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MISSING

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

Plan for Emergency Development at Niagara Falls

Includes Temporary Intakes Along Crest of American Falls, Deepening of American Channel, Weir for Diversion of More Water to American Channel, Intakes Along Crest of Horseshoe Falls on American Side and Littoral Penstocks or Canal on Canadian Side, With Dam Extending from Canadian Shore

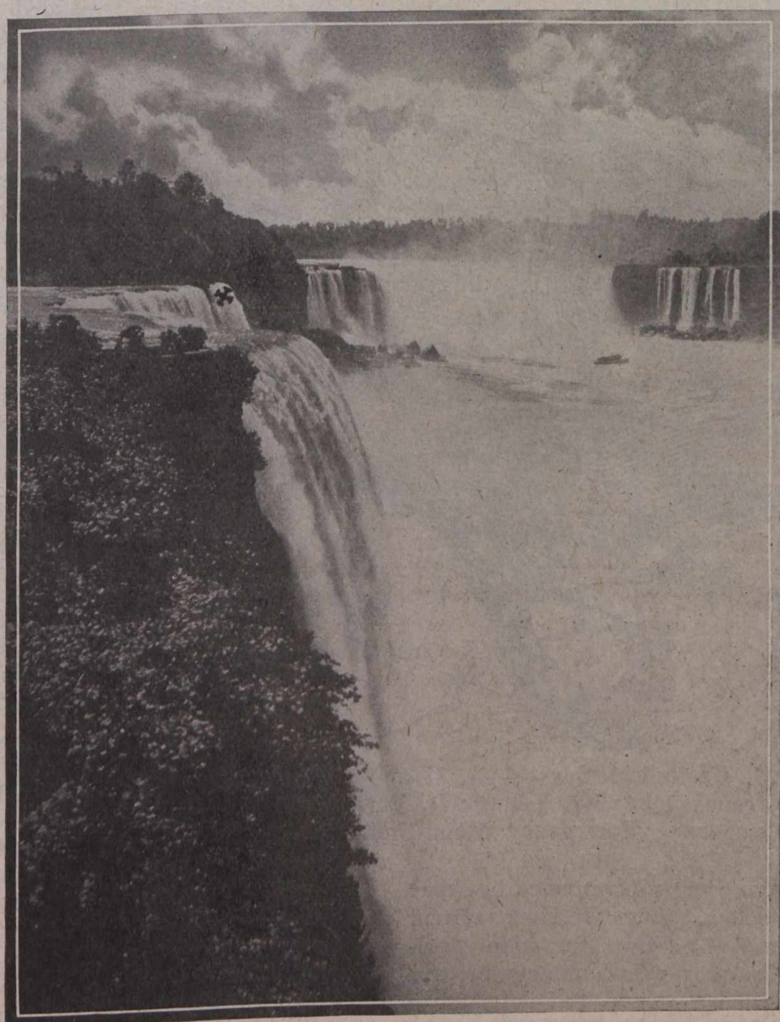
By W. W. YOUNG
Consulting Engineer, New York City

THE objects of this article are to outline a brief summary of: (1) Some reasons necessitating an emergency development of Niagara. (2) Some conditions essential for the conception of any development. (3) One of a number of definite plans for such development.

All the power now permitted to be developed under the international treaty is used, and, though numerous steam plants have been added, the insistent power demand is so far from being satisfied that there is a vital power famine which has attracted international attention.

The improvements in the transmission and wide use of electrical power and its products, particularly in transportation, metallurgy and electrochemistry, have rapidly made it of very great value. It is said if the nitrate trade were stopped by Chile or by submarines, or by both, that the Allies would be defeated in sixty days. We hope this is not true; we know it would not be possible if Niagara were harnessed, for, even though the power now be used only to make the fertilizer which Canada needs, it could be quickly and easily adapted to the requirements of explosive nitrate manufacture.

With factories shutting down for days at a time, may not the time come when Canada can obtain no coal from the United States? The utilization of Niagara means not only a saving of coal and of cars, but also the release for urgent needs elsewhere of thousands of miners. At twice the rate of locomotive efficiency, it would replace the continuous movement every day of thirty trains of two thousand tons each, and would free these and 15,000 miners for urgently needed aid to the Allies.



Niagara Falls—Cross Indicates Luna Fall—American Falls in Foreground, Canadian (Horseshoe) Falls in Rear

Sight-seeing and touring might be discouraged. The best viewpoints in Canada are barricaded and the tunnel under the Horseshoe closed for military reasons. At what more opportune time than when both countries are united in one vital, common purpose, could co-operative development be proposed and effected?

The discharge of the Niagara River varies from 314,000 second feet and more (1856) to 158,000 second feet (1902) and less, and recently from 265,000 s.f. to 180,000 s.f. within a day's time. The conservative average discharge, 204,000 s.f., given in the Canadian report, is attainable for subsequent permanent development, and also would improve navigation, by International headworks between the Buffalo Breakwater and Goat Island. The sixty-year discharge profile shows periods of years when the average monthly discharge is never under 200,000 s.f. In order to take advantage of prevailing high flows, and because of the latitude of subsequent deductions and of the preliminary nature of the discussion, this last round figure will be used.

From the flow of Niagara River at least twenty per cent. must be deducted for diversion losses and aid to caring for ice. At least twice this will be required at times, but for periods too short to justify so much reduction in installation. During the war, when viewpoints are barricaded, travel discouraged and resources husbanded, maintenance for scenic effect is ill-timed; but in the transition period at the end of the war, and later, this latter 40,000 s.f., equitably distributed, will not only improve the present and former scenic effect, but—by throwing the heaviest flow over the margins—will stop and tend to remedy the increasing self-defacement of the Horseshoe, where what may occur is exemplified by what appears at the next bend below, where the river turned a similar angle and narrowed itself from the wide whirlpool section to form a series of rapids but three or four hundred feet wide. Into such a narrow self-dug gorge the Horseshoe seems, with increasing rapidity, to be surely disappearing.

Most of the main existing plants at Niagara Falls require tunnels or canals through town,—valuable for scenic preservation or economic use of head, but too slow in construction for war development, which must be almost instant to serve at all. We, therefore, are not further concerned with them except to deduct the sum of existing plant and canal diversions to get the net flow of the river for our problem. The treaty allows some canal and sanitary diversion, etc., and 56,000 s.f. beside. Hence, at least 60,000 s.f., in round numbers, should be deducted for existing canals, plants, etc. Deducting from the useful flow, taken as 200,000 s.f., the minimum installment allowance for ice, etc., and for installations now operating, a total of 100,000 s.f., we have the other 100,000 s.f. remaining. The fall, about 160 feet, means approximately 1,800,000 horse-power.

Plan of Niagara Falls, U.S. Geological Survey—A, G and C Indicate Littoral Penstock Installations Proposed by Mr. Young; D, Vertically Controlled Deflector; S, S, Temporary Emergency Main Spillway Section

Another condition essential to a clear grasp of the situation is the treaty with the United States, which, in effect, forbids further developments of boundary waters until after a year's notice of its abrogation, unless, of course, this be waived by mutual agreement.

The proposed developments of the rapids below the falls by tunnel, long penstock or dam, are not quick enough to make them of any war value, for so much labor will have to be put into them that the war may be over before it could be gotten back by the added force and efficiency given to other labor. There is nowhere else so quick and cheap a way to get vast power in the heart of the market as to apply machinery to the dam which nature has already installed at Niagara!

Plan for Rapid Development

Almost every way conceivable for partial peace-time development has been studied or suggested, but no plan for complete development except the following, which was proposed by the writer at a meeting of engineers in January and brought to the attention of those in touch with the engineers of both governments during the following month. It is at least better than no development at all, and has been definitely set forth to meet such a catastrophe as the termination of nitrate shipments would produce, or as really now exists, could the people but realize the importance of the manufacturing emergency.

As a minor example of one method, were it desired to develop five or ten thousand horse-power, it would be no feat to block the channel between Luna and Goat Islands—not fifty feet wide nor two deep—install penstocks, etc., on or near the face of Luna Fall, and then remove the obstructions. This might temporarily murder the scenery, but things far more precious are being murdered for the lack of power. If more power were wanted, nobody could gainsay the feasibility of stopping the inter-island escape channels and diverting to the Luna Channel all the water flowing between Green and Goat Islands.

Similarly, the American channel passes but a twentieth to a thirtieth of the total river flow and is under 170 yards wide and but little over three feet in mean depth near the head of Goat Island. Here it would be no great feat to hold about 170 cubic yards of obstructions of an easily removable character, until penstocks with a proper removable intake dam had been placed just behind the margin of the Falls or a distributor emplaced along the bank. Then the removal of this small obstruction from water moving less than four miles per hour, would free 9,000 second-feet or 160,000 horse-power for these penstocks.

When more power were wanted at this point, three or four times this amount, or more *ad libitum*, could be sent down this American mill race by deepening the channel and extending a weir averaging under three feet high from the head of Goat Island southerly by southeasterly to the International Boundary, without interfering with the plants on either shore. Instead of literally placing obstructions, particularly in an installation of this size, a dam with movable gates could be used at the head of Goat Channel. The rate of progress for this part of the work would exceed the progress on the machinery.

The development of this, say, 600,000 h.p. would make it easy to bare the Terrapin Rock end of the Horseshoe, where further penstocks could be placed and then some water diverted toward them (by placing a gated dam on the shortest line between the Horseshoe and the Canadian shore below the Canadian Niagara Power Co.) to develop 300,000 h.p., more or less, depending on the amount of power wanted for development below the dam by an installation of overhanging penstocks and littoral penstocks or canal. The International Railway plant could be compensated by flume or electric power.

The Canadian and United States Government technical reports favor putting a protecting weir just above the apex of the Horseshoe; but an engineer, attempting to elaborate on this plan in the press, was ridiculed as attempting the impossible in such a raging torrent. If there were a risk of failure in this step of the way here proposed, there are others to turn to; but to divert a torrent is a thing that has been done and can be done again with greater certainty. Anyone, who has pushed a canoe over rapids or falls two or three times its depth, or has ever travelled the rapids of the St. Lawrence, knows that a boat can be held in swift water, whether from a cableway or otherwise, and from the boat the rocks beneath can be drilled and fastened into at any place to any extent, if suitable pier frames and works for movable gates cannot otherwise be held and set.

The mere closing of the gates above, while it will provide a way to set the intake openings for 900,000 h.p., more or less, on the Canadian side, will not divert the maximum quantity to the Terrapin end nor will their opening supply enough water for the wheels and a full flume or canal along the cliff, unless the Horseshoe channel be obstructed. The long weir or dam above the apex, favored by reports of both governments, would therefore be constructed to distribute properly the remainder of the water between the Terrapin penstocks and the proposed Canadian shore works. From this dam any water not taken will be utilized, as has been done similarly elsewhere, by river bed shafts and tunnels with unseen power plants under the floor of the rapids, which would develop secondary power in the final post-bellum design. Otherwise, the power as mentioned is equally divided by the international boundary lines.

It is evident this plan can be varied to any extent, both as to quantity or so that most or all of the development is either on the Canadian side or in the United States. Thus, by abrogating the treaty, either country might develop at will; but the treaty covers the St. Lawrence, and friction would result, not to mention the year's notice the treaty requires.

Regarding conversion to permanent international development by equal flow canals to the escarpments behind Queenston and Lewiston, the U.S. Congress has been advised by the highest officers against permitting fractional developments of either fall or flow, while the Canadian authorities have taken the lead in seeking to get all of the inter-lake fall possible and in opposing as wasteful any developments using only part of the attainable fall. Several hundreds of men are now at work for the Hydro bringing to completion a construction which will give double the power they now have developed in Canada.

Immediately upon the conclusion of peace, the permanent development must be made, reserving enough flow for ice and a uniform flowage over both falls equal in thickness to that on the American. Canada has already taken the first step in this direction by building a power canal over the escarpment to get all possible of the 326 feet of inter-lake fall. The United States cannot do better than follow her example. While 210 feet can be had from the hydraulic companies' canal, less is available for the existing tunnel and enlargement is expensive; and, while the development of the rapids will (considering friction, backwater and ice) give 80 feet head, the total is scarce 290 feet, while the fall from Chippewa to Queenston is over 312 feet, which (in combination with a regulated flow of 204,000 second-feet) gives over 7,000,000 continuous horse-power!

The larger electric generators are the more economical. There are few on hand, and although the plan outlined makes it feasible and handy to use every possible size, many must be made. The biggest now is 90,000 h.p., and would ordinarily take a year to make. The wheels, penstocks and controlling dams can soon be ready. By priority orders, the United States government could be of great aid in speeding up the electrical machinery.

Legislation should be obtained proposing the prompt draft and conclusion of a new treaty to exclude Lake Erie and Niagara River from the present treaty, and naming an authority to develop them for war use,—a single plenipotentiary, as proved best at Panama, or at the most, one from each country.

Among such able public servants as former United States presidents and British ambassadors are men who have the confidence of the people in both countries, and have pre-eminently the judicial temperament so essential to prevent injustice to individuals and corporations affected by their acts, and to give the public confidence that this great national resource would be strictly conserved solely for public benefit. Nor need a representative be sought overseas, for pioneers in the public control of hydro-power in the Dominion have the knowledge, experience and personality for the undertaking. Experience has shown that a single head, or at the most two, is vital to prompt decisions and the progress needed to make Niagara a great and timely help in winning the war.

Conclusion

It is, therefore, evident:—

(1) That power, coal, transportation, nitrate and general war manufacturing conditions necessitate an emergency development of Niagara.

(2) That a clear grasp of conditions can be had by considering that while rapids and other sites require equal machinery and a tedious dam besides, Niagara's nearly two million horsepower is larger than them all, located in the centre of manufacturers and transportation, and with a dam built and waiting.

(3) That this dam is favorably formed for the quick application of power in many ways; for instance, by making a millrace of the American spillway and constructing a corresponding littoral development in Canada.

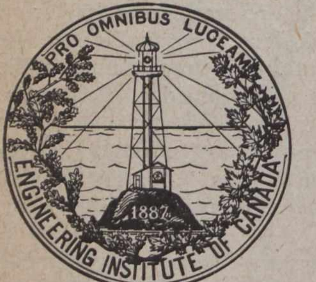
Will the people of the United States and Canada allow the prodigious waste at Niagara to continue for years more after nearly four years of war have already passed?

Letters to the Editor

Proposed Emblem for Institute

Sir,—I have placed the enclosed sketch before the committee of the council of the Engineering Institute of Canada, as a design which seems to me to be suitable as an emblem for the Institute.

The main emblem is a lighthouse placed on a rock and shedding its welcome light over an expanse of sea. At the lower edge is the name "Engineering Institute of Canada." Above is a motto, "Pro Omnibus Luceam," let me shine for all. On the left, a bough of English oak, and on the right, one of Canadian maple. On the rocky base you may notice the date of the foundation of the society, 1887.



The oak leaves are to remind one of our connection with the British Institution of Civil engineers, and of the many distinguished British engineers who have become Canadians.

A lighthouse (Pharos) is almost a living being. It is one of the choice products of the engineer's skill, and one of the few that have never been turned against humanity. Its rays either show the way to safe harbors or they mark the hidden dangers of the route. Does it not seem aptly to express the ideals of the profession?

Publication of the enclosed sketch may bring out desirable discussion and perhaps other designs from the members of the society.

LOUIS G. PAPINEAU, A.M.Can.Soc.C.E.

Montreal, P.Q., April 8th, 1918.

Power Possibilities on the St. Lawrence River

Sir,—An interesting pamphlet recently issued by the Commission of Conservation deals with the "Power Possibilities of the St. Lawrence River." Arthur V. White, the consulting engineer of the commission, who prepared this pamphlet, very succinctly shows the enormous power going to waste between Lake Ontario and Montreal. Taking the minimum flow of the St. Lawrence, and disregarding the enormous increase available by regulating dams on the Great Lakes, it is possible to provide, with the "diversity load factor," over three million horse-power —a quantity about eight times greater than the present combined developments of the Canadian Niagara powers and the Shawinigan Company with its subsidiaries.

Despite these vast power possibilities, Mr. White points out that the power shortage in Eastern Ontario is acute,—as indeed it is also in the Niagara District, with all its world-famous facilities for hydraulic power. Some 20,000 h.p. could be absorbed immediately by the Eastern Ontario municipalities adjacent to or within easy transmission of the high-tension power line of the Cedars Rapids Manufacturing and Power Company, which in its course to Messena, N.Y., passes through the Eastern Ontario territory most affected by this power shortage. Deploring this state of affairs, the Commission of Conservation points to the fact that some 65,000 h.p. of electrical energy developed at Cedars Rapids, near Montreal, is being exported to the United States for manufacturing purposes, and incidentally part of this load supplies certain municipal requirements in New York State.

If the Cedars Rapids Company is transmitting power through Eastern Ontario on its way to Messena, one is naturally tempted to enquire why on earth this transmission line cannot be tapped to serve the Ontario municipalities so urgently in need of hydro-electric power. Briefly stated, it is probable that the Cedars Rapids Co. has no desire to extend its system into Ontario at great expense and under the covetous opposition of the Ontario Hydro-Electric Commission, to be no doubt finally confiscated by the said commission. It is a well-known fact that the Cedars Rapids Co. is selling large quantities of power for export and to Montreal consumers at prices below what the Ontario Hydro-Electric Commission is selling for, and this company is no doubt willing to sell to anyone who will "pay cash and carry"; but to venture into Ontario as a distributor of power would be showing a reckless disregard for the interests of the investors, who are to be congratulated in having kept themselves beyond the aim of the confiscatory tendencies of Ontario "Bolshevism."

Returning to the lament of the Commission of Conservation on the subject of power exportation, Mr. White suggests what could be done in Canada with the 65,000 h.p. going to Messena. It could supply, he says, at cheap rates, all the light and power required for a manufacturing city of 300,000 inhabitants; or, if distributed through Canadian municipalities, it would supply light and power to some thirty-five manufacturing cities of 10,000 inhabitants each; or, it would practically take care of one-third of the present demands of the Niagara system of the Hydro-Electric Power Commission.

Of what United States communities could do with the enormous quantities of anthracite and soft coal that they export to Canada, we are not advised by the commission. But referring to this question of coal, Mr. White recognizes our dependence upon the United States, and further states that Canada should appreciate the fact that the United States has been dealing generously with her. "Canada," he says, "however, must conserve against the day of her own need such resources as are available for barter."

We wonder if the Commission of Conservation is aware, or realizes, the amount of hydro-power that is available, and whether in the face of such enormous unharnessed resources we are to remain in wait for the day that Canada's population increases sufficiently to warrant their development. We admit that we are contending with power shortages, yet these shortages are too insignificant for us to consider the development on such a huge scale as required with any one of the St. Lawrence powers. The Commission of Conservation should realize that no government or private capital can afford to develop, say, half a million horse-power with a market for only 50,000 horse-power.

We must, therefore, co-operate for an understanding, with a view to selling sufficient power by export to warrant harnessing potential forces, part only of which we so urgently need ourselves.

Taking Mr. White's figures at 65,000 h.p. being equal to the needs of 300,000 urban inhabitants, it is well to note that we have as Eastern Canada's share of undeveloped power some 7,000,000 h.p., capable of supplying the needs of over 30,000,000 inhabitants of manufacturing centres:

St. Lawrence	3,000,000	horse-power
Niagara	2,000,000	"
Ottawa	1,000,000	"
St. Maurice	1,000,000	"

It is, therefore, not quite clear just why the Commission of Conservation in its eagerness to conserve would, indirectly perhaps, prevent utilization as exemplified in their opposition to application recently made to develop Coteau Rapids on the St. Lawrence. The commission took a similar obstructionist attitude a couple of years ago in regard to a proposed development of the Long Sault Rapids on the St. Lawrence.

To point out the alarming power shortage and to oppose private enterprise in its development, all in the one pamphlet, is an attitude upon which the commission owes more explanation to the public.

R. O. SWEEZEY, B.Sc.,
Consulting Engineer.

Montreal, P.Q., April 5th, 1918.

RESEARCH COUNCIL GETS APPROPRIATION TO BUILD LIGNITE BRIQUETTING PLANT

The Advisory Council for Scientific and Industrial Research has been informed officially that the government has approved the council's recommendation that a plant be erected in the province of Saskatchewan for briquetting lignite. The government has provided a sum of $400,000 for the construction and operation of the plant.

In this undertaking the Dominion Government is acting in co-operation with the governments of the provinces of Saskatchewan and Manitoba.

The council has received a request from the Ontario Government asking that R. A. Ross, E.E., one of the members of the council, be appointed to act with Arthur Cole, C.E., as a committee to take immediate steps for the development of the peat bogs of Ontario, and the production from them of a merchantable fuel. The Research Council has concurred in these appointments and the investigation will be proceeded with.

Leslie R. Thomson, C.E., who is at present on the staff of the Dominion Bridge Company, has been appointed as secretary to the council.

SASKATCHEWAN BRANCH, CAN. SOC. C.E.

A special meeting of the Saskatchewan Branch of the Canadian Society of Civil Engineers was held in Regina to deal with the first of a series of papers devoted to the subject of power. J. D. Peters, electrical superintendent of Moose Jaw, gave a paper on load factor and diversity factor, and their effects upon the production of power. In the discussion following the paper, members expressed the opinion that a great saving in power and coal might be effected by the establishment of central power distributing stations at the various coal fields. The engineers in the study and investigation being carried on now hope to arrive at some conclusion which will dispel the popular belief that Saskatchewan cannot produce cheap power because of the absence of large water powers.

CATALOGUES WANTED

The British American Nickel Corporation, Sudbury, Ont., advises *The Canadian Engineer* that it possesses practically no catalogues of engineering machinery and materials manufactured by Canadian firms, although the company is starting to build a $3,000,000 plant for the smelting and refining of nickel.

ELECTRICAL THAWING OF WATER PIPES*

By Fred C. Adsett
Hydro-Electric Power Commission, Trenton, Ont.

THE extremely cold weather this winter arrived early in December, before the snow came in sufficient quantities to afford a protection to the earth. Thus the frost got off to a good start in its descent through the ground, and soon succeeded in gripping the water pipes in a frigid embrace of no mean consequence. In view of the extensive trouble experienced on this account with the freezing of water services throughout the country, a description of the thawing apparatus used at Trenton, Ont., might be interesting.

Electrical thawing of water pipes comes near to being the ideal method of overcoming the difficulty. There is no digging, no splitting of pipes, nor shutting off of the water to other consumers. All that is necessary is to connect a wire to each end of the frozen pipe and pass sufficient current through the circuit. The chief drawback is the extremely severe weather at times encountered by the linemen while at this work.

The thawing outfit used at Trenton consists of a transformer, cut-out, water resistance, ammeter, switch, and reels of wire. A 15-kw. transformer has been used all winter, connected to give 110 volts on the secondary side. To regulate the current, a barrel of salt water is provided; the resistance used, however, is generally very small. The switch is on the secondary side; the ammeter is of the portable type. Near the transformer is a small reel of 8-w.p. wire; this wire is used to connect the cut-out to the live primary. Connection is made to a bare primary without danger by a clip device on a long wooden stick.

At the back of the sleigh are two larger reels each containing five hundred feet of No. 1 copper. These reels are turned by a crank when the wire is to be rewound. The primary distribution system in Trenton is 3-phase, 4-wire, with 2,200 volts between any phase and the neutral, or ground. Hence only one side of the transformer primary need be connected to the line. The other side is permanently grounded to one of the large secondary wires. Two men are required to operate the outfit efficiently; sometimes three are used. The entire equipment is hauled by one horse.

Practically all the trouble encountered this year has been in wrought iron service pipes. These are generally ½ inch pipes, but occasionally are 1 inch and two inches in diameter. For the ordinary ½-inch service pipes we have found that 180 amperes are the most efficient. This current is sufficient to heat the empty pipes to about 200° F. in fifteen minutes, but with water running in the pipes, this temperature will not be attained. At times, however, obstacles are encountered, such as where the water is frozen in the brass shut-off cock. For thawing services only, and where the main is free from ice, the two secondary wires may be attached at two different houses that are without water; both are thus thawed out at the same time.

The resistance of the main between the two services is naturally very small. Sometimes as many as six or eight services may be thawed at one set-up. To thaw a main, care must be taken to have one wire connected ahead of the freeze-up, and the other on any convenient lawn or house tap along the main. At times it is necessary to

*From the Bulletin of the Hydro-Electric Power Commission of Ontario.

attach to the curb cock outside, which is done by lowering the ordinary turn-off key with connection at the top end of it.

To thaw larger pipes a 25-kw. transformer is hauled out on another sleigh; this has not been necessary this winter. As high as 200 amperes have been taken from the 15-kw. transformer when necessary, care having been exercised to not expect too much of an overload from it. The 2-inch pipe requires from one to three hours to heat up.

The secondary wire is attached to the water pipes by being wrapped with a short piece of No. 8 bare aluminum of which there is a supply of scrap on hand. Variations from the usual sometimes occur. At times a transformer on the line is handy and may be used in place of that on the sleigh. In one case, after disconnecting the ground connection, we have attached the line side of the 110-volt service in the cellar direct to the water pipes. In this way the current flowed to the ground connection of a neighbor and registered 62 amperes without resistance. This house had No. 6 wire in the service conduit and was fed from the 20-kw. transformer.

Nor is the use of electrical thawing confined to water pipes alone. We frequently are requested to thaw soft-water pipes, soil pipes, and even sewer pipes. In Guelph, last winter, an underground cable was thawed in a conduit which had been flooded and frozen. Fifty amperes loosened this cable in thirty minutes, after steam had been tried for two days.

As the electric and water utilities both come under the one management in Trenton, some thawing jobs are charged direct to the water department. In cases where the consumer bears the expense, the time of the men and horse and the current used plus a small profit for depreciation of the apparatus, has averaged in the past between $1.50 and $2.25. This compares very favorably with the prices in Binghamton, N.Y., where the average return for each job was $13 with a minimum of $10.

The average number of thawing jobs completed in one day would range from six to twelve, depending upon how they might be grouped. Where the electric department is entirely distinct from that of the water department, there should be a good revenue netted from this work. There is also the satisfaction of supplying a timely service to the people.

RAILWAY EQUIPMENT CONTRACTS

The government has given the following details in the House of Commons regarding the $32,966,515 orders recently placed for railway equipment:—

Canada Car & Foundry Company, 5,000 forty-ton steel frame box cars, $13,750,000; National Steel Car Company, 1,000 cars, $2,750,000; Eastern Car Company, 750 forty-ton flat cars, $1,777,800; Eastern Car Company, 650 fifty-ton coal cars, $2,066,675; Hart-Otis Company, 250 side-dump cars, $760,000; Hart-Otis Company, 200 side and centre-dump cars, $625,000; Pressed Steel Car Company, 25 general service tanks, $134,956; Pressed Steel Car Company, 25 water service tanks, $129,593; Canada Car & Foundry Company, 250 refrigerator cars, $1,024,250; Pullman Car Company, 14 sleeping cars, $502,460; Pullman Car Company, 7 dining cars, $238,700; Montreal Locomotive Works and Canada Locomotive Company, 50 consolidated freight engines, $2,900,000; 10 switching engines, $405,000; 30 Pacific type engines, $1,800,000; 50 Mikado type engines, $3,720,000; Canada Locomotive Company, 6 switching engines, $246,000; 4 narrow-gauge engines, $136,080.

MORE EQUITABLE CONTRACTS BETWEEN HIGHWAY COMMISSIONS AND CONTRACTORS*

By James C. Travilla
Consulting Highway Engineer of the Dunn Wire Cut Lug Brick Company.

THE relations of the contracting parties to a contract for highway construction are closely allied; they should be co-operative and their joint efforts should be constructive. Unfortunately, at times, the duties and responsibilities of highway commissioners are not properly interpreted, or are limited by laws which make it difficult to successfully direct, finance and construct highways on a basis equitable to both parties to the contract.

The highway commissions' duties frequently are prescribed by laws which are inadequate, inelastic or mandatory. The commissioners, in their capacity as trustees for the public in the expenditure of road funds, are not in a position to deal with contractors in the same manner as though they were directing or adjusting a private business transaction. This limitation can be appreciated only by those who have held public office. The highway commissions, in providing for the construction of a system of highways to meet traffic requirements and in keeping within the financial limitations, prescribe definite plans and specifications, form of contract, bidding blank and estimates of cost, etc. The specifications for highway construction have been very generally standardized. The conditions and stipulations entering into contracts and specifications, together with their interpretation, have not. The estimates of cost of work frequently are based on incomplete or indefinite information regarding the cost of labor and material, average haul, approximate quantities, available water supply, suitable railroad facilities for receiving and unloading material, etc. These uncertainties have resulted in introducing an element of risk to contractors bidding on highway work.

Highway commissioners and contractors in estimating cost of work have not given sufficient attention to the fixed, overhead, incidental and plant expenses, labor and material market and cost data. The result has been low estimates and low bids, with unsatisfactory results to both parties, which have brought about a desire for a more equitable contract. The fixed, overhead, incidental and plant charges are very significant items in highway construction. Under this head may be properly classed the following:—

Cost of bidding, contract bond, liability insurance, legal expenses, interest on deferred payments, discounting paper, travelling expenses, home and local office expenses, cost keeping, demurrage, miscellaneous freight and express charges, equipment charges, depreciation on equipment, moving equipment, tools lost, broken or stolen, loss due to weather conditions, damage to work by elements, pay roll expense during rainy and cold weather, watchmen, labor shortage, loss in damaged cement sacks, delays due to breakdowns and material shipments, cost of inspecting material, damage to private property, water charges, boarding and transporting men, entertainment, etc.

The above items do not represent imaginary or accidental expenses connected with highway construction,

*Paper read before the annual convention of American Road Builders' Association.

and, therefore, should be given consideration by highway commissions in preparing estimates and forms of contract, also by contractors in preparing bids.

Careful consideration should be given commissions for proper engineering service, and they should not expect or require highway engineers to design, lay out or supervise and inspect work involving large expenditures without adequate assistance or recompense. In France and England from 3½ to 6 per cent. of the estimated cost of the work is authorized for engineering service. This is money probably better expended than other sums devoted to highway construction. Too much cannot be said as to the importance of technical experience in road construction. The specification, design of pavement, supervision, inspection and final results of the work depend largely on the ability of the engineer.

Modern highway construction presents to contractors as great a number of financial risks and uncertainties as will be experienced in any branch of public work. For example, the difficulty and expense of securing labor and holding it on the job, due to the work frequently being in isolated places; the problem of material transportation by wagon, truck, tractors or light railways; definite figures cannot be prepared as to the fixed expense for car demurrage, unforeseen weather conditions, transportation difficulties and labor conditions having a direct bearing on this item; freight rates and their subjection to change have been a factor during the past year; assuring material supply by prompt unloading and storage piles; cement storage under cover and distribution of same; the expense and uncertainty of providing an adequate water supply; the difficulties and red tape in securing necessary railroad sidings and right-of-way for roads to the same; providing temporary roads and bridges during the period of construction; damage to work by automobile joy riders or from other vehicle drivers, who are selfish or ignorant of the damage it is possible to do to green construction by their unwillingness to be inconvenienced for a reasonable length of time (police powers of some kind should be granted to contractors to enforce observances of their road-closing signs and barricades); being responsible for damages to work by floods or other acts of God; specifying that contractors shall employ local labor and material; the loss of time by reason of delays in securing right-of-way, injunction proceedings, etc.; payment for work in warrants of questionable value. These possibilities in executing contracts help make the uncertainty and gamble to the contractors in preparing bids and in contracting for highway construction.

Highway commissioners have not always given sufficient attention to the proper classification of material and details of construction in preparing specifications. It is not unusual to provide for grading with no classification. This also applies to foundation excavation where no distinction is made between "wet" and "dry" excavation. The equalization of cuts and fills and proper provisions for borrow pits, disposal of surplus material and the determination of overhauls are essentials. Preparing the subgrade and compensation for removal of soft or spongy material and its replacement with durable material are items of expense that should be provided for. The problem of drainage should be predetermined, and items should be provided in contracts for tiling and ditching. A reasonable unit price should be stipulated for rolling both the subgrade and road materials. Many contracts fail to allow monthly estimates for material delivered on the job, nor do contracts provide for acceptance and final payment for part of the completed roadway. Where the work is of sufficient magnitude, requiring one or more years to complete, this provision does an injustice to the contractor. There should be a fixed unit of two to ten miles of a completed roadway accepted and final payment allowed. A reasonable retainer of the monthly estimates is desired. Ten per cent. should be considered sufficient to properly protect the commission's interests. However, it is not unusual to find the retained percentage to be 15 or more per cent.

The economic value of inspecting materials at place of loading instead of at the point of delivery would frequently result in saving time and money to both parties. The question of maintenance of roads used for hauling road material from railroad sidings and gravel pits is sometimes raised, and it is not unusual to place this burden upon the contractor.

These features of highway construction are cited to show the importance of equitable contracts between highway commissions and contractors. If the highway commissions are known to be fair and equitable in the adjustment of such difficulties as they arise, it is not unusual for contractors to submit lower bids on the work proposed. Where specifications and stipulations therein are rigidly adhered to, without reasonable adjustment of differences, according to the spirit and intent of the contract, the bids are usually higher.

In suggesting features coming directly under the direction of highway commissions in preparing specifications, contracts, and in the execution of work, there is also an obligation on the part of contractors and the material interests identified with them to be fair and reasonable in their dealings with the highway commissions. Contractors should take pride in their work, be financially responsible to carry it through, provide modern equipment and an organization of competent men; and, further, have established a reputation for doing good work. It should not be difficult to agree upon more equitable contracts when these features as set forth are fully appreciated by both parties.

At road lettings it has been the general practice to call for unit bids based upon approximate quantities. Under normal conditions this method is more satisfactory in road work than to bid a lump sum for the completed improvement. The unfortunate feature of public lettings is the awarding of contracts to the lowest bidders, regardless of their responsibility or experience. The highway commissions not infrequently figure it will be necessary to depend upon the sureties or "some angel" to complete the work.

This condition may be somewhat remedied by requiring certain qualifications of bidders as to financial ability, experience, equipment, etc., before assigning them bidding blanks. The size of the job should be sufficient to attract responsible bidders and warrant the expenditure of proper sums for modern equipment and appliances.

The officials of railroad and electric railway companies, when about to build railroads, generally invite a limited number of responsible contractors to submit proposals for the work at cost, plus a fixed sum or on a unit basis. Such contracts usually are executed without "grief" to either party.

Owing to legal restrictions placed upon highway commissions under our present form of government, this procedure does not seem possible, especially when we realize that politics have not been entirely eliminated from road construction, the limited tenure of office of public officials and the general lack of confidence on the part of the public in its servants, regardless of their honesty, ability or unselfish efforts to faithfully carry out the trust imposed in them.

The precedent established by the American Institute of Architects in adopting standard documents, including contract, specifications, etc., and by making the general conditions and stipulations more equitable to the contracting parties, and by introducing the very important principle of arbitration, if followed by highway commissions, would result in the creation of more equitable contracts between the contracting parties. The State Highway Engineers' Association is working on the standardization of highway specifications and forms of contracts. The enactment of laws where necessary, authorizing arbitration of all questions in dispute between highway commissions and contractors is considered an essential before standard and equitable relations can be established between the contracting parties.

The suggestions herein offered for more equitable contracts between contracting parties for highway construction are not all that are desired under the present abnormal conditions of the labor and material market, which necessitate contractors assuming an unjustifiable amount of risk in signing contracts.

The recognized necessity of continuing building selective highways that will best serve the country in time of war as well as peace, and to further provide for the employment of a class of labor not adapted for work in munition plants and other industries necessary to help win the war, make it of sufficient economic importance for the prosperity of all classes of labor to proceed with the improvement of selecting highways in a manner equitable to both parties to the contract. Several methods of letting work to accomplish this end are suggested:—

The contractors to submit proposals on form provided by the highway commission, setting forth the rates of labor, estimated cost of manufacturing materials and quotations on the materials required; the bids to be tabulated, analyzed, and the award to be made on the best bid, considering all the items; the labor and material items shall not be less than the prevailing rates and quotations recognized at the time of bidding. This information should be set forth in the instructions to bidders. The contractor shall at any future time, if required, be prepared to show by what procedure said prices were arrived at. Thereafter the commissioners, on due proof of pay rolls, bills and receipts that the rates and quotations used in preparing bid have been substantially increased, shall grant a hearing to the contractor and be authorized to allow such additions to the unit prices stated at time of letting as will insure the contractor against actual loss due to the changed raes and prices, but this shall in no case cover the losses due to inefficient handling of the work or from faulty estimating of said cost. It is preferable that at the time of change in the wage scale or advance in price of material the contractor be requested to at once ask for a hearing before the commissioners to determine whether the request shall be allowed. If the commission decide that it is better to delay the work, they shall make an equitable adjustment with the contractor to cover the fixed charges, such as plant rental, overhead and incidental expenses, for the delay caused in completion of contract. It should be further provided that in the event of extraordinary conditions, such as embargoes on cars or material beyond the control of the contractor, which caused delay in the completion of the work, an allowance shall be made in the specified time limit for doing the work, and if a loss is incurred from such delay, to be reimbursed for the expense of plant rental and necessary overhead and incidental charges.

Another equitable method of constructing highways is to have the highway commission purchase and deliver road material, f.o.b. nearest railroad siding, the contractor's proposal to provide for furnishing labor, equipment and appliances, the labor to be paid the prevailing rates and the equipment at a fixed rental per diem for the actual time used, all of which is to be definitely set forth in the bidding blank, including the percentage of the cost of labor to be allowed the contractor for his profit and overhead expense.

A method sometimes adopted in awarding contracts is to allow the contractor the actual reasonable cost of labor and material entering permanently in the work, as determined by the highway commission, plus a fixed per cent. of such work. In figuring the labor cost of highway construction the following items shall be included:—

(1) Actual pay roll expenditures for labor.
(2) Foremen and timekeeping on the work.
(3) Liability insurance paid on same.

The cost of materials entering into the work will be determined by the material, freight and hauling bills for the same. The fixed per cent. allowed to cover the profit, overhead equipment and incidental expense.

In conclusion, it may be stated the personnel of the commissioners and laws on the statute books are important factors in arriving at equitable contracts between the contracting parties. Commissioners who have had liberal business or technical training, working under reasonable restrictions and dealing with contractors of the same type, both parties appreciating the financial risk and uncertainty in entering into contracts under the present abnormal conditions, the contingent expenses heretofore referred to and the suggested methods of eliminating such risks, both parties should be in a position to co-operate in drafting an equitable contract between highway commissions and contractors.

$50,000,000 FOR RAILWAY EQUIPMENT

Parliament this week passed a resolution appropriating $50,000,000 for expenditure by the Minister of Railways on railway rolling stock, equipment and materials. The resolution as introduced called for an expenditure of $50,000,000 each year for the duration of the war and one year thereafter, but after debate the resolution was altered to cover only this year's expenditure.

Whether complete nationalization of any or all of the railways in Canada materializes this year or not, the government at any rate is standing behind the financing of all roads excepting the Canadian Pacific, and even in connection with that road the government is buying new equipment and rails, but expects to be paid for them promptly upon delivery.

Including the $25,000,000 loan provided for the Canadian Northern, $75,000,000 for the Grand Trunk Pacific, probably $10,000,000 for Canadian Northern stock, and $50,000,000 just voted for equipment, the government will spend this year on railway account no less than $160,000,000. Orders for equipment, rails, etc., to the extent of $32,966,515 have already been placed. This does not include the 100,000 tons of rails recently purchased and which will probably cost five or six million dollars. The government also expects to have to purchase ten or fifteen snow ploughs at a cost of about $100,000, 100 tourist cars for carrying troops and possibly about 20 baggage cars.

THE GREATER WINNIPEG WATER DISTRICT

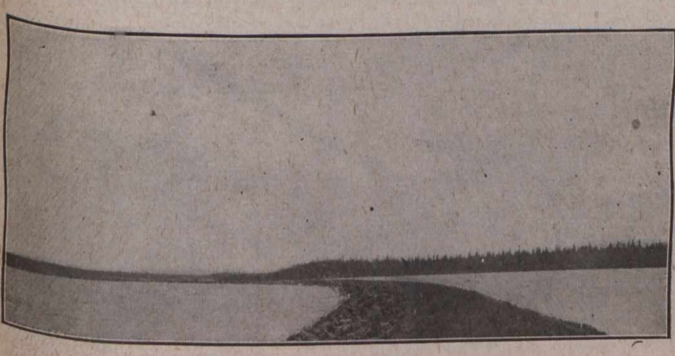
By C. S. C. Landon, A.M.Can.Soc.C.E.

(Concluded from last week's issue)

THE invert or "floor" of the aqueduct is laid between profile forms and in lengths of 15 feet each. These forms are usually of wood, so that they can be easily handled, and the upper edge is shod with angle iron. The lower edge is cut to a section to conform with the standard trench bottom section and the upper edge is curved to the exact curvature of the invert section. The engineering staff set stakes every 30 feet, which establish the grade and centre-line of the top of the invert. The contractor is thus able to set and align correctly each set of invert forms. There is a copper expansion strip having a V-shaped groove which is set in place at each joint. Every 45 feet this copper joint is allowed to extend above the face of the invert haunches so as to form an over-lap with the corresponding copper joints placed in the end of the arch to follow. The inverts or pads, as they are sometimes called, are poured alternately in order to provide space to perform the screeding, floating and trowelling necessary to give the face of the invert the smoothest possible finish. When the concrete has hardened sufficiently the forms are taken off and the intermediate or closure pads are poured. The concrete in the inverts is screeded with tools made from 3½-in. x 3½-in. angle iron 16 ft. long and equipped with handles at each end. This is pulled lengthwise of the invert back and forth across the face from the centre to the sides, and the process is continued until the pad is true to form, and until no stones are visible at the surface. It is then finished with floats and trowels.

To guard against leakage at the longitudinal joints between the invert and arch joint, a strip of soft pine ⅝-in. x ¾-in. is sunk to about half its depth along the length of each side of the inverts and adjacent wood strips are abutted at their ends.

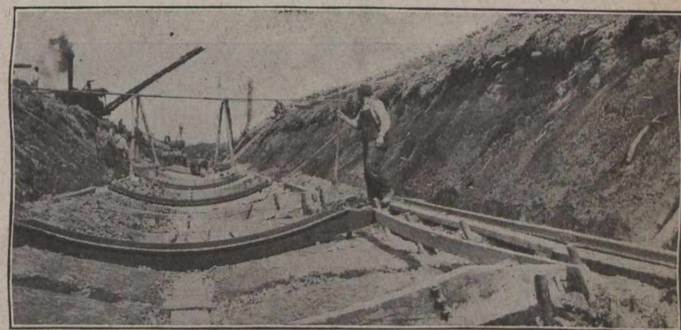
The arches are built in 45-foot lengths with a copper expansion strip at each end. The forms for the archwork are of the collapsible type, and are made of steel by the Blaw Steel Company. The inner portion of the forms is



General View of Falcon River Dyke

moved on carriers which run on a 2-foot gauge track laid upon the invert and these forms, when in position, are shaped up by means of turnbuckles attached to the carriers. The outer form is made in sections 5 feet in length, bolted together in 45-foot units of nine sections. Methods of moving these forms differ in detail according to the ideas of the contractor. On some contracts, the forms are moved in sections, on others, half of the form is moved at one time, which, of course, must be done by a derrick or other similar machinery. At the majority of camps, however, the outer forms are moved intact with a carrier which runs on a track laid along the two sides of the trench bottom.

When the concrete is being poured into the form some of the outer panels are removed and the concrete is brought up evenly on both sides throughout the entire length of the arch. As the concrete reaches this level these panels are replaced and bolted until the whole arch has been poured. Spading of the concrete is continuous during the process of pouring and, contrary to the opinion held by some engineers that setting concrete should not



Invert Profile Set. Note Excess Excavation Due to Roughing Too Close

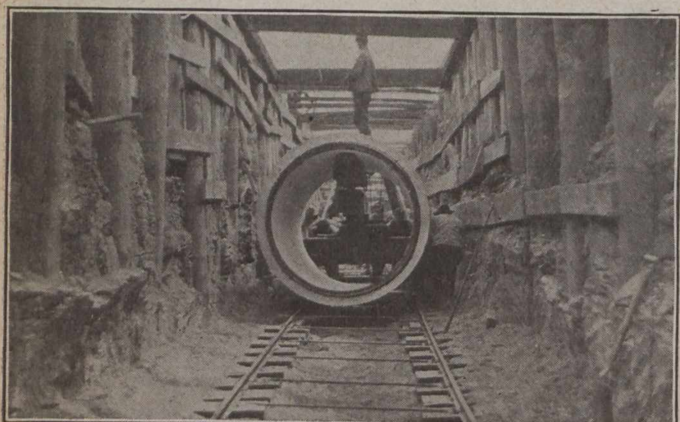
be distributed, the portion at the top of the arch is spaded until it becomes too stiff to be worked satisfactorily. This being done prevents hair-line settlement cracks which otherwise would occur in dense concrete placed similarly. The pouring of each arch is a continuous process and must be continued until the form has been filled. The arches are poured alternately as in the case of the inverts and when sufficient time has elapsed the forms are removed and sprinkling or earth covering adopted to prevent the evaporation of the water from the concrete.

When the concrete has been completed for a distance and has become sufficiently hardened, the backfilling or placing of the protective coat of earth is begun. This work is carried out in two stages; first material is tamped into place along the base of the arch and reaching to a height of 4 feet, and then the machine backfill is proceeded with. Instructions are issued to bring the earth up evenly on both sides of the arch and thus provide lateral support. Care also is insisted on that no earth is dropped directly on the crown of the arch until the height of the backfill on the sides is high enough to bridge over the sudden weight applied. If a cubic yard of wet backfill were dumped from a height upon the crown of the arch it would cause sudden and unnecessary stresses.

The depth of the finished backfill is 4 feet over the crown of the arch and the width of the top about 8 feet with the sides sloping to the ground line. After the backfill has been exposed to the elements for twelve months and all settlement filled in, the top and sides of the embankment are seeded with a combination of seeds calculated to produce the heaviest sod and thus protect the embankment from further weathering.

Work on contract 55, which was awarded to the Winnipeg Aqueduct Construction Company, working in conjunction with the Canada Lock Joint Pipe Company, was carried on successfully during last summer. The contract price for this work is $1,308,753 and includes the manufacture of reinforced concrete pipe 5 feet 6 inches in diameter and in lengths of 8 feet each; the transportation of these and the setting of them in a trench previously excavated by the contractor; the backfilling of the trench and the final jointing of the pipe after the backfilling has been done and the jointing of this pipe with the westerly end of the aqueduct section being built by the contractor of contract 30. This contract is 9.3 miles in length, and extends from Deacon to the Red River, crossing the Seine River at St. Boniface. The pipe line under the Seine will be an inverted syphon carried on a concrete mattress supported by piles driven to the rock.

Immediately south of the Canadian Government Railway shops in the town of Transcona, the Canada Lock Joint Pipe Co. have established a yard in which all operations of the pipe manufacture are carried on. The reinforcing steel is received and bent to shape there, and the cement and aggregate for concrete manufacture are delivered at the yards over a spur track constructed by the District.



Carrying Pipe Into Place

The yard is divided into two units, each being separate and distinct in so far as pipe manufacture is concerned Each unit has a battery of four concrete mixers near to which the aggregate is delivered. The cement is stored in weatherproof buildings within carrying distance of the mixers. The forms for pipe manufacture are set upon individual concrete footings, arranged on either side of a track upon which moves a locomotive hoist or carrier. This hoist handles the concrete buckets, the steel forms, reinforcing steel and completed pipe; in fact it is utilized for all lifting work in connection with the pipe manufacture except the loading of the completed pipe on to cars, which is done with a locomotive crane.

Concrete is carried in buckets which are made in the form of truncated cones. In the small end of the bucket is fitted a pear-shaped stopper which is raised by a separate cable when the concrete is to be poured into a form. After the filling of each form is completed the whole is encased in a canvass covering and low-pressure steam supplied from a central plant, is admitted to the form. The curing by steam is continued for 48 hours, after which the steel forms are removed and the curing by steam is continued under these conditions. When the pipe has been treated sufficiently it is carefully loaded on flat cars and taken to the open trench on the line of the work, and is lowered into the trench and placed upon a carrier running on a track and with this carrier is moved into place and aligned. The joints are brought up close but the outer portion or primary joint only is filled. The pipe is not laid directly upon the earth of the trench bottom, but is carried upon gravel placed on the earth and tamped to a depth of 8 inches. Backfilling operations follow the setting of the pipe, and when this has been in place at least two months the inner or secondary portion of the joint is then filled with the material specified for filler. The reason for proceeding with the jointing and backfilling in the manner stated is to allow for settlement and to make certain that when the joint has finally been made it will not be opened by future settlement.

The District has recently awarded contracts covering the construction of a tunnel under the Red River at Winnipeg; the building of 2.4 miles of concrete pressure pipe line through the city from the Red River to the McPhillips Street reservoir; and for the construction of an intake structure at Indian Bay. The work at the Red River crossing will consist of the driving of a tunnel through the rock under the river, at a depth of 75 feet below the ground surface and 35 feet below the bottom of the river; the excavating of two shafts, one on each side of the river, and the lining of the same; and the construction of a well or surge tank on the east side of the river.

Cast-iron pipe, 5 feet in diameter, will be used for the tunnel lining. This pipe will have bell and spigot ends, and each joint will be poured with lead. Hand-placed concrete will be poured in the space between the cast-iron pipe and the tunnel walls.

The flow of the water through that portion of the line from Deacon to the tunnel will be, for the immediate future, by gravity and as the velocity will be relatively low it was calculated that should sudden demands for water be made, as in the case of a conflagration, before the velocity of the water in the line had increased sufficiently, the supply would fall short of the quantity required and serious difficulties might arise. Consequently, the surge tank or well expedient was adopted. The tank is designed to hold enough water to take care of any sudden demand upon the line until such time as the water in the pipe has a velocity which will give an increased discharge sufficient to supply the demands upon the line. When the discharge from the pipe has become great enough to meet the demand, the well fills again and an overflow built in conjunction with the unit takes care of any excess of water caused by the surge, discharging such excess into the Red River.

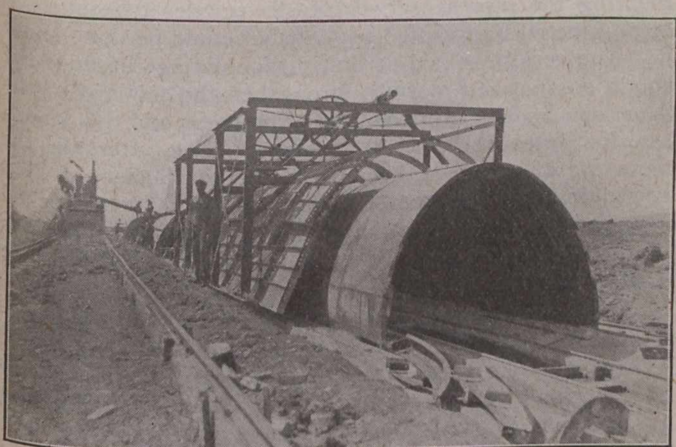
It was the original intention to construct the pipe line from the Red River to the McPhillips Street reservoir of cast iron, but the price of iron has increased so rapidly that a saving of approximately $175,000 is being effected by building the line of reinforced concrete.

Drag-line Excavating Aqueduct Trench

The work consists of trench excavation, the removal of all permanent pavements crossed by the trench and the replacing of these by gravel, the supply of the pipe and the setting and jointing of it in the trench, the temporary removal and final replacing of all water mains, sewers, conduits, poles, etc., and the backfilling of the trench when the pipe has been set. There are other details, such as gravel backfill and vitrified pipe drains. A Venturi meter is to be supplied by the contractor for this work and in addition the contract calls for the construction of a meter house and the furnishing of recording apparatus and a supply of recording dials, ink, etc., sufficient for one year of service. There will be eight Venturi meters of varying sizes at different points on the line.

Work on the intake is well under way. The main features of the work are: Construction of a reinforced concrete gate house in which sluice gates will be located, provision being made in the plans for the supporting of a crane; also two gravel-filled wing walls or dykes extending out into the lake; the rip-rapping of these; the excavation for the bed of the dykes and excavation of the intake channel and the setting of screens at the intake. All details relative to the clearing, grubbing and final clearing up of the entire site are also included in the contract.

The wing walls will serve the double purpose of reducing and regulating the flow of water toward the intake



Traveller for Moving Outside Forms

and of counteracting the action of wind and wave in the intake channel. The channel is also to be deepened and thus all water entering the intake will be deep water which will be cooler and always clearer. The aqueduct will be completed about the end of December, 1918, after which the inhabitants of the water district, which at present number 300,000, will for the first time have an abundant supply of pure soft water, highly suitable for domestic and industrial purposes.

NEW INSPECTION COMPANY

Announcement has been made of the formation of a new inspection and testing company in Canada. The promoters of the new company are T. F. Griffiths, formerly President of the Canadian Inspection and Testing Laboratories; N. H. Manning, formerly manager of the Toronto office of that firm; R. Robertson Deans, formerly assistant to Mr. Griffiths; R. J. Marshall, lecturer in ferro-metallurgy in the University of Toronto; and L. J. Rogers, lecturer in chemistry, University of Toronto.

The new company is operating under the name of the Canadian Inspection and Testing Company and has taken over the equipment and laboratories of the Canadian Inspection and Testing Laboratories, Limited. Offices have been opened in Toronto and Montreal.

The city of Guelph's estimates for this year include $20,500 for the Light and Heat Department, $20,000 for the Water Commission.

ENGINEERING AND CO-OPERATION*

By Dr. Ira N. Hollis

President, Worcester Polytechnic Institute, Worcester, Mass.

ONE can hardly speak to a group of engineers on any subject at this time without some reference to that which is present in the minds of all Americans, the war into which we have entered, perhaps the greatest struggle in all history. Under any circumstances, it is the greatest in the cause of freedom and democracy. It is truly a war for the union, in the same sense that our Civil War was a war for freedom and unity.

I have heard it called an engineers' war, but I prefer to put it in another way. It is a war in which engineering training or, at least, the kind of training that is given to all engineers and men in applied science, counts most.

I listened a few days ago to a Frenchman who had come to this country to ask help of Americans by means of certain specialized regiments behind the lines in France. He suggested the need of at least 60,000 men, without any military training, for service behind the fighting lines, and he described the war as an industrial enterprise, rather than the kind of thing that we have always thought of in discussing the war. The organization is essentially that of any great company for manufacture and transportation. This French officer spoke about the immediate necessity for engineers to make arrangements for transmission of power, for communications, for the continuous supply as the English and French surge forward into the country occupied by the Germans. To a limited extent, America has already begun to send specialized regiments to France for railroads, forests and mines.

In this sense, the was is an engineers' war, but in the larger sense it is everybody's war, as it involves the co-operation of every interest in the United States, from the infant to the old man. It is not to be won by the farmers, as some would have us think, or by the mechanics, or by the railroads, or by the soldiers. It is to be won by all of us.

When one speaks of war, the word "co-operation" comes into one's mind as a matter of course. That is the one element of success for an army. Devoted and willing co-operation in obeying orders for this great cause is bound to bring us to a glorious success. It seems to us at present as if co-operation were a new discovery and we hear so much of it that the world seems to have been heretofore poor in that spirit which enables men to work together to a common end. All civilization has been built up on co-operation from the time of the first lonely savage on this earth, through the long period of history that has brought us to the great American democracy. It has all been co-operation; that is what modern life is; so that when we talk of co-operation, we must not forget that civilization bears a direct proportion to the capacity of human beings to work together. In a representative government, that means always the rule of the majority.

There are two kinds of co-operation. The first perhaps is not co-operation at all. It is that kind where the great mass of a nation are more or less forced to work under a privileged class. We are in the habit of calling that autocracy, but it is, after all, the strongest kind of co-operation developed by a few men whose business and power it is to plan for a broad co-ordination of everything within national boundaries. I cannot believe that it is the best kind of government, although it does stimulate the kind of intense activity that we see now in Germany, and

*Abstracted from paper read before the Cleveland Engineering Society.

have seen for the past forty years. In the long run, however, men will get along better where there is a willing surrender of self to the needs of a great democracy like ours. I do not believe that democracy has yet had its fair test on this earth, and the comparison that demonstrates the efficiency of an autocratic empire in war as contrasted with a republic is not based upon a sufficient experience. So long as there is one autocracy left or one nation where a privileged class has the right to arrange the fate of every man and to plot in secret against races all over the earth, there will be no opportunity to determine what democracy can do for a new race. It can never have a fair test until the other kind of government is wiped off the face of the earth.

It is possible to have co-operation gone mad, and there are some examples of it in the United States, wherein the trade unions have banded together to limit the enterprise of the individual. Labor has even gone so far as to put on the Department of Labor Building in Washington, "Dedicated to Labor, Freedom, Justice and Humanity"; as if labor in the machine shops and on the railroads had any more right to freedom, justice and humanity than the rest of us. The motto applies to all of us. The only true co-operation I know of in this sense is the right or power to sacrifice one's self to the nation and to what might be called the social ideals of our country. That is the true liberty and the true equality referred to by the founders of this republic.

We must not forget, therefore, as engineers, when we begin to talk about co-operation, that it is nothing new. The topic for discussion ought rather to be how best to make it effective. What means should be adopted to bring it to something more than simply talk? How can it be applied to engineers in a special way, so that they can be more able to serve their country, or so that they may be more able to dedicate themselves to real service? Few engineers obtain great wealth unless they get out of engineering entirely and go into business or into manufacturing on a large scale. Consequently, I think of our profession as that which listens most willingly to the call of service. You have evidence of that in every state. The only profession I know of that is superior to it in the dedication of self is that of the school teacher or the ministry.

How can this word be made to mean something more to us as engineers than it has meant in the past? We ought not to think of it so much in terms of this war, although God knows that we need all the co-operation we can get to bring us to a successful end; but rather in terms of that brotherhood over the whole earth which will never permit another international difficulty to be settled by bloodshed.

I spent nineteen years in the American Navy, and during that time I do not recall a single American who wanted to see the United States at war for the purpose of testing out the ships and war machinery accumulated for national defence, and I never knew an officer who wanted to fire the guns in anger. I never knew a man in the Navy who did not look with horror upon the prospect of bloodshed and the misery that would have to be brought to every family by war. Consequently, my chief hope is that through co-operation of exactly the type that the engineer is capable of exhibiting, we may solve our difficulties in the future between nations without war and without bloodshed.

Engineers have always worked together more or less. We call this an age of specialization in connection with engineering, but what is specialization but co-operation? "Everyone to his trade" is taking co-operation for granted, and success is dependent upon it.

I want to say to you gentlemen to-night before I go into this subject that it is comparatively unimportant how co-operation is brought about amongst engineers, whether it comes through national engineering societies, through local engineering societies, through clubs, through colleges, or through the efforts of individuals in different parts of the country, so long as it is effective. If engineers can be made to recognize themselves as members of a great profession with exactly the same interest in serving the country, the incomplete efforts in the past, and various conferences and discussions to bring them all together, will seem but imperfect beginnings to us. The war has provided a psychologic moment when everything can be accomplished, because attention is called to our combined effort as the important thing toward the future. It will also be the most important thing in the readjustment of peace after this war is over, when every industry will have to get back to normal conditions.

A number of years ago I was president of the Boston Society of Civil Engineers, and we made a special effort to bring the representatives of all societies together. A committee was appointed to see what could be done about it. The result seemed at first disappointing, because the conditions worked more to strengthen the sections of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, but, after all, the main end was reached, because the Boston Society of Civil Engineers and the two sections mentioned have worked together like brothers in the profession ever since. Besides that, the Boston Society of Civil Engineers has since grown from 600 to 1,000.

Your own society here in Cleveland is a first rate example of what I mean by a local society of engineers. When you take part in the good government of the city of Cleveland, you are only fulfilling your obligations as citizens, and your engineering society not only has a right to take that part, but it has a duty to see that all that relates to sanitation, streets, transportation, and water supply are properly safeguarded. The only thing is to extend your society to the entire state, either by having it reach out to every part of the state or by affiliation with other engineering societies; so that you may have an Ohio State Engineering Society. Personally, I believe that the very best can be done by a union of a large number of local societies, just as I believe that the best government is based on local autonomy in sections of the country under one glorious flag.

There are several methods by which the engineers can be brought together into better co-operation:

(1) By means of a congress of all the engineering societies, to which a number of representatives shall be sent with power to commit the societies within limits.

(2) By means of a conference called from year to year for the purpose of recommending lines of common action to all societies.

(3) By means of a council beginning with a few societies and gradually extending itself into a nation-wide senate, with power to speak for the engineers along defined lines.

(4) By organizing in every state an engineering society composed of the smaller groups in the cities, having some national central congress to represent all the state societies.

The more the engineers study public questions, the more derelict we seem to have been in the past. As a matter of fact, our profession lacks in citizenship, because we have confined ourselves too much to technical problems. We have been too long content to occupy subordinate positions in the civic life of the nation.

What are the great public questions at the present time? The first relates to commercial standards. There is nothing more important in enabling our country, after this war is over, to hold its place in the modern world. A committee of the four societies mentioned has already been formed to stimulate and encourage standardization. The Society of Automotive Engineers has done splendid work in this direction. It is hoped that the new standardization committee will include a large number of societies. It will certainly have representatives from the government as, for instance, the Bureau of Standards, the Army and the Navy. Its functions will relate to the acceptance, or promulgation of new standards. The standards themselves must necessarily grow out of commercial practice and must be established by the men who are most familiar with the commercial demands.

The second involves the great national question of coal saving by means of water power, by reduction of waste, and by increase of efficiency. Up to this time, our Congress has held back from development of water power on all public lands and has thereby rather encouraged the wasteful expenditure of petroleum and coal. All engineering societies are interested in this in one way or another.

The third great question is concerned with research on a great scale for peace and war. A large number of groups in colleges and in societies have been formed to conduct special kinds of research, but there is much overlapping, and this is a public question involving broad co-operation.

It would be possible to name a large number of activities undertaken in spasmodic fashion by individual societies, and yet which are common to all. If the newly organized council can develop contact with all of the engineers of the country and thus create a thoroughly democratic body, whose work extends to every field common to the engineering profession, it deserves zealous support. If it cannot, it should give place to some other body. Our country is peculiarly dependent upon the willing co-operation of individuals and of societies. In a nation like Germany with an autocratic government and a social caste which predominates over the individual, co-operative movements may be forced, but in our country, where every individual has complete freedom to develop himself, nothing but willing sacrifice of selfish motives will enable us to make of this country all that it deserves to be.

It has been suggested that the engineers as societies cannot go into politics. That is true, and no organization, whether it be engineering, legal or medical, ought to go into politics, so far as partisanship is involved. We cannot support a man because he is a Republican and we cannot support him because he is a strong advocate of the trade unions, but we can enter the legislative field in the interest of the entire country. Legislative matters connected with water power form a perfectly legitimate subject for activity among engineers and engineering societies. It may be said that the local societies can be more effective in relation to Congress or a Legislature than national societies. Furthermore, it is more natural for local societies to take part in the acts of State Legislatures and city councils; but there are a large number of interests in which the great national societies can act together and can be very influential in informing Congress on matters of importance to the country.

The estimates for the Board of Works, Windsor, Ont., this year, amount to $64,970. City engineer, M. E. Brian.

The Dominion Parliament has passed an estimate of $478,000 for dredging and maintenance of the St. Lawrence River ship channel.

Premier Charles Stewart, of Alberta, has announced that the government is making an effort to enlarge the market for Alberta coal, and is endeavoring to plan storage buildings at Winnipeg for lignite coal from that province, thus enlarging the marketing period to ten months in the year.

THE NIAGARA POWER SHORTAGE

A BRIEF review of the power situation in south-western Ontario has just been issued by Arthur V. White, consulting engineer of the Commission of Conservation. He reports that the capital investment of the province of Ontario in connection with the systems which it operates, including the purchase price of the Ontario Power Company and of the Central Ontario System, is approximately $48,500,000. In addition, the municipalities have a total investment of over $21,000,000 in connection with their local distribution and operating systems. The Commission serves over 121,000 customers, of whom 4,000 are power consumers.

In August, 1917, the munition plants supplied with power by the municipalities and the Commission from the Niagara system were taking a total of over 78,000 h.p. with firm contracts amounting to 94,600 h.p. In the same month, the Ontario Power Co. was supplying some 44,600 h.p. for munitions and war materials. This makes a total demand upon the Hydro-Electric Power Commission and the Ontario Power Co. for munitions, of over 186,000 h.p. Of this, however, 30,000 to 35,000 h.p. may be considered as "off-peak" power, leaving a net requirement of some 150,000 to 155,000 h.p. The shortage on the Niagara system for munition plants supplied with power by the Commission and the municipalities alone, considered by themselves, may be placed at about 65,000 h.p. It is very interesting to note that, as a result of the campaign conducted through the daily press and by means of other agencies, the various municipalities have so adjusted consumption of electricity within their respective jurisdictions as to reduce the load "on peak" by from 20,000 to 30,000 h.p.

The following are some of the means by which this shortage may be supplied:—

(1) Increased utilization of steam power. This, at the present time, is out of the question as a means of dealing with the problem as a whole.

(2) Supplying temporarily, water from the unappropriated surplus, thus permitting the utilization of the excess capacity of the plants at Niagara.

(3) Curtailment of the power now used for street and other lighting, such, for example, as ornamental lighting.

(4) Utilizing the water of existing plants under more efficient conditions, such as will exist in connection with the new Chippawa project, which will operate under a head of 300 to 305 feet and provide about 200,000 h.p. It will, however, be approximately three years before relief can be obtained by such means.

The Hydro-Electric Power Commission of Ontario has recently installed equipment to supply an additional 50,000 h.p. from the plant of the Ontario Power Co.

(5) Limitation of the quantity of power at present being exported from Canada to the United States. As manufacturers of war munitions in the United States also are short of power, such limitation will require very careful consideration in its international aspects, so that full justice will be done to interests on both sides of the boundary.

The purchase of the Essex County Light and Power Company by the Hydro-Electric Power Commission has been completed. The properties of this company were owned and controlled by the Detroit-Edison Company, and situated in Essex. The plant comprises 55 miles of high voltage lines, 26,400 volts, and distribution systems in the municipalities of Amherstburg, Kingsville, Essex, Leamington, Harrow, Canard River and Cottam. Until power can be used the plant will be operated by steam, a contract for which has been arranged with the Canadian Salt Company. The purchase price was $226,000.

THE RESISTANCE OF A GROUP OF PILES*

By H. M. Westergaard
Instructor in Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill.

THE distribution of pressure among a group of vertical piles carrying a vertical load is often determined by considering the total horizontal cross-section of the group as the cross-section of a beam under similar loading. For this special case such a solution is satisfactory; but when some of the piles are battered and the group is irregular, like that shown in Fig. 1, the solution based on beam theory would be seriously in error. Exact analysis of the group in the figure gives the separate pressures indicated on each pile. It is noted that the maximum pressure coming on any pile in the group comes on one of

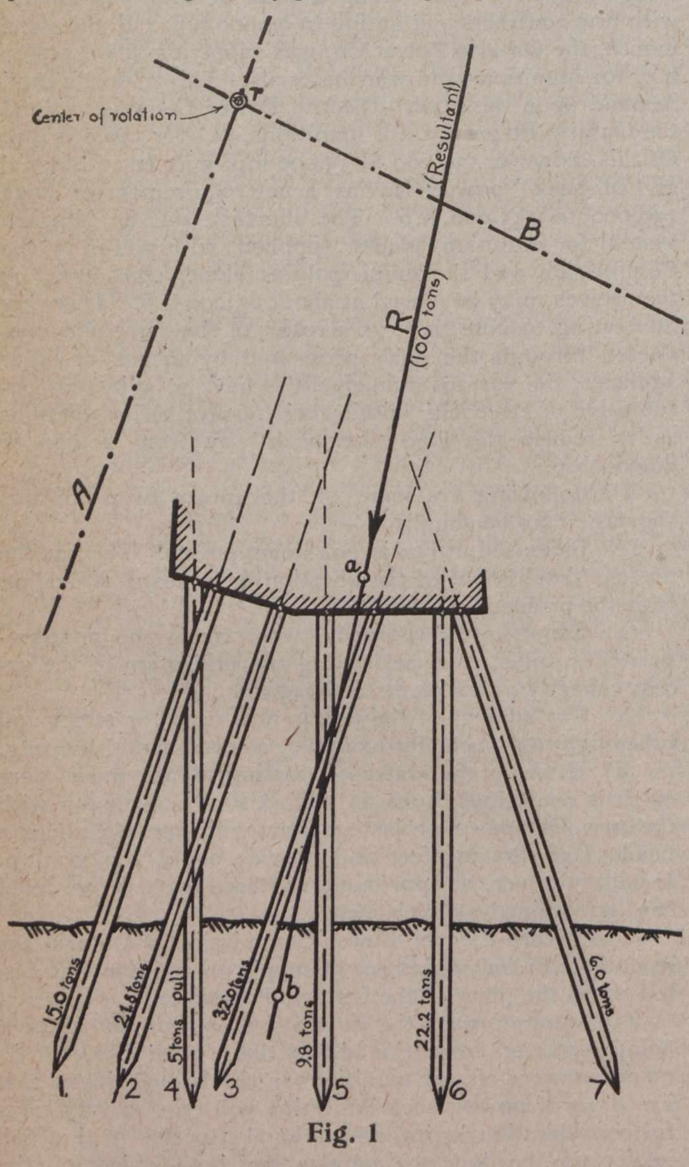


Fig. 1

the central piles, a result widely at variance with results of the solution mentioned above. (A solution of the general case is proposed by Max Buchwald. See Deutsche Bauzeitung, Betonbeilage 1913, 2, p. 188, and 1915, 1, p. 77. This solution is incorrect as it does not take the deformations of the piles into consideration.)

It is proposed in this paper to present a method of determining the distribution of pressure among any irregular group of piles such as that shown in Fig. 1.

*Paper read before the Bridge and Structural Section, Western Society of Engineers.

The piles are assumed to be arranged in planes parallel to the plane of the paper, and parallel to the resultant force, R. The displacements considered are parallel to this plane, and, in general, will be considered as infinitesimal. Each pile will be assumed to be hinged at its head and at some theoretical point near the lower end; thus, only axial loads will be considered as acting on the pile. The portion of the supported structure which rests immediately upon the piles will be called the "pier." It will be assumed to have the character of a solid mass, such that only small internal deformations will exist, when compared with the changes in length of the piles. The pier will be assumed to be supported by the piles only, both vertically and horizontally.

The pier and the piles taken together are assumed to constitute an elastic structure in which the displacement will, within certain limits, be proportional to the loads causing them. Such limits will in some cases proceed from the assumption that certain piles may not be designed to take tension. If, by applying the method which follows, any such pile is found to have tension the analysis is to be reapplied with this pile omitted, as though inactive in the structure.

The action of the structure under the load is defined when the motion of the pier is known. In the general case this motion may be characterized as a rotation of the pier through a certain angle about a certain centre of rotation. In special cases the displacement of the pier is a parallel motion. Such a motion may be considered as a rotation about a point at infinity. We may in all cases, therefore, speak of a rotation as characterizing the displacement. It will first be shown how the pile pressures depend on the rotation centre and rotation angle; then a lemma relating to certain qualities of reciprocity will be introduced. On this basis a method of dealing with any particular case will be developed. Finally, the resistance in general will be discussed, assuming a varying resultant.

To Find the Pile Pressures When Centre of Rotation and Angle of Rotation Are Given

The notation used to find the pile pressures when centre of rotation and angle of rotation are given is as follows:

r = centre of rotation.
ϕ = angle of rotation measured in radians.
p = distance from centre line of any pile to centre of rotation. p shall be considered positive if a shortening of the pile would increase ϕ, otherwise negative.
l = length of pile measured from the assumed hinge at the top, to the theoretical point of support (at which a hinge is assumed), near the lower end.
e = shortening of pile.
EA = modulus of elasticity times cross-section of pile.
P = total pressure on any pile.

1-2 in Fig. 2 is the original position of a pile, and 2-3 the motion of the top end due to the rotation of the pile head through the angle ϕ about r. 2-4 is the shortening e. Point 5 is the projection of the centre of rotation on the centre line of the pile. If point 5 is considered as attached to the pier it moves to the position 6. As the displacements are treated as infinitesimal quantities we may write: Distance 6-3 = 6-4, hence 2-4 = 5-6, or, the shortening of the pile is

$$e = p.\phi \qquad - \quad - \quad - \quad - \quad (1)$$

(= distance of centre line of pile from centre of rotation times angle of rotation.)

From formula (1) follows the expression for the corresponding pile pressure

$$P = p. \ (\phi EA/1) \quad - \quad - \quad - \quad (2)$$

Reciprocity of Lines of Resultant and Centres of Rotation

If the rusultant, R (Fig. 3), produces a rotation about a point r, then a resultant S passing through r will produce a rotation about some point s located on R. In other words, if R has its rotation centre on S then S has its rotation centre on R. This applies in general to the displacements of any line element attached to any elastic structure.

A proof of this theorem will now be presented. It follows closely one given by Ritter with his derivation of the fundamental qualities of the ellipse of elasticity.* It is based on the general theorem of reciprocity named after Maxwell and Betti,† which states in one form that the displacement along one path caused by a unit load along some other path is equal to the displacement along the second path due to a unit load along the first path. Applying this to the present case (Fig. 3) we have: The displacement of the point r in the direction S due to a unit load acting along R is equal to the displacement of the points on R in the direction R produced by a unit load acting along the line S. The displacement of r is zero when r is the centre of rotation, hence the displacements of the points on R in the direction of R produced by the

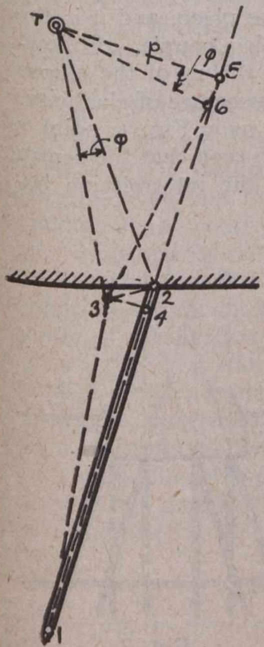


Fig. 2

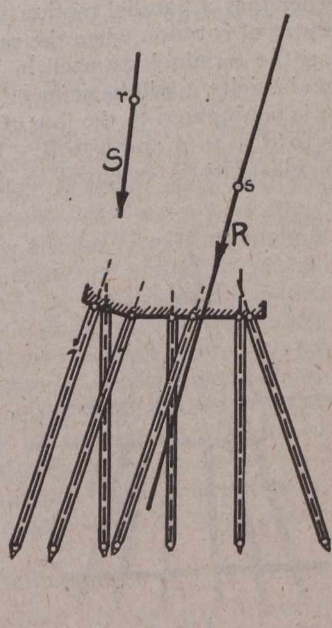


Fig. 3

force S are zero. Hence the centre of rotation s corresponding to a force along the line S is located on R, which was to be proved.

To Find the Centre of Rotation When the Resultant Force is Given

The determination of the rotation centre is the first step in the treatment of any particular case of loading. Let R in Fig. 1 be the resultant force transmitted through the pier to the group of piles. r is the corresponding centre of rotation, which is to be determined. Now, assume temporarily that the pier rotates through a certain angle about the point a chosen anywhere on the resultant R. This rotation would produce certain deformations in the piles. The corresponding pressures on the piles may

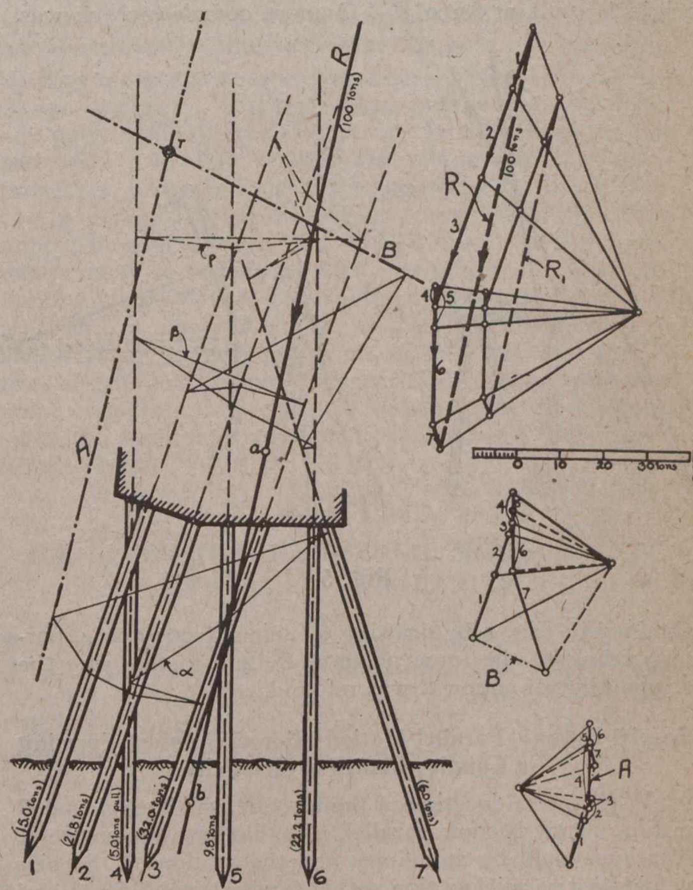


Fig. 4

be found by formula (2). These pressures are composed into the resultant A. By virtue of the above quality of reciprocity between lines of action and centres of rotation the centre of rotation r will be located somewhere on A. We will then choose another point b on R, and find in the same way its corresponding resultant B. The actual centre of rotation r is the point of intersection of A and B.

In Fig. 4 the auxiliary resultants A and B are found by drawing the funicular polygons α and β. The corresponding force polygons A and B are shown to the right in Fig. 4. The piles are in this case assumed to be of equal length, cross-section, and modulus of elasticity. Then, owing to formula 2, the pressures used in the force polygons A and B may be measured as proportional to (for instance, half of) the distances from the respective centres of rotation to the centre lines of the piles.

To Find the Pile Pressures When the Resultant Force and the Centre of Rotation are Known—Methods of Checking Results

Having determined the centre of rotation r it will not be difficult to find the distribution of pile pressures. Assuming arbitrarily some angle of rotation ϕ_1 about the centre of rotation r a set of corresponding pile pressures proportional to the real pressures may be found by formula 2. A force polygon gives the corresponding resultant R_1. In Fig. 4 the piles were assumed of equal length, cross-section, and modulus of elasticity. Accordingly, the pile pressures in the force polygon R_1 are taken as proportional

*W. Ritter: Graphische Statik, III., Ed. 1900, p. 260.

†Given in most texts on Mechanics of Structures. Announced in its first special form by Maxwell (1864), later expanded by Betti (1872) and Lord Rayleigh (1873). For references and for a general proof see A. E. H. Love, Mathematical Theory of Elasticity, 1906, p. 170.

to (half of) the distance from r to the centre lines of the piles. The force polygon for the real pile pressures is found in Fig. 4 by magnifying the force polygon R, in the ratio of R to R_1.

The results may be checked by the fact that R_1 found by the force polygon must have the same direction as the original resultant force R_1. A more complete check was

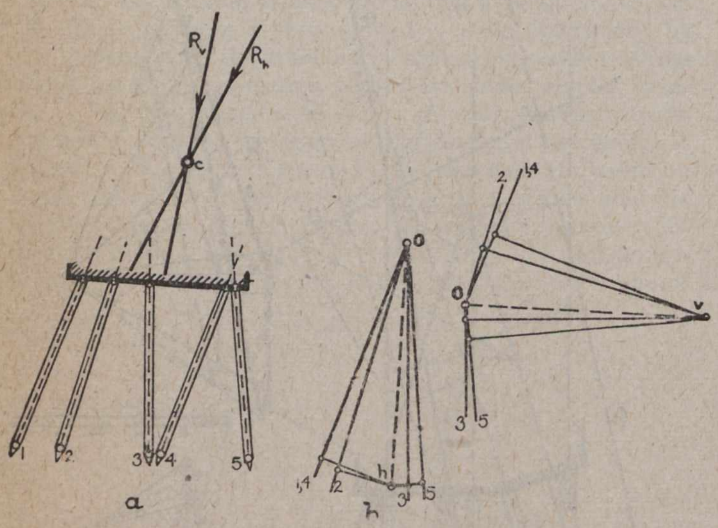


Fig. 5

obtained in Fig. 4 by drawing a funicular polygon ρ, corresponding to the force polygon R, and in this way the original line of action R was refound.

Special Cases: Parallel Motion; Forces Applied Forming a Couple; Centre of Elasticity

With special location of the force R, the lines A and B in Fig. 1 may become parallel. In that case the centre of rotation would be at infinity and the motion of the pier would be a parallel motion perpendicular to the lines A and B. The shortenings or elongations of the piles due to parallel motions of the pier may be found graphically by the method shown in Fig. 5 (a, b and c). Fig. 5a shows the group of piles and the pier under consideration. To find the effect of a unit horizontal motion of the pier lay out $\overline{\text{O-h}}$ = unity on a vertical line, as shown in Fig. 5b. Draw through O lines parallel to the piles 1, 2, 3, 4, 5 in Fig. 5a. A motion towards the left will shorten piles 1, 2 and 4, and elongate piles 3 and 5. The total shortenings and elongations of the piles are found as the distances in Fig. 5b from point h to the lines parallel to the piles. That this is correct will be seen by changing Fig. 2 in the following way: Move the rotation centre r to infinity in vertical direction, make 2-3 horizontal and equal to unity, then 2-4 will continue to represent the shortening of the pile. By turning triangle 2-3-4 90° clockwise we reproduce the part of Fig. 5b which corresponds to one pile.

Pile shortenings due to a unit vertical parallel motion downwards are found in the same way in Fig. 5c. O-v is a horizontal vector equal to unity. The pile shortenings are equal to the distances from the point v to the lines 1, 2—5 through point O parallel to the piles.

The shortenings of the piles determine the pressure on each pile by the usual formula (2). Each set of pile pressures may be composed into a resultant, for instance, by drawing a funicular polygon. In this way the resultants R_h and R_v in Fig. 5a were found; they correspond to the horizontal and vertical translations respectively. Translations in other directions than the horizontal and vertical may be treated by the same method. In all cases resultants passing through c will be found.

Another important special case is that in which the resultant load is a couple. This case will appear to be closely related to that of a parallel motion; in fact, the two cases are in some respects reciprocal. Assume that the resultant is a couple; this may be interpreted as the limiting case in which the resultant force is at infinity. Then it is possible to apply the method illustrated in Fig. 1 and Fig. 4. We assume that R in Fig. 1 moves out to infinity. The two auxiliary centres of rotation a and b may be chosen as the points at infinity in the vertical and horizontal directions, respectively. The corresponding rotations are the parallel motions in horizontal and vertical directions, respectively. Assume that the group of piles under consideration is that shown in Fig. 5. Then the lines of action A and B corresponding to the rotations about a and b will be the same as R_h and R_v, the lines of the resultants producing horizontal and vertical translations. Their point of intersection c is the rotation centre when the resultant is a couple. Instead of using the horizontal and vertical translations, any other two directions might have been introduced in determining c. The relation between the moment of the couple and the corresponding angle of rotation is found by first determining the pile pressures for a certain angle of rotation, using the usual formula (2), and then composing these pressures into a couple.

It is evident that the point c is of particular importance in defining the general elastic qualities of the structures. It is the point through which the resultant must pass in order that a parallel motion shall take place, and it is the centre of rotation when the resultant is a couple. Following the terminology used in Ritter's theory of the ellipse of elasticity it will be referred to as the centre of elasticity. It is conjugated to the line of infinity as in Fig. 1, point r is to R, a to A and b to B. It is also seen that the centre of elasticity is essential in defining the interrelation be-

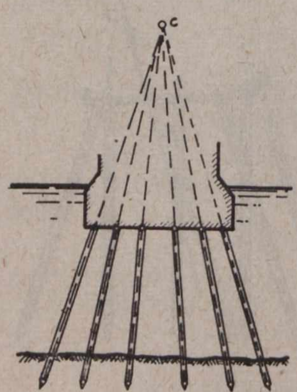


Fig. 6

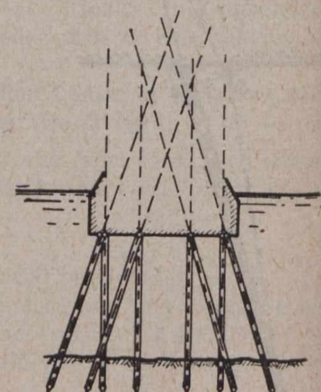


Fig. 7

tween the cases of parallel motion and that in which the resultant is a couple.

General Elastic Qualities of the Group of Piles

The elastic qualities of the group of piles as a whole may be described by the following characteristics:—

The centre of elasticity (c in Fig. 5a).

The resultant R_h corresponding to a unit horizontal translation (Fig. 5a).

The resultant R_v corresponding to a unit vertical translation.

The couple necessary to produce a unit rotation about the centre of elasticity.

It is worth noting that R_h and R_v must be known both in magnitude and direction. Owing to Maxwell's and Betti's theorem of reciprocity, they are interrelated in that the vertical component of R_h is equal to the horizontal component of R_v.

The general state of elasticity of the group is defined by these data because any resulting load may be decomposed into components along R_h and R_v, and a couple. Each of these three component loads may be treated separately, as causing, respectively, a horizontal translation, a vertical translation, and a rotation about the centre of elasticity.

Reference is made to three general methods of treating such cases of elastic resistance:

First, the method of the ellipse of elasticity, developed by Ritter.* The centre of the ellipse is the centre of elasticity, and force and centre of rotation correspond as anti-polar and anti-pole.

Secondly, the application of Land's stress circle† should be mentioned. This method gives information about the elastic displacements of the centre of elasticity due to resulting forces in varying direction. The method is convenient in graphical analysis.

Thirdly, attention is called to the use of a linear vector-equation (dyadics equation) in representing the relation between the displacement of the centre of elasticity and the magnitude and direction of the force applied.‡

Any of these three representations bring out the principal axes of the elastic resistance, that is, two directions perpendicular to one another, having the quality that forces in these directions produce motions of the centre of elasticity in their own direction. The second method, applying Land's circle, gives a convenient graphical determination of these principal axes.

Classification of the Method Applied

If there are more than three rows of piles in the group the structure is statically indeterminate. It is treated by determining certain displacement qualities, say, two co-ordinates of the centre of rotation, and the angle of rotation. In primarily determining displacements the method is contrasted with the great number of cases in which stresses in redundant members are the variables in the equations of elasticity, and it is classified with such methods as the slope-deflection method applying to frames.§ In our graphical treatment the two lines A and B in Fig. 1, intersecting one another in the centre of rotation correspond to two of the necessary elasticity equations, while the solving of a third elasticity equation is replaced by the graphical determination of the magnitude of the resultant (Fig. 4, force polygons at right-hand corner at top).

General Conclusions

The greater the distance between the centre of rotation and the centre line of a certain pile, the greater is the load transmitted to that pile. This explains that in Fig. 4 the second and the third pile from the left carry greater pressures than the first pile. In general, it is seen that when the piles are not all parallel the greatest pressures are likely to occur in other than the extreme piles.

Figs. 6 and 7 show two designs of pile groups supporting, for instance, a bridge pier. In Fig. 6 all pile centre lines intersect in one point c. A resultant load not passing through c cannot be resisted by the resultant of the pile pressures. Unless the pier or the piles are supported transversely such a resultant would cause an unrestrained rotation about c, and the pier would act as if it were hinged at c. The arrangement in Fig. 6 would not be adequate as an abutment support for a continuous arch system, neither would any arrangement in which the piles are approximately intersecting at one point.

Fig. 6 represents an extreme case. Now consider the design in Fig. 7. It is seen that a possible rotation about any point would be resisted by at least some of the pile pressures. In this respect the pile group in Fig. 7 possesses a superior rigidity compared with that in Fig. 6. In general, to obtain rigidity and strength with a limited number of piles in a limited space, two requirements must be satisfied: First, resistance against the various components of the resultant loads is to be secured by battering a proper number of piles. Secondly, to prevent turning of the pier, points of intersection of centre lines should be at proper distances from at least one other point of intersection of centre lines of piles, and, if possible, the resultant load should pass between these points of intersection.

*W. Ritter: Graphische Statik, for instance, Vol. III., Ed. 1900, pp. 259-264.

†Robert Land, Der Spannungskreis, etc., Zeitschrift des Vereines deutscher Ingenieure, 1895, pp. 1551-1554.

See also L. J. Johnson, The Determination of Unit Stresses in the General Case of Flexure, Association of Engineering Societies, Vol. 28, 1902, pp. 251-289.

‡See for instance: L. Silberstein, Vectorial Mechanics, 1913, p. 92.

§Wilson-Maney, University of Illinois, Eng. Exp. Station, Bulletin No. 80, 1915.

ICE DIVERSION, HYDRAULIC MODELS, AND HYDRAULIC SIMILARITY

In *The Canadian Engineer* for January 17th there appeared a paper on "Ice Diversion, Hydraulic Models, and Hydraulic Similarity," by B. F. Groat, M.Am.Soc. C.E. The following discussion of Mr. Groat's original paper appears in the Transactions of the American Society of Civil Engineers:—

J. Waldo Smith, M.Am.Soc.C.E., New York City: It does not seem that the point made by Mr. Groat as to the efficiency and value of small models in solving hydraulic problems can be emphasized too strongly. It is truly surprising how nearly the results indicated by his models were verified by subsequent actual experience. The results obtained on small models are usually to be considered as being indicative rather than absolute, and this is especially the case in the new fields of hydraulic construction where we have to deal with what may be called excessive head, quantity, or velocity. In such situations the search must be for a guiding experience which will tend to indicate all possible limitations as to structural dimensions, and as to the factors of flow, of velocity, and of turbulence in the passing water.

With these ends in view, a model was constructed in connection with the design of the spillway and channel of the Boonton Dam, at Boonton, N.J. The line of the spillway channel was at a very acute angle with the axis of the overfall section, so that when the water had passed into the channel, after a fall of 50 ft., its velocity would have been very high. Such a condition would have called for a high and massive retaining wall, in order to keep the waters within the channel section. This problem was solved by constructing a model and by studying the behavior of the water when passing over it. As a result of these studies, a steep chute was constructed at one end of the spillway section, so that the water passing down it would acquire a high velocity parallel with the axis of the overfall, and thus by its weight and volume cause the resultant between it and the volume of the overflowing water to coincide with the axis of the channel.

At the present time, the general plans of the new overflow dam on the Schoharie development of the Catskill water system are being studied, and there will be built a good sized model of the dam and spillway before deciding on the various structural details involved. Here the dam is to be at right angles to the stream bed. The water will pass over its crest for a length of 1,300 ft., all on one side of the valley. The fall will vary from 160 ft. at one end, decreasing up the side of the valley to about 20 ft. The down-stream face of the dam is to be formed in large steps, from 10 to 20 ft. in height and from 10 to 18 ft. in width. The water will finally fall into a spillway channel along the toe of the dam, the bottom of the channel having a steep grade to the present stream bed. A high wing-wall will be built along the far side of the original stream bed, nearly at right angles to the dam and also at right angles to the axis of the spillway channel. It is expected that the model will give much information as to the action and behavior of the water and in determining many details as to the structural design, with particular reference to any features which may be needed in order to guide and control the direction of flow.

The author's reference to the skimming process recalls to the speaker's mind one of the best examples of this process which he has seen. At Omaha, Nebr., the very turbid Missouri River water was pumped into a settling reservoir, composed of a series of basins about 30 ft. deep. The water paused in these basins and then successively passed over long weirs separating the basins. The sediment settled quite rapidly, so that the thin skin passing over the last weir was, when seen, quite clear—for water of such character—and reasonably satisfactory for use without coagulation or filtration.

Robert Fletcher, M.Am.Soc.C.E., Hanover, N.H.: The author has made a very positive and questionable statement on the "Performance of Models" in the following words:

"His conclusion concerning this matter is that models perform in much the same way as the full-size prototype. In fact, there was nothing in the results of the experiments to indicate that they did not perform exactly as their prototypes. These statements apply equally to hydraulic models of all kinds, whether they be of machines, such as water-wheels and pumps; of structures, such as overflow dams, weirs, and spillways; of sections of an actual river or canal; or of ships."

The inexorable laws of Mechanics forbid any such sweeping general conclusions. William M. Torrance, M.Am.Soc.C.E., has made a convincing exposition of this question in an article entitled "Use of Models in Engineering Design" (Engineering News, December 18th, 1913), and has warned his readers against misconception of the value of such models in practical applications. Having made a model of a concrete water tank on a concrete trestle tower to a scale of 1 : 30 he showed that the model was proportionately stronger than its prototype of full size, inversely as the scale, or thirty times as strong. The apparently surprising strength and agility of diminutive creatures, like frogs, fleas, etc., in leaping power, was shown not to be remarkable, because the proportionate strength of their limbs, being as their cross-sections, are as the square of the linear scale of their size, though the weights are inversely as the cube of the scale; hence their relative muscular power is as the scale of their dimensions. Therefore, a frog or a flea can leap as far as a man can jump, because he has relatively more strength in proportion to his weight.

Commenting on this article, the writer added, among others, the following examples:

Passing from statical conditions to dynamical the following examples are to the point:

"Before the elevated railway was built in Boston the late Capt. J. V. Meigs made strenuous efforts to have his single-truss elevated railway adopted. The track or 'way' or truss was provided with two bearing rails for the horizontal wheels and two lower rails for the diagonal wheels of a unique form of truck, and the truss was supported on a single line of columns, as in the first New York elevated railway. This is fully described in Vol. VII., Transactions, Am.Soc.M.E., paper No. 189. An expensive working model was set up in a large upper room of a warehouse in East Cambridge, Mass., where the inventor demonstrated the 'successful working' of his scheme to visitors, as he did to the writer and a class of students in November, 1885.

The model engine weighed 275 lbs., the tender 80 lbs., with a model car six feet long. Steam was 'gotten up' quickly and the train developed an average speed of 10½ ft. per second, passing curves of 6¼ ft. radius and mounting grades equivalent to 610 ft. per mile (adhesion increased by accumulator pressure on the horizontal truck wheels). On level track a speed of 22 ft. per second was made.

"This performance doubtless convinced the most skeptical; but on this occasion the spectators were reminded that the forces in action, especially the centrifugal reaction (not force, but the opposing effect of inertia as the body is incessantly pushed by the curving rail toward the centre) on the curves, would be vastly out of proportion to the scale, in the full-sized train. The model was made on a one-eighth scale, and, if W represents the weight and v the velocity of the model, this centrifugal reaction would be expressed by $\frac{W}{g} \times \frac{v^2}{r}$. Assuming a velocity in the same proportion, one-eighth of, say, 66 ft. per second (45 miles per hour) = 8¼ ft. per second, and radius r of curve in like ratio, then, since W of the large engine will be as the cube of the scale, we have the action of the actual engine measured by $\frac{(8)^3 W}{g} \times \frac{(8)^2 v}{8r} = 4{,}096 \frac{W}{g} \times \frac{v^2}{r}$. To resist this the strength of track-frame, trusses, columns, etc., which depends upon the cross-sections, would be in the ratio of $(8)^2 = 64$ to 1: and the disproportionate dynamic effect of the full-sized engine would be $4{,}096 \div 64 = 64$ times greater than any which the model could exert. The numerical measure of the larger effect would be, on a curve of $6\frac{1}{4} \times 8$ ft. radius: $4{,}096 \times \frac{275}{32} \times \frac{8\frac{1}{4}\, 8\frac{1}{4}}{6\frac{1}{4}} = 384{,}000$ lbs. This is 2.7 times the weight of the machine ($275 \times 8^3 = 140{,}800$ lbs.); but it will be noticed that the radius is quite short and the speed (66 ft. per second) for so sharp a curve is not permissible. Right here is where the uninstructed experimenter is deceived if he infers proportionate dynamical stability from the beautiful behavior of the model.

"A different case is that of an experimental model dam. In a discussion we usually consider only a unit of length, say, 1 ft. Assume a model 2 ft. high with any acceptable cross-section, to represent by a one-ninth scale a proposed dam 18 ft. high. Here relative statical effects depend upon the hydrostatic law that the [total] pressure varies as the square of the depth $\left(w \times h \times \frac{h}{2} = \frac{wh^2}{2} : w \times 9h \times \frac{9h}{2} = 81 \frac{wh^2}{2}\right)$. But the similar cross-sections also vary as the square of the scale; and all pressures and resultants in the two cases hold the same relative position. Hence, this is a case where the full-sized dam really has stability proportionate to that of the model.

"This condition, however, is far from true when overflow occurs. For instance, assume 6 ins. gauge depth of flow over the model, which would represent 54 ins. over the proposed crest. Now, the hydro-dynamic law of discharge over weirs is (the quantity) $Q = c\,l\,h^{\frac{3}{2}}$, in which c is a constant, l the length and h the gauge height above the crest; and $(9)^{\frac{3}{2}} = 27$. Here, then, the discharge over the full-sized dam would be 27 times that over the model; and, more than that, it has nine times as far to fall (really 9½, from the centre of gravity of the overfall). The energy acquired, which measures its capacity for destruction, varies with the height of fall and is, therefore, $9 \times 27 = 243$ times that of the water discharged over the model dam.

"Considering this inexorable mechanical law, the designer may anticipate in some degree the tremendous impact against the backwater below, the scour on the bed of the channel, the 'kick-back' or reaction against the apron and toe of the dam, the vacuum effect upon the dam itself, etc.; but these would not be even faintly suggested by the behavior of the model and its 6-in. overflow."

It may be objected to this discussion that we have assumed 1 ft. in length, both for the actual dam and its model; whereas we should make the comparison by using only 1/9 ft. of the model; and that, therefore, gives only 27 to 1; or, the relative effects are as the $\frac{3}{2}$ power of the scale ratio; but that is just where we are deceived. It is true that the total effect of shock and destruction along a line only one-ninth as long in the model as in the dam is only as 1 to 27; but the destructive effect will not be confined to a proportionate length. The convenient unit of 1 cu. ft. of water and 1 lin. ft. in both cases is proper, because it is required to compare the energy, symbolized by Wh (of the model), with that of $W'\,h'$ of the real conditions; that is, Wh compared to $27\,W\,9\,h$; or, to state it otherwise, we are concerned here to compare the shock or destruction per foot or other equal length.

In a recent work, J. L. Van Ornum, M.Am.Soc.C.E., gives an interesting account of some elaborate experiments made by German engineers at the Experimenting Establishment in Berlin. These are right to the point in this discussion. The problem and plan of procedure are stated thus:

"Because of uncertainties with regard to the attainment of entire success in being able to definitely represent on a small-scale model all the conditions of a natural river and to be assured that the effects of artificial modifications in the streams are correctly indicated by corresponding changes of the model, it was decided that the first requirement was the true reproduction of a definite part of the natural Weser River, and then to compare the effects of flowing water upon it with the state of the river bed which had been produced by corresponding conditions. If this experimental verification of the correctness of the details of reduction in scale and choice of materials proved satisfactory, then it could be confidently assumed that experimental investigation of the effect of any proposed plan or detail of regulating works would show, on the model, the consequences that would result from the same construction of full size in the river itself. For this purpose a portion of the Weser, 1.6 km. in length * * * was chosen because of its availability in its definitely known characteristics both in its natural state and after works of improvement had been installed, the stability of its bed in showing similar conditions to exist at each recurring low-water stage, and because a more effective regulation of that stretch of river was desired.

"The condition of the facilities of the hydraulic laboratories caused the adoption of a scale of linear reduction of 1 to 100 for both horizontal and vertical dimensions. With regard to the character of material which should be used for the bed of the artificial stream, it was evident that a variation in size corresponding to that of the river itself is important; but the question of the suitable proportionate size was not so clear. It was said that apparently the ratio of volumetric reduction should be as 1 to 100, which would call for an average diameter of grain of about 1.7 mm. inasmuch as that of the river gravel was about 8 mm. However, after some investigations of the behavior of graded sand of various average sizes under the action of flowing water, * * * a river sand of an average diameter of about 1.2 mm. was chosen for the material of the model; this was, in later experiments, changed to 1 mm., or six-tenths the diameter which would keep the volumetric ratio of the particles the same as the linear ratio of reduction for the general dimensions of the model."

So, to begin with, a scale reduction was made, reducing the size of particles to be transported to only 0.6 of that required by the geometrical relations. Then the account goes on to state that four other requirements had to be satisfied, *viz.*:

"A correspondence in relative height of mean low water, mean high water and mean water levels, the range in the model, of course, being one one-hundredth that observed in the Weser; all these water levels are to have a similar corresponding relation with respect to the tops of the groynes; the depths and cross-sections of the three water levels must have a like relation to those of the natural river; and the discharge in the model is to have a constant ratio to that of the Weser at all three stages mentioned."

It was considered that the continued product of the slope, depth, and reciprocal of the diameter of the grain should have the same value in both the model and the river. For the river this product was 0.0000235 and for the model 0.021; but we learn that:

"Repeated experimental attempts to attain satisfactory results on the basis of that computed slope seem to have proved disappointing; at any rate, a slope of about one-tenth that value and a ratio of unit discharge of 1:40000 were experimentally found more satisfactory. Later, a surface slope of about 0.0015 and a corresponding discharge ratio of 1:50000 were found to produce a channel in the model still more nearly coincident with that of the river itself, especially for the higher stages."

So here, again, preliminary trials led to very considerable changes in the computed quantities. Then, in conducting experiments, the bank protection and controlling groynes in the model were made with "small sacks of shot," and "small pieces of slate, at slopes of 1 on 1." It would appear that the density and stability of such materials are almost as much out of proportion to the resisting qualities of the materials on the actual river as would be steel sheet-piling vs. brush mattresses and riprap. Erosion in the model was prevented or corrected by these bags of shot.

Although some interesting similarities in effects were found, on comparing the profiles and cross-sections of the model and the river, it was admitted that there is

"A lack of coincidence in details which suggests the conclusion that the system is not yet perfected. Such irregularities are found as differences in distribution of shallow and deep portions of the channel, the smaller depths in the reach shown by the model, the greater variability in the experimental depths, and especially the greater comparative depths in the concave banks. While the last-mentioned difference is not important with regard to the effect upon navigability, it is, nevertheless, one of the characteristics by which the question of the adequacy of experimental methods must be judged."

Following the statement quoted at the opening of this discussion, Mr. Groat makes the following further positive statement:

"In the case of hydraulic models, it can be shown that homologous velocities in models of different size must be proportional to the square roots of homologous linear dimensions. When the quantities of water have been properly adjusted to comply with this requisite, it may be said that the mechanical and hydraulic conditions in the two models are mechanically and hydraulically similar, just as the configurations of fluids and solids in the models are geometrically similar."

He then states that experimenters with water-wheels have overlooked these relations and conditions, and have failed to make proper tests of model wheels.

Now, the writer thinks that the instances cited by Mr. Torrance and himself plainly refute the idea of simple and always uniform inter-relations and analogies. It is shown that, in a model of a static structure, additional load must be supplied to the extent of the weight of the model multiplied by the scale ratio. (A model bridge made by the writer had to be loaded with 350 lbs. before the individual members were stressed in proportion to the homologous stresses in the bridge represented.)

In the single case of the model dam, as the pressure (load) itself varies as the square of the depth, the behavior of the model and its prototype are the same; but in all cases where dynamic effects are involved, we cannot usually make the model and its prototype comparable or analogous by simple adjustments or contrivances.

Referring now to the experiments conducted by Mr. Groat, the writer would not presume to criticize the procedure or question the validity of the conclusions, so far as they relate to the particular object sought, and strictly under the conditions stated. No doubt, as the German experimenters found, useful lessons may be learned from "model" performances, but only under very special and tractable conditions. We have seen how their protracted and painstaking endeavors resulted in admitted failure to gain the full result sought. For one thing, changes in the model or miniature could be made with ease; but similar modifications under actual conditions might involve great labor and expense or develop unexpected forbidding conditions which the mere model would not suggest. (Like a plan "on paper" vs. a procedure necessitated in face of the working conditions.)

Engineers familiar with our northern rivers, even those flowing from north to south, and thus under more favorable conditions for getting rid of ice in the spring, know too well some of the extreme conditions that defy calculation. Although pieces of paraffin in a small stream may simulate ice carried under ordinary conditions of moderately high water, they are essentially different from ice. They will not freeze together as will ice after a thaw followed by a "cold snap"; they would not readily be subjected to the great side pressure which drives ice laterally into side channels and high up on sleeping banks; they would not so easily simulate the great jams which fill the entire channel, pile up high above it, and cause an excessive rise of the river, leading to destruction of dams, mill buildings, etc.; neither would the miniature contrivance be likely to produce baffling conditions of backwater which vex the souls of those who operate power plants. The writer's observations and experience on a river like the Upper Connecticut is that artificial furrows or transverse ridges in the bed of the river would be speedily obliterated in whole or in part, either by erosion or filling up; and such aids as jetties for con'rolling the flow, as proposed, must needs be of expensive construction to be permanent, and may easily be overtopped by high floods. The following instances illustrating the above stated points are only a few among many which might be cited.

At Summer's Falls a rocky barrier extends so obliquely across the river that its length is nearly double the direct width of the river. About 50 years ago at this site there was a dam, a canal lock and approach canal for river boats, and a very large saw-mill running seven saws. A spring flood brought down ice which jammed and froze; a second flood increased the jam, piled the ice high on the dam and against the banks, and finally carried the mill down stream, and wrecked the dam and lock, which were never rebuilt. The writer has seen (Engineering News, November 14th, 1912, p. 893) an impressive picture of blocks of ice up to 4 ft. thick (a man standing beside one) wedged together over an extent of many acres, on one side of the Lower Yellowstone dam, in Montana, as the result of a high flood. This suggests in part the possibilities of destruction by a spring flood carrying ice.

At the Vernon dam and power house the spillway is 650 ft. long, and the fall, without flash-boards, is 32 ft. The river just below widens to 1,200 ft., but below that is a short curved narrows, about 400 ft. wide. Yet the engineer reports that in a high flood the water below the dam has risen to within 0.8 ft. of the crest, so as to make it for a time practically a submerged dam. How could any model dam and section of this bay and gorge, extending actually a mile on the concave, have suggested this condition of back-water?

When we consider the demonstrated fact that the transporting power of a stream varies as the sixth power of the velocity; that the energy of the flowing water varies as the cube of the velocity; and know that, by geometrical necessity, any model on a reduced scale lacks weight and stability in itself to test its full capacity, under diminutive conditions, we are obliged to object to the quoted all-inclusive claim for the validity of model studies and experiment, especially where hydro-dynamic operations are involved.

A. F. Parker, M.Am.Soc.C.E.: The writer has been actively interested in the problem of canal intakes and keeping them clear. This paper mentions only the matter of ice and floating materials, and in large streams, presumably of not very great fall. Under conditions of ice flowing in such large rivers, and with only moderate velocity, the sub-diversion channels described may produce very good results; but, in smaller streams, of heavy fall, such as are usually found in mountainous districts, it is not so evident that the method presented would produce the results sought. In mountain streams it is usually necessary to build a diversion dam at each intake. Sometimes such dams may be permanent, and in other cases movable dams are necessary in order to pass the annual spring floods. In the case of a permanent dam, the basin back of it always fills up with silt, sand, and sometimes heavier drift materials, so that in time there is only a limited space of any considerable depth at the intake. Movable dams are erected only at low-water stages, and, when removed to pass the spring floods, the current sweeps the deposits accumulated in the basin cleanly away. Thus the action resulting from the use of either form of dam would evidently preclude the use of sub-diversion channels.

In such cases—and such conditions obtain almost everywhere in mountainous localities—it is always very difficult to keep intakes clear of ice. The main reliance must be placed on drawing the water from the greatest depth possible below the surface. The still water above the dam holds the ice flow, but sometimes the mush ice reaches nearly the full depth of the water. Usually, a large gang of men is required to keep the intake clear, and it is impossible to prevent considerable quantities of ice from entering it.

In streams of the kind mentioned, however, the ice problem is not the only one involved in intakes, for it is equally difficult to contend with sand, gravel, and floating and submerged driftwood. During high water driftwood lodges against trash racks, as commonly placed, finer materials are then caught, and, with sand and silt, often make an almost watertight dam; sometimes it is as difficult to keep such racks clear, as when there are ice formations. Sand and gravel, washing into intakes and thence down the canal or pipe line, cause much damage to water-wheels, or they clog the canal and are not easily prevented. It is evident that sub-diversion channels are likely to be easily filled in by the river drift in times of high water, even in large, slowly moving streams; it is absolutely sure that the swiftly flowing streams common to the mountains

above the middle of a concrete channel, with side-walls flush with the bottom of the river. The water is discharged below the dam, the flow through the concrete channel being controlled by a wooden gate. The diaphragm wards off all floating materials, and the space under it allows the water to pass to the intake. The channel or trough of concrete catches all sand and gravel washed down by the current, and the rush of the current of water through it removes all such material and prevents clogging; the channel has been given a heavy fall in order to accomplish this.

Below the diaphragm, and some distance away, there are two Tainter gates, each 18 ft. wide and 13 ft. high. Between the gates and the diaphragm, and on the river side, there are five wooden gates which serve as relief

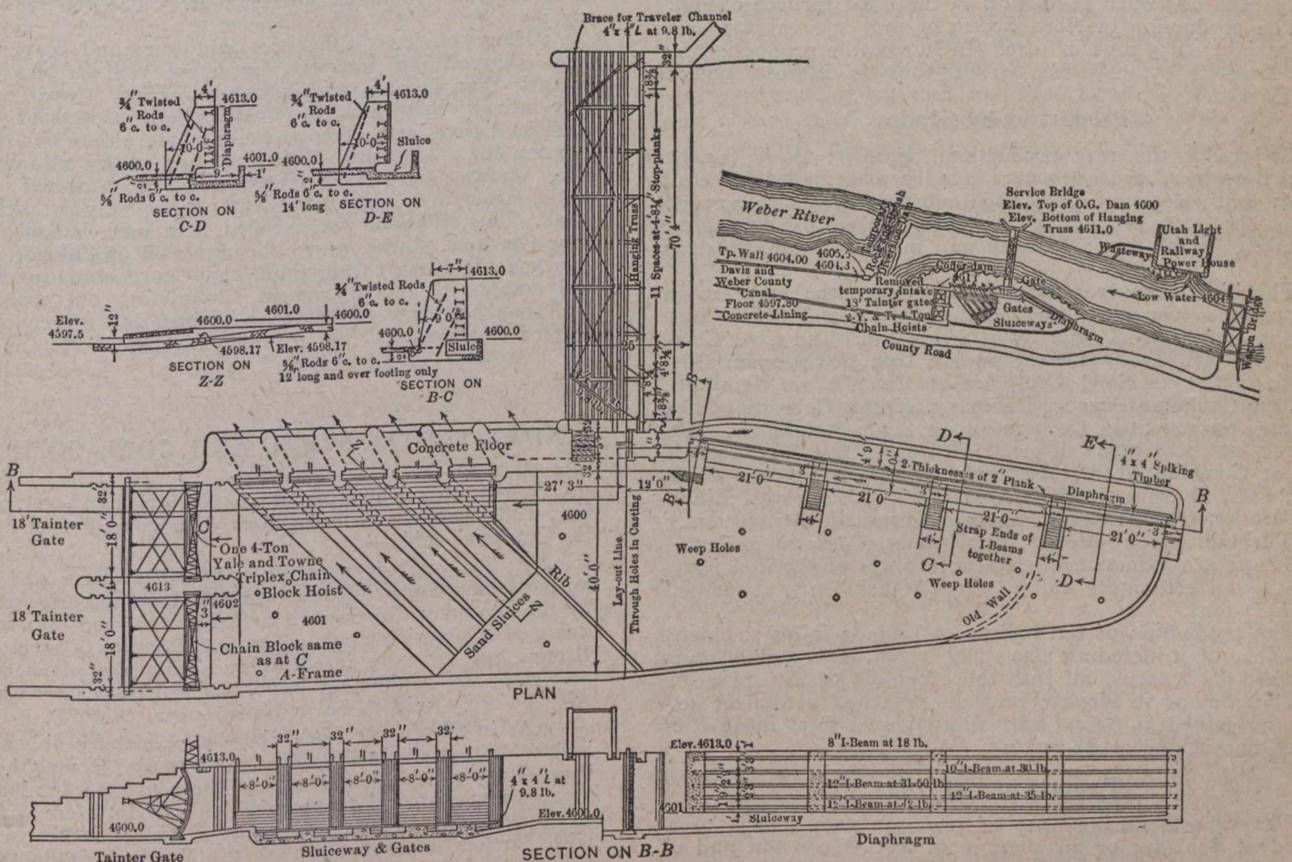


Fig. 1—Main Canal Headworks of the Davis and Weber Counties Canal Company.

would either fill them up or that they would serve to divert the sand and gravel—carried in great quantities by the torrential flows—into the intake; a condition it is desirable to avoid.

Perhaps it is unfair to discuss conditions differing so much from those assumed in the paper, as do the usual mountain streams, but the excuse is in the great interest and importance of the matter under all conditions. The writer submits plans (Fig. 1) showing an intake designed for an irrigation and power canal, where it was very difficult to deal with the ice in winter and the floating drift, sand, and gravel in summer. This intake was not built just as shown on the plans, and does not now give the best results. Had it been built as designed, it would surely have done the work in the best possible manner.

The plans show a movable dam across the stream, operated from a service bridge above it. In place of the usual trash rack, there is a vertical diaphragm of wood fastened to steel beams extending between undercut concrete piers and reaching in a straight line up and down stream and nearly parallel to it. This diaphragm is set

gates for the pool of water that the Tainter gates may be made to form. In the bottom, and leading to these five gates, there are some channels extending diagonally across and below the floor of the intake, and these catch and remove the sand which passes the diaphragm channel; the pool above the Tainter gates acts in some degree as a settling basin. The five wooden gates serve only to close the side of the channel and provide an overflow, but are arranged so as to operate the sand trap, being left up a short distance when there is water enough to waste, or are raised occasionally for flushing out the sand.

The arrangements to care for all conditions of flood or frost, and to remove the sand and gravel entering the intake are complete, and, provided there is sufficient fall to the location, cannot fail to do good work. The arrangement would need modification where the fall is light, but the general idea could be preserved. From the plans the design may be easily understood. It it not reasonable to regard a deflecting diaphragm, as shown here, with a subsurface intake entry, as promising better results under all conditions, and more logical to adopt in place of the usual rack so easily clogged either by trash or ice?

PIG IRON AND STEEL

The production of pig iron in blast furnaces during 1917 was supplemented by a small production of high grade low phosphorus pig iron in electric furnaces made from shell turnings and other steel scrap, according to preliminary returns of Mr. John McLeish, B.A., Chief of Division of Mineral Resources and Statistics, Ottawa. The total production from both sources (not including the output of spiegeleisen, or other ferro-alloys) was approximately 1,171,789 short tons (1,046,240 gross), final returns not yet having been received from all manufacturers of electric pig iron. Of the total, 1,156,789 tons were produced in blast furnaces and the balance in electric furnaces. In 1916 the production all made in blast furnaces was 1,169,257 short tons (1,043,979 long tons).

The small increase in pig iron production in 1917 was therefore due entirely to the electric furnace production, there having been an actual falling off in the blast furnace output.

The production in Nova Scotia in 1917 was 472,147 tons as against 470,055 tons in 1916. InOntario the production by blast furnaces in 1917 was 691,632 tons as against 699,202 tons in 1916.

Production by Grades

By grades the 1917 production included: Basic, 14,092 tons; Bessemer, 961,656 tons; foundry and malleable, etc., 181,041 tons; electric furnace pig (subject to revision), 15,000 tons. The 1916 production included: Basic, 953,627 tons; Bessemer, 31,388 tons; foundry and malleable, etc., 184,242 tons.

The blast furnace plants operated were the same as in the previous year—viz., the Dominion Iron and Steel Company at Sydney, N.S., the Nova Scotia Steel and Coal Company, at North Sydney; the Standard Iron Company at Deseronto, Ont., the Steel Company of Canada, at Hamilton, Ont., the Canadian Furnace Company, at Port Colborne, Ont., and the Algoma Steel Corporation at Sault Ste. Marie, Ont.

Pig iron was made in electric furnaces by: The Canada Cement Company, Ltd., Montreal; Frazer, Brace and Company, Ltd., Shawinigan Falls, Que.; British Forgings, Limited, Toronto, Ont.; Electro Foundries, Limited, Orillia, Ont.; and Turnbull Electro Metals, Limited, St. Catharines, Ont.

The total production in electric furnaces of pig iron ferro-alloys and steel ingots and castings was in 1917 about 99,000 short tons.

The production of ferro-alloys in Canada in 1917, chiefly ferro-silicon but including also spiegeleisen, ferro-molybdenum and ferro-phosphorus, all with the exception of the spiegeleisen being made in electric furnaces, reached a total of 40,329 tons valued at $3,471,934, as against a total in 1916 of 28,628 tons valued at $1,777,615.

Exports of Pig Iron

The exports during 1917 of pig iron were 12,081 tons, valued at $423,814 or an average of $35.08 per ton and of ferro-alloys 33,212 tons, valued at $2,616,924, or an average of $78.79 per ton.

The imports during 1917 included 82,758 tons of pig iron, valued at $2,744,055, or an average of $33.16 per ton; 632 tons of charcoal pig iron, valued at $19,447, or an average of $30.77 per ton; and 12,828 tons of ferro-alloys, valued at $2,029,990, or an average of $158.25 per ton, making a total import of pig iron and ferro-alloys of 96,218 tons, valued at $4,793,492. The United States trade records show exports to Canada during the 11 months ended November, 1917, of pig iron and ferro-alloys amounting to 130,087 gross tons (145,697 short tons), valued at $5,170,005, a figure considerably higher than the Canadian record.

Production of Steel

The estimated production of steel ingots and direct steel castings in 1917, final returns for all operations not yet having been received, was 1,736,514 short tons (1,550,459 gross tons) of which 1,690,170 tons were ingots and 46,344 tons direct steel castings.

The total production in 1916 was 1,428,249 tons, compared with which the 1917 production shows an increase of 308,265 tons, or 21.6 per cent.

The total production of electric steel in 1917 was probably not less than 50,000 tons, as against 19,639 tons in 1916 and 5,625 tons in 1915.

The exports of steel ingots, or billets, ingots and blooms, during the nine months ended December (such exports not being separately classified previous to April, 1917) were 41,558 tons, valued at $1,831,917. The recorded imports of iron and steel ingots and billets during the year was 20,429 tons, valued at $1,378,576. This item is also much lower than the United States trade record which shows exports to Canada during 11 months ended December, of 143,209 gross tons (160,394 short tons), of billets, ingots and blooms of steel, valued at $11,418,033.

STEEL SHIPBUILDING PLANT IN NOVA SCOTIA

The shipbuilding commission appointed in May, 1917, by the Nova Scotia government to investigate the possibilities for the shipbuilding industry in that province has made its report. The conclusion arrived at is that the encouragement of the steel shipbuilding industry and the measures to be taken for its development and growth is a matter primarily and essentially for the Dominion government. The report reads in part:—

"Many obvious difficulties will surround a permanent steel shipbuilding industry, but these will be less on the Atlantic than in any other part of Canada. Nova Scotia is rich in raw materials, can easily be equipped to furnish fabricated parts and offers a choice of more than one excellent location for a shipyard. The workmen of the province, who have shown such well tested skill in building wooden ships, can, we are confident, also build ships of steel. This, if proof were needed, has been demonstrated at New Glasgow, where, under the direction of Colonel Thomas Cantley, the Nova Scotia Steel and Coal Company, Limited, has completed and placed in commission one fine vessel, will soon be ready to launch a second and larger one, and a third of the same class is well under way.

NOVA SCOTIA STEEL AND COAL COMPANY

At the annual meeting of the Nova Scotia Steel and Coal Co., Ltd., held recently in New Glasgow, President Frank H. Crockard said:—

"At the blast furnace, open hearth furnace and rolling mill, we have amply demonstrated that the material possessed by the company can be satisfactorily converted into steel products of a superior grade. The manufacture of steel in Cape Breton has virtually just emerged from the pioneer period, and compared with other important iron and steel centres, it may be truly said to be in its infancy.

"As in all pioneer work, there were many problems which had to be satisfactorily solved and to-day it may be stated that as a result of these efforts there are no fundamentally serious metallurgical features which will interfere with quantity production. The development of wider markets will come with further diversification of the finished products, which necessarily must be produced by plants possessing all of the economic features characterizing modern mills. In forwarding such plans it would seem desirable to await the re-establishment of normal conditions."

The character of the products was very substantially changed during the last half of the year 1917. The ordinary commercial products constituted nearly 50 per cent. of the market value, compared with 15 per cent. during the preceding year. This was due to cancellation of contracts covering shell forgings. The company was compelled to adjust itself as quickly as possible to this radically altered condition, and in so doing, found it expedient to intensify the plate mill production. Owing to the large reserves on hand and due to unsatisfactory market and shipping conditions prevailing in 1917, it was found necessary to mine only about one-third of the furnace requirements during the year.

President Crockard quoted from a report received from mining engineer Edwin C. Eckel, in which Mr. Eckel refers to the Nova Scotia Steel and Coal Company's ore properties as representing perhaps the most important single iron ore holding in the world, in which, Mr. Eckel says, the coal properties are second only to the ore holdings in tonnage and value. "At the present rate of use," says Mr. Eckel, "the ore and coal would each last for over a thousand years, and at any probable future rate of use they will probably last for several hundred years. Putting the matter on a competitive basis, the Nova Scotia Steel and Coal Company will in all probability be mining iron ore at Wabana for a hundred years after the Lake Superior ore beds have been exhausted."

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Principal Contents of this Issue

"EMERGENCY" DEVELOPMENT AT NIAGARA

ON another page of this issue, W. W. Young, a consulting engineer of New York City, outlines one of a number of schemes that have been suggested for emergency development of Niagara Falls. Mr. Young's scheme is no doubt quite feasible, provided that the two governments are prepared to ignore the scenic factor for some years to come. But, despite all the arguments in favor of discouraging tourist travel at present, we doubt exceedingly whether any measure could be passed through the House of Commons at Ottawa, or through the House of Representatives at Washington, which would mean the total elimination of any part of Niagara Falls,—even temporarily.

The only possible argument in favor of an emergency measure of such far-reaching consequences as that proposed by Mr. Young, is the saving in time. The power-house, penstocks, etc., for the emergency scheme would no doubt cost quite as much, in proportion to the power secured, as would those for a permanent scheme. The great question, therefore, is how much time would be saved by such an emergency development in comparison with a plan of permanent development which would preserve the beauty of the Falls and at the same time take advantage of nearly the whole head between the two lakes? Mr. Young suggests priority orders to facilitate the manufacture of the machinery, but would it be physically possible to get the necessary machinery built—under present conditions—for two or three years? And by that time the Ontario Hydro-Electric Power Commission will be in shape to supply 300,000 h.p. from its new plant at Queenston, and that should satisfy much of the power shortage until the completion of New York State's scheme for permanent development under high head. Moreover, in connection with any emergency development of Niagara, there would no doubt be construction difficulties which might take no short period to overcome, although, given time and money, they could unquestionably be conquered.

The unwatering of the American channel would probably be the easiest part of Mr. Young's scheme. The hasty construction of intakes along the American cliff might not be so easy if ice trouble were to be obviated. For the safe operation of the emergency plant in winter, the removable low dam at the crest of the American Falls presents difficulties of design that would take time to overcome. But the American side of Mr. Young's scheme is easy of rapid accomplishment compared with the Canadian side. Mr. Young has rendered a national service—both to the United States and to Canada—in directing public attention once more to the urgency of the power problem at Niagara and its importance in winning the war. That more activity should be shown in the development of Niagara—particularly on the American side of the border—cannot be gainsaid, but it is a matter for very careful engineering deliberation as to whether such development should follow "emergency" or permanent plans.

CONSERVING OUR WATER POWERS

NON-DEVELOPMENT of our fuel resources may in some sense be considered as conservation, because posterity benefits. In other words, it is conservation of our fixed capital. No such reason, however, exists in the case of our water powers, which renew themselves continuously and partake more of the nature of revenue producers, which revenue being lost from year to year through non-use, is lost forever.

In considering the development of many of our natural resources, we are prone to reason from the point of view of private capital investing in a business from which stock profits are expected. Considered as a national asset and apart from private ownerships, a wider view is necessary for that development which under existing conditions might not yield a stock profit, yet would if developed from the larger point of view yield a living for many; and in addition, even though no profits were made, money would be kept in the country instead of being exported, and immigration would take advantage of the increased labor market.

It is, therefore, incontestable that from a national standpoint our power should be developed, even although no cash dividend results. This involves retention in the hands of the government of the ownership of our water powers for development by the government; or if in private hands, under such regulations as will permit their resumption by the State under fair conditions which will not preclude the utilization of such private capital as may be obtainable.

Canada has a superabundance of water powers for all present needs, but in view of the increasing demand for power for electro-chemical and electro-metallurgical processes, it becomes pertinent to inquire as to whether we are utilizing our resources in the wisest possible way.

First consideration should be given to the question as to the population which can be supplied with the necessary power, both now and in the future, for ordinary manufacturing purposes. In other words, conservation and increase of population. Secondary to this is the development of bulk production of materials from this power through the establishment of electro-chemical, metallurgical or other industries which, while demanding large amounts of power, support but few people. In other words, a policy of hand-picking our powers should be adopted by the federal and provincial governments, tending to conserve for the thickly populated parts of the Dominion such powers as are necessary for their common uses, and permitting the development for electro-chemical and electro-metallurgical processes only of those which are more remote from centres and therefore less valuable as supporters of population.

This is not to say that no power should be developed in manufacturing districts except for small manufacturing purposes, for it will frequently happen that a large and expensive power can only be developed in a manufacturing district if a large load be obtained which is sufficient to pay the bond interest from the start; but in this case it should be clearly understood that the electro-chemical user has only the right of use at cheap rates until the demands of the community require his power, which would then be salable at much higher rates for the greater good of the community as a whole. Neither are the above references pertinent when applied to such electro-chemical and metallurgical industries as can utilize off-peak power, provided again, of course, that these do not interfere with the overtime needs of the ordinary manufacturing plant. Furthermore, when only a limited amount of power is available, true conservation does not consist in so reducing the cost that it can be wasted, with a final result that industries for which such power is essential are robbed by those which under true conservation would utilize other agencies less valuable in that particular district.

The above is a mere academic discussion of obvious things as they ought to be, from which the very practical question arises as to how such matters can be adjusted and kept adjusted under a well-understood and accepted doctrine of conservation.

Some of our powers to-day are under the jurisdiction of the Dominion Government, but most of them are under the jurisdiction of the provinces. No true conservation in a national sense is possible except by the co-operation of provinces and Dominion. It is suggested, therefore, that some body,—call it "Ministry," "Department," "Commission" or by any other name,—should be constituted whose administration of our powers would be accepted by all governments under a general policy agreed upon, the results being logical development and the elimination of present patchwork methods.

Reference has been made to fuel resources as distinguished from water power resources. While in detail the doctrines applicable to these resources are different, the ultimate result expected from both is production of energy. Wide districts of Canada are bare of fuel but abundantly supplied with water power; others are without water power but are well supplied with fuel; therefore it is suggested that whatever steps are taken by the government in connection with our water powers, should carry with it the conservation and development of our fuel resources. In other words, whatever central body is constituted should deal with the energy problem of the country as a whole, and its jurisdiction should extend not only to water powers but to fuel resources, which are complementary thereto. It is only by such a method that the best use of our water powers can be determined.

The Quebec Railway, Light, Heat and Power Company is negotiating with several concerns in regard to the location of factories at or near Quebec City. The company has upwards of 20,000 h.p., which it can readily develop at short notice, and is looking for a market for it.

PERSONALS

J. W. ADAMS, city engineeer of Chatham, Ont., has resigned.

Lieut. ALEX. ROSS ROBERTSON, of Toronto, has been wounded. He graduated in 1909 from S.P.S., Toronto.

R. C. HARRIS, commissioner of works, Toronto, has been appointed a member of the national committee to investigate the peat industry for the province of Ontario.

Lieut.-Col. WILLIAM G. MACKENDRICK, D.S.O., who has just returned from France, will address the Engineers' Club of Toronto this evening on his experiences as director of road-building for the Fifth British Army.

HENRY J. FULLER, vice-president of Fairbanks, Morse & Company, and president of the Canadian Fairbanks-Morse Company, Limited, has been elected a director of the Liberty National Bank of New York City.

F. C. LANE, O.L.S., has been appointed town engineer of Sudbury, Ont. He will have entire charge of the road, street and bridge departments and will also do all necessary engineering for the fire, water and light committee.

NORMAN HOLLAND, F.S.C., will give an illustrated lecture this evening before the Montreal Branch of the Canadian Society of Civil Engineers, on "Modern Varnish Making." As a chemist and manufacturer, Mr. Holland will speak with authority in regard to wood and metal protective coatings.

W. CHASE THOMSON, consulting engineer, Montreal, will address the Montreal Branch of the Canadian Society of Civil Engineers this evening, on the "Kettle Rapids Bridge," giving the reasons for his adoption of the unusual design (a thousand feet continuous girder in three spans) and describing the construction methods used and difficulties successfully overcome in the erection.

ROBERT A. ROSS, E.E., consulting engineer, Montreal, has been appointed by the Quebec provincial government as one of the five members of the new city commission that is to govern Montreal. Mr. Ross has not yet announced whether he is prepared to accept the appointmeent. He is a member of the Advisory Council for Scientific and Industrial Research, vice-president of the Canadian Society of Civil Engineers, and consulting engineer to the Hydro-Electric Power Commission of Ontario and to a number of municipalities and private companies.

OBITUARIES

EDGAR M. MCDOUGALL, son of the late John McDougall, founder of the Caledonia Iron Works, died on April 4th at Los Angeles, Cal., where he had gone some time ago for his health. He was a graduate of the Royal Military College, Kingston. At the time of his death he was president of the Canada Iron Foundries, Limited, successors to the Canada Iron Corporation.

JOHN B. BROPHY, C.E., of Ottawa, who has been connected with the engineering staff of the Cornwall Canal for the past seven months, passed away on March 31st, following a stroke of paralysis. A couple of weeks previously Mr. Brophy had been taken ill with pneumonia, but appeared to be well on the road to recovery when he was stricken. He was in his 73rd year. Two daughters survive him. Mr. Brophy's only son, Lieut. "Don" Brophy, a well-known athlete, lost his life a short time ago while with the Royal Flying Corps.