N. Ry. has built its embankment across old channel.

General Order No. 119—January 31—Ordering that whenever a railway company subject to jurisdiction of Board, intends to remove a regular station agent, it shall first notify the local municipality or Board of Trade of its intention to apply to the Board for and Order permitting such removal.

21271—January 29—Authorizing the C.N.R. to construct its line of railway across and divert public road between Secs. 5 and 6, Tp. 41, Rge. 18, W. 4 M.

21272—January 29—Relieving the Que., Montreal and Southern Ry. from maintaining, for the present, a watchman at the Chemin de Lac Crossing, in the village of Bucherville, Que.

21273—January 29—Rescinding Order No. 21155, which required the C.P.R. to stop its train No. 33 at Claremont on flag for a period of three months from date of Order, December 31, 1913.

21274—January 24—Authorizing the G.T.P. to construct its main line of railway across the Government road at mileages 213 and 214, Cariboo District, B.C.

21275—January 30—Authorizing the G.T.P. Branch Lines Co. and the C.P.R. to operate their trains over the crossing of the C.P.R. Co.'s Moose-Jaw-Lacombe Branch at Druid, Sec. 6, Tp. 33, Rge. 20, W.3 M., without first bringing trains to a stop.

21276—January 29—Amending Order No. 20937, December 1st, 1913, by striking out the figures "10" after the word "Block" where they occur in the recital and operative parts of the Order, and substituting therefore the figures "16."

21277—January 28—Approving revised location of G.T.P. Railway from the east boundary of the N.E. ¼ of Sec. 25, Tp. 53, Rge. 17, to the east boundary of the E.E ¼ of Sec. 22, Tp. 53, Rge. 17, W. 5 M., Alta., from mileage 3.14 to mileage 5.88.

21278—January 28—Authorizing the C.P.R. to construct, maintain and operate branch line of railway or spur for the Boyd Pressed Brick Syndicate from a point on C.P.R. main line, Ont. Div., London Subdivision, at mileage 34.5, in Lot 3, Con. 7, Tp. Nassagawaya, Ont.

21279—January 29—Authorizing the C.P.R. to open for the carriage of traffic portion of its double track from Islington to Guelph Junction, mileage 9.98 to mileage 39.86, Ont.

21280—January 29—Authorizing the C.P.R. to change the grade of its main line of railway, Ont. Div., Havelock Subdivision, across road allowance between Lots 20 and 21, Con. 3, Tp. Bathurst, Co. Lanark, Ont., and to change the grade of present grade crossing at mileage 15.44 on said main line.

21281—January 30—Approving plan No. 55085-2, dated November 27th, 1913, showing proposed crossings over tracks of G.T.R. adjoining Front Street, Toronto, Ont.

21282—January 29—Authorizing the C.P.R. to construct, maintain and operate branch line of railway or spur for the Canmore Coal Company, Limited, Canmore, Alta., from a point on existing spur in the S.E. ¼ Sec. 29, Tp. 2, Rge. 10, W. 4 M., at Canmore, Alta.